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CONTENTS

THE IMPACT OF DROUGHT AND ANTHROPOGENIC ACTIVITIES ON EDAPHIC MESOFAUNA COMMUNITIES IN CERTAIN NATURA 2000 STEPPE GRASSLAND HABITATS

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Abstract

The mites from the orders Parasitiformes, Trombidiformes, and Sarcoptiformes, as well as microarthropods from the Entognatha class (Collembola), insects, and other groups, were analyzed. The mites which belong to suborder Oribatida were identified at the species level. The analysis was conducted both quantitatively and qualitatively in Natura 2000 steppe meadows. The vulnerability of these sites, including susceptibility to drought and the impact of grazing, influenced the structure of the microarthropod communities. The density of individuals was higher in strictly protected areas; however, there was no significant qualitative difference compared to the buffer zones. Humidity deficiency and grazing negatively affected the mesofauna, particularly species sensitive to drought. Oribatids exhibited a rich diversity, indicating good habitat conservation. Continuous monitoring of the impact of natural and anthropogenic factors is necessary, especially in buffer zones.

Key words: Soil biodiversity, microarthropods, meso-xerophilous meadow, protected areas.

Natura 2000 is a network of nature protection areas in the territory of the European Union. It is designed to ensure the long-term survival of Europe's most valuable and threatened species and habitats. Mârzeşti Forest and Meadows (ROSCI0171) and Bârca Meadows (ROSCI0077) were declared sites of community importance by the Order of the Ministry of Environment and Sustainable Development No. 1964 of December 13, 2007 regarding the establishment of the regime of protected natural areas of sites of community importance, as an integral part of the European ecological network Natura 2000 in Romania. These areas were designated as SCI with the aim of protecting biodiversity and maintaining a favorable conservation status of the wild flora and fauna, as well as the natural habitats of community interest within the protected area.

The vulnerability of the site Mârzeşti Forest and Meadows is caused by inappropriate anthropogenic activities (sporadic plowing perpendicular to the contour lines, which favors landslides; grazing, flock transit, penning, etc.), as well as the presence of active landslides. For Bârca Meadows site, the vulnerability lies in the danger of being converted into agricultural land. Observations and field activities carried out during sample collection confirmed the presence of the aforementioned anthropogenic activities in both sites, which are likely to create a real impact on the strictly protected areas.

In both natural and anthropic ecosystems, soil mesofauna, in interrelation with soil microorganisms, actively participates in the processes of degrading necromass and, thus, in nutrient cycling. The density of microarthropods and the relationships between systematic and trophic groups decisively determine the speed and direction of decomposition, the dynamic balance of mineralization-humification, a balance that ensures soil fertility (Brussaard *et al*, 1997, Jeffery *et al*, 2010, Menta, 2012, Wardle *et al,* 2004). Considering all these factors, as well as the fact that the degree of anthropization of an ecosystem fundamentally influences the components of the biocenosis, it is particularly important to know the quantitative and qualitative characteristics of the soil microarthropod fauna.

MATERIAL AND METHOD

Field observations and sample collection were carried out in mid-June 2023 from the two natural reserves - Mârzeşti Forest and Meadows and Bârca Meadows, which are located in the Northeastern part of Romania, in Iaşi County (*table 1*).

Soil samples were gathered from habitats characterized by Ponto-Sarmatic steppes (62C0),

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which prevail across both reserves. The collection included areas under strict protection as well as buffer zones in each location. The extraction of microarthropods was carried out using the Tullgren - Berlese method, improved by Balogh. The faunistic material was studied microscopically, with the abundance of each group recorded for each sample

Table 1

Characteristics of the investigated sites

Natura 2000 Site	Location	Area (ha)	Altitude			Biogeographic region	Protected plant species
			min.	max.	med.		
Mârzeşti Forest and Meadows	N 47º 14' 24" E 27º 29' 55"	232	67	179	125	Continental	*Echium russicum, Crambe tatarica, Pulsatilla grandis*
Bârca Meadows	N 47º 4' 48" E 27º 29' 35"	159	66	129	88		*Iris aphylla ssp. hungarica, P. grandis*

The primary data thus obtained were processed using analytical and synthetic ecological estimators:

- average abundance in individuals/100 cm² or per m², calculated for both species (ā) and groups (Ā);
- standard deviation (σ), a statistical measure that indicates how much individual values in a data set deviate from the mean (average value) of that data set; it quantifies the dispersion or variability of the data;
- Pearson's coefficient of variation (cv%), a statistical measure used to express the relative variability of a data series compared to its mean;

For oribatids, a representative group with bioindicator value, species-level identification was performed, and an additional use of the following indicators:

- number of taxa, respectively species (S), genera (G) and families (F);
- frequency (C), expressed in classes: IV-euconstant species (C > 75%), III-constant (C between 50.1-75%), II-accessory (C between 25.1-50%), I-accidental (C < 25%);
- relative density (D.r.), expressed in classes: V-eudominant species (D.r. > 10%), IV-dominant (D.r. between 5.1-10%), III-subdominant (D.r. between 2.1-5%), II-recedent (D.r. between 1.1-2%), I-subrecedent (D.r. < 1%);
- ecological significance (W) (Dziuba, 1968), expressed in classes: V, IV-edifying species (W > 5%), III-influential species (W between 1.1-5%), II, I-accompanying species (W < 1%);
- specific diversity (H(s)max, H(s), H.r.), estimated based on the Shannon-Wiener equation.

In addition, the adult/pre-adult ratio was also calculated, which provides information about the demographic structure of the community and its likely evolution.

The nomenclature of species and their world distribution follows Subías L.S., 2004, updated version 2024. Ecological peculiarities for each oribatid species were summarized according to (Pérez-Iñigo C.,1993, Pérez-Iñigo C.,1997; Subías L.S. and Arillo A., 2001; Weigmann G., 2006; Vasiliu N. *et al*, 1993).

RESULTS AND DISCUSSIONS

The assessment of soil microarthropod biodiversity in the analyzed reserves was conducted through inventory and analysis of mites from the suborders Parasitiformes (order Mesostigmata) and Acariformes (orders Trombidiformes and Sarcoptiformes - suborder Oribatida and cohort Astigmatina), microarthropods from the class Entognatha (Collembola), and overall insects and other groups belonging to the soil mesofauna (*table 2*). The average density of soil microarthropods ranges between 163.6 individuals/100 cm² and 274.6 individuals/100 cm², with the highest value observed in the strictly protected area of Mârzeşti Forest and Meadows Reserve and the lowest in the buffer zone of Bârca Meadows Reserve. However, in both these Natura 2000 sites, it was observed that microarthropod abundance is greater in the strictly protected area compared to the buffer zone. A comparison with the findings from Valea lui David nature reserve (ROSCI 0265), another site of community importance in northeastern Romania, reveals that the density of mesofauna at Bârca is only slightly lower, while at Mârzeşti it is slightly higher (Călugăr A., 2006). This suggests a good conservation status for both reserves at this stage. However, the calculation of the standard deviation revealed high values, indicating significant variability in the distribution of mesofauna. This variability could be caused by various ecological factors such as soil conditions, resource availability, human interference, or other environmental factors. This may have important ecological implications, as it could indicate greater natural variability in mesofauna communities or suggest that certain conditions are more unpredictable or fluctuating in those locations (*table 2*).

The Pearson variation coefficient also showed high values, indicating a moderate positive

correlation between two measured variables regarding soil mesofauna.

Table 2

Global average density (individuals/100 cm²) of soil microarthropods

Taxa		sites	Mârzeşti meadows		Bârca meadows	
			1	2	1	2
Mesostigmata		Ā	13.6	6.9	10.2	33.7
		δ	10.7	6.4	6.0	15.4
		cv%	78.7	93.7	59.0	45.5
Trombidiformes		Ā	68.3	99.6	99.2	52.6
		δ	41.6	79.1	60.7	18.8
		cv%	60.9	79.4	61.2	35.8
Sarcoptiformes	Oribatida (O)	Ā	88.0	92.9	22.2	78.0
		δ	55.6	68.8	12.0	49.9
		cv%	63.2	74.1	54.0	64.0
	Astigmatina (A)	Ā	2.1	4.0	1.6	1.4
		δ	3.4	5.0	2.7	1.4
		cv%	158.6	124.6	170.5	98.0
Total Acari		Ā	172.0	203.3	136.2	165.7
		δ	87.1	104.6	78.0	68.7
		cv%	50.6	51.4	57.3	41.4
Entognatha (Collembola - C)		Ā	2.6	3.1	4.0	8.1
		δ	3.3	1.5	2.5	5.2
		cv%	126.2	46.4	63.3	64.1
Insecta		Ā	14.0	67.3	23.2	29.1
		δ	12.2	52.9	23.1	34.0
		cv%	87.4	78.6	99.5	116.7
Other groups		Ā	0.3	0.9	0.2	6.4
		δ	0.7	1.4	0.4	10.9
		cv%	20.0	158.1	200.0	170.0
Total		Ā	188.9	274.6	163.6	209.4
		δ	93.5	113.7	84.2	82.4
		cv%	49.5	41.4	51.5	39.4
O/C			34.2	29.6	5.6	9.6
O/A			41.1	23.2	13.9	54.6

Legend: 1- buffer zone; 2- strictly protected area; O/C - numerical ratio between Oribatida and Collembola; O/A - numerical ratio between Oribatida and Astigmatina; Ā - average abundance/density; δ - standard deviation; cv% - Pearson coefficient of variation

For example, it might suggest that an increase in a particular soil characteristic or factor (such as organic matter content or pH modification due to grazing) tends to be associated with a moderate increase in soil mesofauna diversity or density.

The Entognatha representatives, specifically collembolans, are represented by a much smaller number of individuals compared to those of the class Acari, both in the buffer zones and in the strictly protected areas of Mârzeşti and Bârca (*table 2*). Thus, the abundance of collembolans is over 60 times lower at Mârzeşti and over 20 times lower at Bârca compared to that of mites. This situation may be attributed to the drought period preceding sample collection. Grazing animals can compact the soil, which also negatively affects soil mesofauna, particularly groups sensitive to dryness, especially during prolonged drought conditions. Organisms from the class Collembola are generally sensitive to this phenomenon and try to protect themselves in dry environments by seeking shelter under organic material or in deeper soil layers when moisture conditions become unfavorable. Additionally, they feed on bacteria, algae, and decomposing organic material in the soil, and a lack of precipitation can affect the availability of these food resources, leading to a reduction in collembolan populations. Indeed, the calculation of the Pearson variation coefficient indicates high values, reflecting an uneven distribution of these organisms due to insufficient resources.

Among mites, Trombidiformes represent a group with a varied diet and are well-represented, especially in meadows, while Oribatida, which are detritivorous and microphytophagous, have the highest abundance in forest ecosystems (Krantz G. W., Walter D. E., 2009). The study found that Oribatida is the most numerous group but only in the buffer zone of Mârzeşti (51%) and in the strictly protected reserve area of Bârca (73%, respectively 47% of the total mites) (*table 2*). At Mârzeşti, in the strictly protected area, Trombidiformes mites are slightly more numerous than those from the suborder Oribatida (49% and 46% of the total mites, respectively), while at Bârca - the buffer zone, they represent the majority

(74%). With a reduced share, the suborder Mesostigmata, which includes zoophagous mites, occupies the third position, with the highest percentages in the strictly protected area of Bârca (20%) and the lowest in Mârzeşti (3%). The least represented among mite populations, with percentages of only 1-2%, are the acarid mites (cohort Astigmatina), known to be microphytophagous (Krantz G. W., Walter D. E., 2009), and are stimulated by moist, anaerobic environments rich in nitrogenous substances (Călugăr M. *et al*, 1989; Huţu *et al*, 1992; Călugăr A., 2005). Therefore, grazing should have been a stimulating factor for this group of mites by increasing the organic matter input from animal droppings. However, the deficient precipitation, as experienced during the period preceding soil sample collection, had a negative effect on acarid populations, as drought can influence their food availability by making organic matter less accessible or harder to decompose.

In this study, a bioindicator of the humification stage of an organic substrate was assessed, specifically the numerical ratio between oribatid mites and collembolans/astigmatid mites (Huţu *et al*, 1992). The results showed high to very high values for this ratio, with collembolans and astigmatid mites appearing sporadically and in much lower densities compared to oribatids across all analyzed samples. These findings suggest a trend towards advanced humification in both buffer zones and strictly protected areas within the Natura 2000 sites under study.

The fauna collected from the two Natura 2000 sites totaled 1411 specimens of adult oribatid mites, to which 512 juveniles were added. The study of this rich material led to identification of 51 species, classified into 43 genera and 28 families of the suborder Oribatida Dugès, 1834. The weight of the major groups in the whole fauna is as follows: "lower" oribatids (Macropyplina) - 19.6%, "superior" oribatids (Brachypylina), picnonotic – 45.1% and poronotic – 35.3%. Such a representation of the two groups of Brachypylina proves to be a characteristic of silvosteppe meadows, it being known that, in grassland ecosystems, poronotic oribatid mites are dominant, and in forest ones, picnonotic oribatids (Ivan O., 2007, Ivan O., 2010). In this study was identified and recorded for the first time in the fauna of Romania *Berniniella inornata* (Mihelčič, 1957), a species with Mediterranean distribution. In addition, some rare species, such as *Jacotella neonominata* Subias, 2004, *Birsteinius clavatus* Krivolutsky, 1965 or *Liacarus (Dorycranosus) zachvatkini* Kulijev, 1962 were found. The families Oppiidae (9 genera, 10 species), Brachychthoniidae (3 genera, 4 species) and Liacaridae (2 genera, 4 species) are the best represented in terms of number of taxa, and the species of the families Oppiidae, Ceratozetidae and Phenopelopidae have the widest distribution in the investigated sites.

Analysis of the fauna from zoogeographical point of view shows that the most numerous are the species with a wide geographical distribution, cosmopolitan and semi-cosmopolitan (33.3%), followed by the Palaearctic (27.5%), Holarctic (19.6%), and European species (17.6%). Species with a southern distribution represent 25.5% of the total, an important share, taking into account the latitude at which the investigated sites are located (Ivan O., 2018).

Table 3

Structural global parameters of oribatid communities

Sites		Ā		F/G/S	Adults/ juveniles	Specific diversity			Edifying species*
		total	adults			$H(S)_{max}$	H(S)	H. r.	
Mârzeşti meadows	I	9290	6700	20/27 /30	2.59	4.9069	3.7066	75.54	*Punctoribates punctum, Tectoribates ornatus, Oribatula pannonica, Ceratozetes minutissimus*
	II	8800	6100	25/32 /36	2.26	5.1699	4.1823	80.89	*Jacotella neonominata, Discoppia (C.) cylindrica, Sphaerochthonius splendidus*
Bârca meadows	I	7800	6128	13/19 /20	3.67	4.3219	2.7578	63.81	*Anomaloppia differens, Ceratozetes minutissimus, Oppiella nova, Poecilochthonius spiciger*
	II	2220	1720	8/10 /10	3.44	3.3219	2.7795	83.4	*Ceratozetes minutissimus, Subiasella (L.) subiasi, Discoppia (C.) cylindrica*

Legend: I – protected area; II – buffer zone; Ā - global average abundance (individuals/m^2); number of taxa: F-families, G-genera, S-species; H(S)max – maximum specific diversity; H(S) – real specific diversity; H.r. - relative diversity (%); *V and IV classes of ecological significance (W≥ 5,1%, see Material and method).

As regards the autecological particularities of species, the largest share have grassland species or species with a preference for such habitats (27.5%), followed by euryplastic elements, with wider ecological valence (19.6%), and finally preferentially forest ones (17.6%). Analyzing the

preferences of the species in relation to the humidity factor, it is found that the xerophilous, meso-xerophilous and thermo-xerophilous species are more numerous than the mesophilous ones, although the weight of the two categories is close (31.4% and 29.4%, respectively).

The analysis of the global structural parameters of the oribatid communities indicates higher or close values of the global average density, the number of taxa and the specific diversity in the protected areas compared to the buffer zones (*table 3*). In the meadows at Mârzeşti, the number of taxa and, implicitly, the specific diversity, are even higher in the buffer zone than in the protected area, a fact that can be explained by the different location, which determines different stand conditions. In the case of Bârca meadows, notable differences can be observed between the protected and the buffer zone, both in terms of quantitative and qualitative parameters, with much lower values in the buffer zone. The groups of edifying species bring together typically grassland species, most of them being meso-xerophilous or thermo-xerophilous, alongside species with wider ecological plasticity. The demographic structure is balanced in all the investigated sites, illustrated by the low values of the adults/ juveniles, ratio; the good representation of the immature stages, as well as the relatively high values of the diversity indices, characterize some functional and stable communities over time and their functional integration within the ecosystem.

CONCLUSIONS

The characteristics of the reserve, including its vulnerability, were key factors influencing both the numerical and qualitative structure of soil microarthropod communities. In terms of quantity, differences were observed between the buffer zone and the strictly protected area, with a higher density of individuals in the strictly protected zone.

Concerning the qualitative aspect of the communities, no significant differences were observed between the two Natura 2000 sites or between their distinct zones – buffer and strictly protected area. For mites, it was found that oribatid mites and Trombidiformes alternated in dominance, without clear connections to specific ecosystem characteristics. Overall, mites constituted the majority of the mesofauna communities, while collembolans were present in low numbers across all sites. Two stress factors were identified in both Natura 2000 sites: grazing activities and the drought period preceding sample collection.

The drought, along with grazing present in both sites, had a negative impact on the entire mesofauna, particularly on groups sensitive to drought, such as Astigmatina and Entognatha, which were almost absent in samples from both sites.

The study of oribatid mites showed that the fauna of the two protected areas is relatively rich and diverse, characteristic for the main habitat type, Ponto-Sarmatic steppes. In the ecological spectrum of the fauna, grassland species and euryplastic ones have the largest share, notable being also the increased proportion of xerophilous and meso-xerophilous species, higher than of mesophilous ones, a fact that supports the bioindicator value of this group of edaphic microarthropods.

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CHANGES IN METABOLIC EFFICIENCY DURING CORN SEED GERMINATION

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Abstract

Plant growth can be defined as an irreversible process of increasing size and biomass, often associated with the formation of new structures: root and shoot growth is a complex multistage biochemical and physiological process. The purpose of this study was to evaluate changes in the metabolic efficiency of corn seeds during ten days of their germination. The objects of the study were seeds of corn hybrids P280, P398 and P402, which have different ripening periods and differ in endosperm structure. The metabolic efficiency of seeds was determined after 5, 7 and 10 days of germination under optimal conditions. The maximum content of reserve substances utilized for germination and root/shoot growth was observed during 5-7 days of seed germination. Moreover, for two hybrids (P398 and P402) it was necessary to germinate for 7 days to achieve the highest metabolic efficiency, but hybrids P280 had the maximum metabolic efficiency on the 5th day. After this period the metabolic efficiency of seeds decreased. The obtained results can be used to change the methodological approaches to the comparative determination of metabolic efficiency of corn seeds of various hybrids.

Key words: corn seed, germination, metabolic efficiency

Germination of corn seeds, like that of all plants, is a complex multifunctional process. Seeds that have a high degree of germination are usually more resistant to various adverse environmental conditions, infection by pathogenic microorganisms, and are characterized by high growth and development speed. The higher the ability of a plant to produce metabolic products necessary for life, the wider the reaction norm of a given plant and the better its ability to adapt. These properties are especially important for food grade corn hybrids, as they are more demanding in terms of cultivation conditions (Jiang F. *et al*, 2023).

Plant growth can be defined as an irreversible process of increasing size and biomass, often associated with the formation of new structures. The growth of roots and seedlings is a complex multi-stage biochemical and physiological process from the point of view of physiology. In order to provide the plant embryo, cells with a sufficiently high amount of energy, complex oxidative reduction reactions and an increase in the efficiency of using reserve substances for seed germination or metabolic efficiency must occur in the plant. Resumption of metabolic activity and mobilization of reserves are key steps to maintain seedling and root growth before photosynthetic mechanisms are activated (Rosental L. *et al,* 2014).

The initial stages in seed development, which affect its subsequent sowing qualities, are the foundation for building the life of a plant; these are, in a way, critical points, the indicators of which will indicate the survival of the species and the plant's resistance to various abiotic factors (Grzesik M., Romanowska-Duda Z., 2014; Meng A. *et al,* 2022). Therefore, it is necessary to learn much more about the key processes associated with seed germination.

The standard method of International Seed Testing Association (ISTA) prescribed the germination of corn seeds during seven days (ISTA, 2017). Earlier, the metabolic efficiency of various hybrids of corn was investigated after 7th day of seeds germination according to international rules (Ivanova R. *et al,* 2022; Borovskaia A. *et al,* 2023). It is known well that under ideal conditions of temperature and soil moisture corn germinates in 7-10 days. However, Grzesik M., Romanowska-Duda Z. (2014) and Omar S. *et al,* (2022) showed that the dynamics of corn seed germination under optimal laboratory conditions reaches its maximum on the 5th day. Sikder S. *et al*, (2009) also determined the metabolic efficiency of corn at 5th

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day after seeds placement for germination. No observations of changes in metabolic efficiency by days of corn seed germination were found.

This study examined changes in root/shoot vigour and metabolic efficiency of food-grade corn seeds at different time during germination using hybrid seeds containing various amount of starch and protein in the grain.

MATERIAL AND METHOD

The experiments were carried out in 2024 in laboratory conditions in the Institute of Genetics, Physiology and Plant Protection, Moldova State University, Republic of Moldova.

Seed materials. The seeds of food-grade corn hybrids were generously contributed by the National Center for Seed Research and Production, Institute of Crop Science „Porumbeni". The hybrids have different ripening periods and differ in the structure of the endosperm, namely:

a) Porumbeni 280su (P280) is medium-season hybrid of sweet corn, FAO 300. In the phase of technical maturity, the grain contains 14.0% total sugar and 31.4% starch. It is distinguished by a large wrinkled angular grain consisting of a floury endosperm.
b) Porumbeni 398 (P398) is medium-early hybrid corn that belongs to the popcorn group, FAO 400. The grain has a siliceous consistency and is characterized by a high specific gravity of vitreous endosperm. The floury part of the endosperm is present only near the embryo. The grain has a high protein content (16%).
c) Porumbeni 402 (P402) is medium-late dent-flint hybrid of corn, FAO 400. The endosperm on the sides of the grain is horn-shaped, in the center and top it is mealy and loose. Corn is the most widespread among other groups. The grain contains 70-75% starch, up to 15% protein and 3-6% fat.

The weight of 1000 seeds of the P280 hybrid were 142.1±4.3 g; of P398 – 157.8±8.3 g; and of P402 – 279.3±7.6 g.

Laboratory testing. Each experiment consisted of 100 seeds (25 seeds on 4 replicates). Vigour and metabolic efficiency determination procedure included following steps:

a) germination of seeds in optimal conditions. Index of total germination was determined on the fifth, seventh and tenth days;
b) measure of roots and shoots length of germinated seeds;
c) vigour I of roots and vigour II of shoots were determined as the common value of the germination percentage and the length of roots and shoots, respectively (Kerecki S. *et al*, 2021);
d) separation of roots and shoots from seeds;
e) drying of biomass (separated roots, shoots, seeds);
f) determination of dry biomass weight;
g) calculation of reserve substances (SMR, g/unit) mobilized from seeds for energetic support of physiological processes of germination as follows:

SMR = SMU- (RMU + EMU + SMG)

where: SMU - dry weight of seeds before germination, g/unit; RMU - dry mass of roots, g/unit; EMU - dry weight of shoots, g/unit; SMG - dry weight of seeds after germination, g/unit.

h) seed metabolic efficiency (SME) was determined as the ratio of the sum of roots and shoots dry weight (g) to the reserve substances spent on energetic support, according to equation, described by (Sikder S. *et al*, 2009, Borovskaia A. *et al,* 2023):

SME = (RMU + EMU) / SMR

Statistical analysis. Analysis of variance (ANOVA) was performed using the software package Statgraphics Plus 5.0.

RESULTS AND DISCUSSIONS

Germination rate and dynamics of root/shoot growth is genotype dependent and can be evaluated in initial stage of development. The length of root/shoot measured at fifth day of corn seed germination was very different in tested hybrids. The significant differences in the root/shoot length between the groups was determined (*table 1, 2*) with a high confidence level (99.9%).

Tabel 1

Analysis of variance for root length of different corn hybrids at 5th day of germination

Source	Sum of squares		Df	Mean square	F-ratio
Between groups	138.37		2	69.188	17.15
Within groups	1169.62		290	4.033	
Total	1307.99		292		

*Significance level is $p < 0.0001$

Our results are in good agreement with the data reported by other researchers (Omar S. *et al,* 2022). The significant differences between the root/shoot lengths of selected corn varieties was also showed (Omar S. *et al,* 2022). However, in our experiments statistical difference was observed only in the first 5-7 days of seed germination.

Tabel 2

Analysis of variance for shoot length of different corn hybrids at 5th day of germination

Source	Sum of squares	Df	Mean square	F-ratio	P-value*
Between groups	456.94	2	228.47	127.86	0.0000
Within groups	511.04	286	1.786		
Total	967.98	288			

*Significance level is $p < 0.0001$

Increasing the duration of corn seed germination from five to ten days showed that root growth occurs more slowly that shoots elongation (*table 3*). During the additional 5 days of seed germination, the length of the roots increased by 0.63 cm (P280) and 2.22 cm (P398), while the length of the shoots increased by 1.98-2.63 times.

During ten days of germination the roots length of the tested hybrids did not differ significantly, but the shoots length varied significantly. A similar pattern was found for the vigour of shoots and roots. As the period of seed germination increased, the vigour index also increased, and more significantly for shoots than for roots (*table 3*). The metabolic processes intensified with increasing the duration of corn seed germination that reflected in more mobilization of reserve substances for root/shoot growth. Thus, in five days of corn seed germination approximately a quarter was used, in seven days - third and in ten days - half of the reserve substances (*table 3*).

The activation of metabolism at the stage of seed germination is caused by the intensity of respiration, which is associated with a number of oxidation-reduction reactions occurring in the plant organism. The starch is the first reserve substances that supports the respiratory process during seed germination and then fats. In this case, a significant release of energy and large losses of dry matter (up to 45-47%). There is a close connection between the growth of plant tissues (root/shoot) and their respiration.

According to our data, 52.8–81.5% of the total amount of reserve substances mobilized from seeds were spent on respiration and energy support for the physiological processes of germination and growth of roots and shoots. As the germination time of seeds increased, the amount of reserve substances spent on respiration and energy support of physiological processes increased in the P 280 hybrid, fluctuated in P398 and was practically stable in the P402 hybrid. Because of increasing in the proportion of reserve substances spent on respiration and energy support of physiological processes in the P280 hybrid, the metabolic efficiency decreased. This may be due to the small size of the grain, the weight of which was 2 times less than that of the P402 hybrid. Metabolic efficiency of the P402 hybrid slowly and no significant increased from five to ten days of germination.

It necessary to mention that, during 5 days of germination the seeds with the lower weight (P280, P398) had the metabolic efficiency higher that the seeds of P402 hybrid. Similar findings were made for mature maize seeds, which showed significantly higher seed weights but exhibited slower seed germination rates (Meena R.K. *et al.,* 2018).

Table 3

Morphological and physiological features of corn seeds in stage of germination

Traits	Hybrids								
	P280			P398			P402		
	Germination days								
	5	7	10	5	7	10	5	7	10
Root length, cm	6.19	6.33	6.82	4.56	5.62	6.80	5.02	5.22	6.16
Shoot length, cm	1.93	3.18	3.82	2.91	2.94	5.77	1.88	3.37	4.95
Root vigour	594.5	626.5	653.1	446.0	541.5	680.5	497.1	517.1	599.9
Shoot vigour	184.8	313.9	367.1	284.8	283.9	577.2	186.1	333.9	480.2
Total reserve substances mobilized from corn seed for germination, %	26.32	37.02	49.82	23.26	27.12	44.23	19.69	31.97	41.89
Reserve substance spent for respiration and energy support, % of total mobilized	67.65	71.10	81.50	63.76	52.80	61.33	73.45	71.56	71.20
Metabolic efficiency	0.4783	0.4064	0.2270	0.5684	0.8938	0.6306	0.3614	0.3975	0.4046

Activation of seed metabolism during swelling and germination, apparently, is a "cascade" process that can be represented as follows: an unswollen seed contains only a limited number of key enzymes; these enzymes are activated when the seed absorbs water, then the products of the reactions they catalyze induce the development of the activity of other enzymes, and this continues until the activity of all metabolic processes in the seed reaches an optimal level.

Metabolic activity is not the same as metabolic efficiency. Metabolic activity can be appreciated by root/shoot elongation and increase in its weight and vigour. Metabolic efficiency is inversely proportional with high the Pearson coefficient of correlation (0.9499 – 0.9991) to the amount of reserve substances mobilized for respiration and energy support of physiological processes of seed germination. In our experiments, the use of reserve substances was more effective in the seeds of P280 hybrid for 5 days, in P398 - for 7 days, and in P402 hybrid for 10 days.

In this regard, comparing the metabolic efficiency of germination of seeds of different hybrids in the 7 days established by ISTA (2017) may lead to erroneous conclusions. Considering that seeds have different sizes and, accordingly, different contents of reserve substances, their metabolic efficiency should be assessed in the first 5 days of germination.

CONCLUSIONS

Corn seeds of hybrids P280, P398 and P402 differing in size, weight, content of reserve substances and endosperm structure demonstrated various dynamics of root/shoot growth and metabolic efficiency on 5, 7 and 10 days of germination. The obtained results show that comparative determination of metabolic activity and metabolic efficiency of different corn hybrids can be carried out during the first five days of seed germination.

ACKNOWLEGMENTS

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THE RESPONSE OF OFFSPRING OF VIRUS-INFECTED TOMATO PLANTS TO ABIOTIC FACTORS AT THE GAMETOPHYTIC AND SPOROPHYTIC LEVELS

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Abstract

The investigation assesses the influence of abiotic factors (heat/drought) on some biomorphological traits of sporophyte and male gametophyte in the virus-free offspring from virus-infected tomato plants (Tobacco Mosaic Virus or Tomato Aspermy Virus). The variance analysis of the evaluated traits, in both sporophyte and gametophyte, under abiotic stress conditions revealed, as a rule, a significant contribution of stress in the variability, followed by the effects of genotype and plant health status with different strength. The analysis confirmed the significant influence of genotype (5.6...19.7%), heat (21.7...81.5%), drought (55.4...82.1%), health status (2.9…36.8%), and their interactions on the variability of male gametophyte traits. In most cases, the influence of stresses caused suppression of the evaluated traits' values. Under conditions of heat or drought, depending on plant' health status, it was confirmed the specific manifestation of some traits in sprout (radicle length, growth intensity), plant (plant height, number and leaves length) and male gametophyte (pollen viability, pollen tube length). Thus, specific effects expressed by stimulation, inhibition or lack of differences for the analysed traits were observed in the offspring of virus-infected plants under heat or drought conditions compared to the optimal one. Analysis of pollen variability spectra for each genotype showed differences in sensitivity to the action of the factors, which allows description of the microgamete reaction to stress and application of the obtained data for predicting sporophyte resistance.

Key words: Abiotic stress, gametophyte, plant health status, sporophyte, virus

The action of biotic and abiotic stress factors, as well as their combination, contributes to a considerable decrease in yield in crops. In this context, the identification of resistant genotypes to the associated action of unfavorable environmental factors is of great interest (Oshunsanya S. et al., 2019). However, in traditional practice, the creation of genotypes resistant to associated stresses is quite difficult, because of specific peculiarities invoking independent reaction and selection for each type of resistance. Solving this task involves increasing plant adaptability by using methods of genotypes' reactions analys at haploid/diploid level under stressful conditions with subsequent selection of perspective forms.

Seed germination is considered to be one of the most sensitive plant stages which is strongly influenced by various environmental stressors including temperature and water deficit (Foolad M. et al., 2007). Research encompassing morphological indicators of tomato sprouts under optimal and heat or drought stress conditions is important and relevant, stemming from the existence of genotypic and phenotypic correlation of resistance at the sprout and plant stage, as well as in the sense of the consequences of stress at early developmental stages on the later ones (Kazmi R. et al., 2012). Associative observations have established that viral infections could under certain circumstances improve plant tolerance to abiotic stress, involving various regulatory mechanisms - osmoprotective and antioxidant (Xu P. et al., 2008), efficienct using of water in plant (Pagliarani C. et al., 2022), by the way involving differential responses in susceptible and resistant genotypes to pathogens (Anfoka G. et al., 2016). In various studies transgenerational effects in the offspring of virus-infected plants, expressing significant changes in the metabolic profile, as well as in resistance to various factors has been attested (Bilichak A., Kovalchuk I., 2016; Luna E. et al., 2011).

Under abiotic stresses conditions in a large number of species it has been established decreased pollen performance both *in vitro* and *in vivo* (Prasch C., Sonnewald U., 2013; Razaq K. et al., 2017). It was found that the influence of abiotic stresses during the development of the male reproductive organs correlates with decreased fruit set in tomato (Sato S. et al., 2000). At the same

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time, there is information on the specific reactions of pollen grains to the stressogenic action, which allows the identification of genotypes resistant to this stage (Boavida L., McCormick S, 2007; Firon R. et al., 2006). It has been found that pollen viability is an important tolerance trait of genotypes to abiotic stresses (Johnson M. et al., 2006). Research results (Razaq K. et al., 2017) showed that the change in *Helianthus annuus* L. pollen viability under heat stress was largely controlled by genetic variability, which indicates that the breeding efficacy by this trait can be improved by recurrent selection. To improve male gametophytic quality and increase the adaptability of the reproductive system to the impact of abiotic and biotic factors, valuable importance belongs to the range and type of genetic variation, associated with pollen viability (Kalyar T. et al., 2014).

In this context, it is of interest to elucidate the contribution of genetic and environmental (high temperature/hydric stress) factors in the variation of male gametophyte and sporophyte functional characters in the progeny of virus-infected plants.

MATERIAL AND METHOD

The following genotypes were included in the research: *S. pimpinellifolium, S. chilense*, Mary Gratefully, Jacota, Flacara, Tomis, Venet, Rufina and Mihaela. All genotypes were evaluated in three different health status: progeny from plants infected with Tobacco mosaic virus (TMV), Tomato aspermy virus (TAV) and healthy – Control (C). In order to inactivate the pathogens, the seeds from virus infected plants as well as control ones were previously exposed to heat treatment at 70^0C for 72 hours.

Sprouts. Heat and drought stress at the germination stage was modelled in Petri dishes. After 72 hours of germination (25^0C), the heat stress (42^0C for 6 h) or water deficit (6.5% sucrose solution, 4.65 atm., 25^0C) was applied. For each genotype 2 repetitions each of 50 seeds in control and treatment variants were included. The roots length were measured until and after the stress application (72 h poststress), and the obtained values were used to determine the intensity of root growth (K) – as ratio of final to initial length. Resistance was calculated according to the formula: R = K1/K2 x 100 (%), where K1 – represent the ratio of the final value of the root length to the initial length in the heat stressed variant, K2 – similarly, the ratio of root length in the control variant. For drought variants K1 and K2 represent differences between the final values of the root length to the initial length.

Plants. Plants about 5 weeks old, progeny form healthy (control - C) and TMV or TAV infected parents were divided into 3 variants each: i. Optimal variant (O): plants maintained under optimal temperature ($27/21^0$C day/night) and water regime; ii. Drought (D) - plants exposed to water deficit by restricting the water regime until leaf wilting, maintained at $27/21^0$C (day/night) with application of stress in 3 rounds; iii. Heat stress (H) - plants exposed to a progressive temperature increase up to $42/25^0$ C (day/night) for 7 days under optimal water regime, air humidity about 65-70% in the climate chamber. Biomorphological assessments were performed 14 days after stress initiation, 7 days of stress and 7 days of post-stress rehabilitation.

Pollen. Plants of different variants (Control, TMV, TAV) were grown under solar conditions during May-July and served as pollen donor. Heat stress for pollen was modelled *in vitro*, by applying temperature of 40^0C for 3 h, and drought stress was simulated by supplementing the culture medium with 35% sucrose (27^0C – as in control). The indices were evaluated based on microscopic studies.

RESULTS AND DISCUSSIONS

Sprouts. The research established the existence of morphological peculiarities in tomato sprouts when the seeds derived from plants infected with TMV or TAV compared to those from healthy plants. The results were confirmed in repeated experiences the particulars by seeds germination rate, the radicle or sprout length were recorded even four generations after the action of the viral factor.

The mean values of radicle length varied widely depending on genotype, phytosanitary status of the seed and growing conditions. Thus, heat stress decreased root growth intensity by 1.9-3.4 (except Mary Gratefully) compared to optimal conditions in control variants (from healthy plants), and for drought the decrease amounted to 1.1-3.3-fold (*figure 1 A*). The progeny of the first generation from TMV and TAV-infected plants also reacted differentially to heat stress, so that for Rufina genotype the decrease in root growth intensity compared to optimal conditions was 1.9 and 4.6-fold, respectively, for Mary Gratefully 3.4 and 1.4-fold and for Flacara 3.0 and 1.75-fold. Under optimal conditions in 4 out of 6 analysed genotypes, higher values for radicle growth intensity were established compared to the control in at least one of the TMV or TAV variants, the exceedance constituting 8-150% (8, 35, 150, 21), only for Rufina and *S. pimpinellifolium* control indicating higher values for this index. The response was also differentiated between control and TMV or TAV variants.

The ratios of intensity of root growth under abiotic stress and optimal conditions result in the index of resistance to the stress factor, which

according to the data in the diagram denotes a broad picture of reactions depending on the sum of factors, stress-health status, expressed by specific genotypes with the highest indices of resistance under drought stress for the control variants (Mary Gratefully, Flacara, *S. pimpinellifolium*, Rufina, Venet and Tomis) vs. heat stress (Mary Gratefully, Flacara, Tomis, *S. pimpinellifolium*, Rufina, Venet) are very similar, except for the Tomis genotype (*figure 1 B*). At the same time we note that the reactions of the genotype depending on the applied stress. We note that in general the ranking of

TMV or TAV variants usually showed resistance index values different from the control, higher or lower values, for both types of stress, as well as in some cases differences between TMV or TAV variants (D - Tomis, SP; H - MG, Rufina, Flacara) were attested.

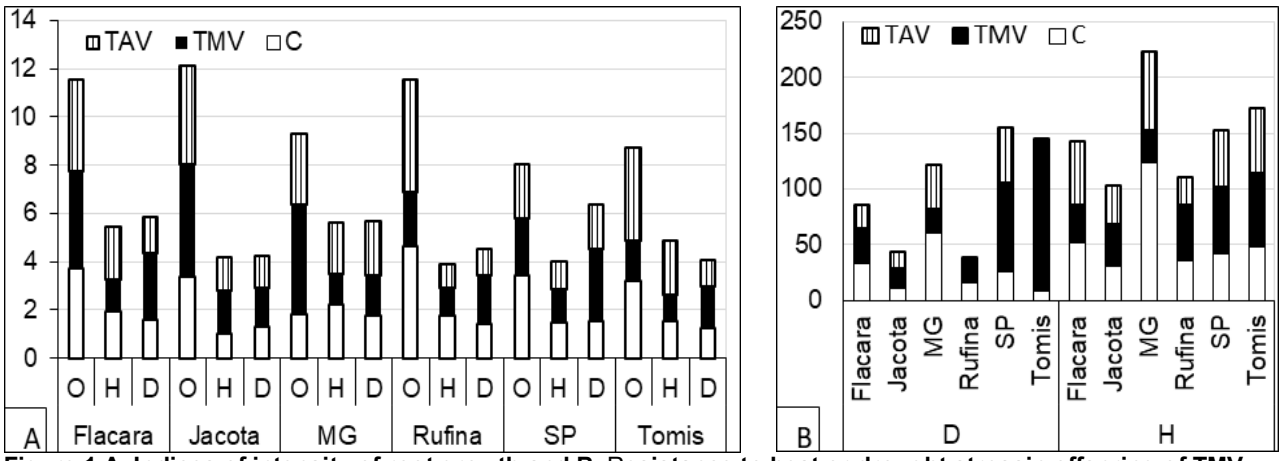

Figure 1 A Indices of intensity of root growth and B. Resistance to heat or drought stressin offspring of TMV, TAV or control (C) variants, %. O - Optimal condition, H - heat stress, D - drought stress; MG - Mary Gratefully, SP - *S. pimpinellifolium.*

In the same conditions, for the genotypes Mary Gratefully, *S. pimpinellifolium* and Tomis, great differences in drought stress resistance values were established between the variants derived from TAV or TMV infected plants and the control. However, the TMV variants of *S. pimpinellifolium* and Tomis genotypes significantly outperformed the resistance indices compared to the control, indicating a better adaptability of these variants to water deficit. These results correlate with higher radicle elongation for the given variants under stress conditions compared to the other analysed variants. At the same time the variants from healthy (control) plants of Mary Gratefully showed much higher heat resistance index values compared to the variants from infected plants. The analysis of the heat stress resistance indices revealed that TMV variants of Rufina, *S. pimpinellifolium* and Tomis genotypes showed slightly higher values compared to the control and TAV variants, but within the same resistance group.

Evaluation of architectural traits in offspring of infected plants under heat or water stress. The evaluation of plant response to stress can be performed by a variety of physiological, biochemical, morphological indices; however, the most eloquent index is productivity and biomorphological parameters of plants. Under optimal or heat stress conditions the values of the plant height were significantly higher in the control plants than in the TMV and/or TAV variants (derived from TMV or TAV infected plants), with the exception of the Rufina genotype, while under drought stress conditions the control variants, on the contrary, showed significantly lower values than at least one of the TMV or TAV variants. We also note that drought stress suppressed more strongly the indices of the plant height, leaves length and number than high temperature for a considerable part of the analysed variants. For example, plant height exhibited significantly lower values in the variants exposed to drought compared to heat stress for all control, TMV and TAV variants of genotypes Rufina and Mary Gratefully, and control and TMV for Jacota, as well as the control variant *S. pimpinellifolium.*

The analysis of variance allowed to establish that the highest contribution to the variability in the manifestation of the studied traits is due to *genotype* (14…24%), interaction of the factors *health status* and *stress* (7…19%), followed by the *stress* (3…18%) (*figure 2 A*). However, some specific features of the stress response can be deduced from the dispersion analysis for each genotype. According to the obtained results we can assume that the greatest contribution to the variability of the plant height trait is due to *stress* and the interaction of *stress x health status* (*figure 2 B*). Thus, the values of the contribution of *stress*

in the variability of the plant height are 22… 32%, followed by the interaction of *stress* x *health status* factors 13…28%. At the same time, we find, that the *health status* had the highest impact on plant height for *S. pimpinellifolium* - 15%, the lowest for genotype Jacota - 9% and insignificant for Mary Gratefully and Rufina. For *S. pimpinellifolium* the highest contribution indices for each factor analysed per experiment were attested.

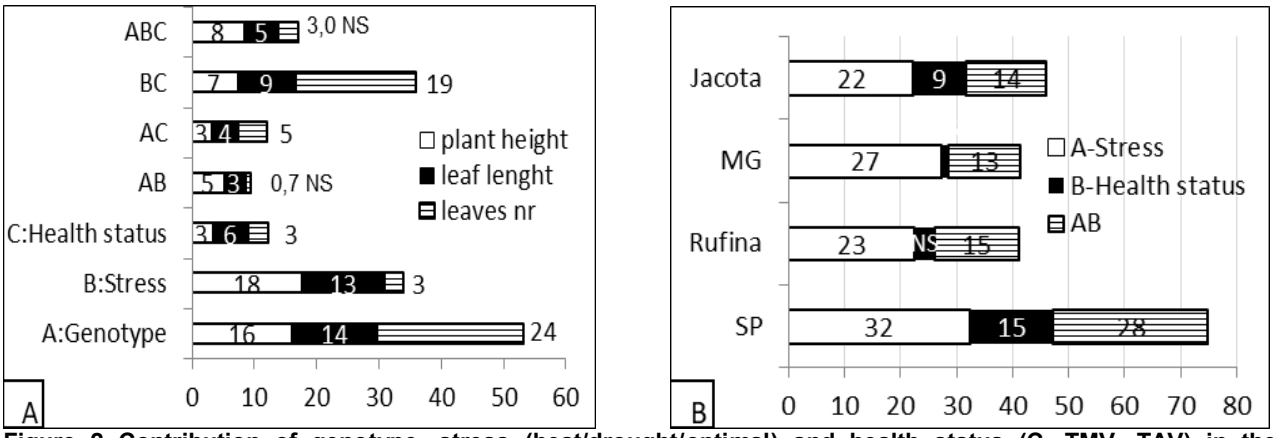

Figure 2 Contribution of genotype, stress (heat/drought/optimal) and health status (C, TMV, TAV) in the variability of traits %: A. Plant height, length and number of leaves; B. Plant height variance in dependence on genotype. All interpretation based on ANOVA analysis. NS - not significant, in rest of cases significant for P≤0.001. MG - Mary Gratefully, SP - *S. pimpinellifolium*

At the same time a differential response of genotypes of different health status depending on the applied stress was attested (*table 1*). Thus, the *genotype* has the greatest effect on the variability of the plant height under both heat and drought stress (17.5% and 22.2%), while the factors *health status* and *stress* have a diametrically opposite effect depending on the type of applied stress, so that *drought stress* has an effect of about 18.5% in the variability of the trait, and against the background of heat stress plant *health status* determined 11.6% of the variability. The interaction of the combinations of analysed factors conditioned a proximate variation similar to the type of stress applied (2.6-5.8%).

Heat stress or drought stress caused specific reactions within the genotype depending on the health status (Control, TMV, TAV), according to the differences between the mean values of the plant height and the dispersion analysis for each type of stress separately established that the interaction of the factors considered *genotype-health status-stress* had a significant impact on the variation of the trait, but not heat stress as a solitary factor (*table 1*).

Table 1

Analysis of variance of plant height according to the type of applied stress

Source of variance		Df	Heat stress			Drought stress		
			Sum of Squares	F-Ratio	Factor Contribution, %	Sum of Squares	F-Ratio	Factor Contribution, %
A: Genotype		3	1888.22	24.31***	17.5	2804.69	40.70***	22.2
B: Stress		1	35.12	1.36	0.3	2334.06	101.60***	18.5
C: Health status		2	1258.32	24.30***	11.6	354.16	7.71***	2.8
Interactions	AB	3	773.29	9.95***	7.2	323.09	4.69**	2.6
	AC	6	833.21	5.36***	7.7	699.19	5.07***	5.5
	BC	2	286.39	5.53**	2.6	620.22	13.50***	4.9
	ABC	6	765.01	4.92***	7.1	1069.07	7.76***	8.5
Residual		192	4971.48			4410.69		
Total		215	10811.0			12615.20		

*****, ** - significant for P≤0.001 and 0.01**

Pollen. The results of our research on male gametophyte variability revealed that temperature significantly impacted pollen viability, reducing it by 1.6 to 2.0 times in both healthy plants and progeny of TMV/TAV-infected plants, respectively. Additionally, TMV/TAV progeny exhibited a 28.4% to 32.9% reduction in pollen tube length compared to the control, potentially due to a slower growth rate of pollen tubes in these genotypes. Based on pollen grain distribution by pollen tube length under optimal conditions in Mary Gratefully TMV/TAV and *S. chilense* TAV

progeny, it was established that the frequency of pollen grains, which formed pollen tubes of large size, increased, exceeding the control. Under water deficit background in most cases pollen grains formed short or medium sized pollen tubes, which confirms the negative action of drought stress on the germination and growth of pollen tubes. To identify the factors determining the variability of functional traits in pollen, the obtained results were processed using a three-factor analysis of variance (*table 2*).

Table 2

Analysis of variance for pollen traits in heat stress conditions *in vitro* in offspring of TMV and TAV plants

Source of variance		Polen viability		Pollen tube length	
	Df	Sum of Squares	Factor contribution, %	Sum of Squares	Factor contribution, %
A: Genotype	7	1226.9*	5.6	1323.2*	17.9
B: TMV	1	631.9*	2.9	473.9*	6.4
C: Stress	1	17748.0*	81.5	3056.7*	41.3
Interactions: ABC	22	2169.0*	9.92	2543.1*	34.3
Residual	64	2.92*	1.3	2.93	0.04
A: Genotype	7	1893.7*	7.9	1495.4*	19.7
B: TAV	1	945.6*	3.95	2799.4*	36.8
C: Stress	1	18931.0*	78.1	1646.7*	21.7
Interactions: ABC	22	2172.0*	9.1	1653.9*	21.8
Residual	64	2.96*	1.1	2.72	0.04

***- significant for P≤0.05**

The analysis confirmed the significant influence of *genotype* (5.6...19.7%), *heat* (21.7...81.5%), *drought* (55.4...82.1%, not presented here), *TMV/TAV* (2.9…36.8%) and their interactions on the variability of male gametophyte traits. Among these, the contribution of *heat* to the overall structure of pollen viability variability was decisive, accounting for 78.1 and 81.5%, while the effects of other factors, including *genotype*, were significantly weaker. The analysis of variability in pollen tube lengths of *TMV* progeny revealed that 41.3 and 34.3 % of the length variability was determined by temperature and factor interactions, respectively. In TAV progeny, the influence of *genotype*, heat *stress* and factor interactions on this trait was approximately equal, ranging from 19.7% to 21.8%, while the effect of the virus was stronger at 36.8% (*table 2*). Thus, heat stress is the main factor determining the variability of pollen viability in the TMV/TAV offspring, whereas the variability in pollen tube length, depending on the virus type, is largely determined by the influence of heat stress or TAV.

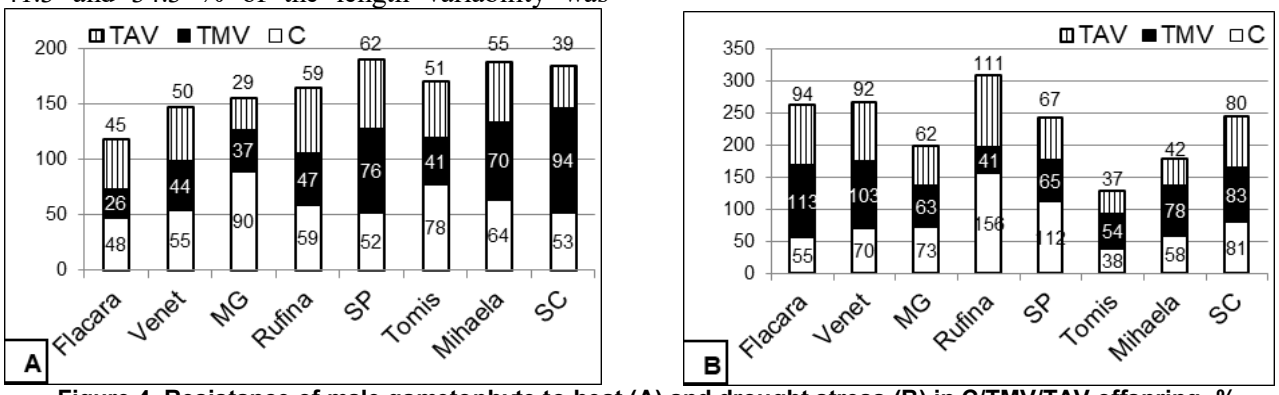

Figure 4. Resistance of male gametophyte to heat (A) and drought stress (B) in C/TMV/TAV offspring, %
MG - Mary Gratefully, SP - *S. pimpinellifolium,* SC - *S. chilense.*

The estimation of male gametophyte heat stress tolerance in control (offspring of healthy plants) and offspring of infected plants established that the plants in control variants showed the highest level of values of this trait - 62.5% (per experience), although in the TMV/TAV offspring, the level of thermoresistance was lower by 13.3 and 22.2%, respectively (*figure 4 A*). Based on the generalization of the obtained data, it was found that the male gametophyte in the control plants and progeny of the infected variants for Mihaela and Rufina, as well as the *S. pimpinellifolium* combine a high level of pollen heat resistance at the germination and pollen tube growth stage, which implies the possibility of their use in breeding research. Under conditions of drought (*figure 4 B*), three varieties: Venet, Flacara and Rufina, as well as the *S.pimpnellifolium* and *S.chilense*, were highlighted by their high pollen resistance.

CONCLUSIONS

Differential manifestation of some biomorphological traits at sporophyte (sprouts and plants) and gametophyte stage in progenies from TMV and TAV -infected vs. healthy plants under heat or drought stress conditions was confirmed, indicating bidirectional variations in mean values. For certain genotype-stress-health status combinations, better values were established under stress conditions compared to the control, indicating a better adaptability of these variants to stress factors. At the plant level variability of evaluated quantitative traits was conditioned by genotype (14…24%), stress (3…17%) and plant health status (3…6%).

The action of abiotic factors (heat/drought) on male gametophyte in offspring of virus infected plants causes differential changes in pollen functional characters, which are determined by genotype (5.6...19.7%), heat (36.8...81.5%), drought (55.4...82.1%) and health status (2.9…36.8%).

Based on the complex approach of gametic selection methods and genetic-statistical analysis, the structure of the variation spectra of male gametophyte indices in offspring of virus infected plants under heat or drought conditions was elucidated, which allows applying the results to predict the response of genotypes to the action of abiotic factors; genotypes with high degree of resistance of male gametophyte to the action of abiotic factors were highlighted.

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SUNFLOWER YIELD AT DIFFERENT NITROGEN RATES AND FERTILIZER PRODUCTS

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Abstract

Current climatic conditions, increasing concern of the entire society regarding the environmental protection, as well as regarding the access to save and safety food, to which it is added the increasingly cost of nitrogen fertilizers require farmers to optimize nitrogen fertilization according to the specific growing conditions of their crops. Choosing the right fertilizer product, rate and time of application are essential decisions for farmers. In this context, the purpose of this paper is to present the results obtained regarding sunflower yield under different nitrogen fertilization conditions as rate and fertilizer product under the specific growing conditions of South-Est Romania. In this sense, field experiments were performed in South-East Romania, respectively in Dobrogea region, under rainfed conditions in the years 2022 and 2023. The experimental factors were the following: Factor A – Nitrogen rate, with 3 gradations, respectively 60 kg/ha, 80 kg/ha, 100 kg/ha; Factor B – Nitrogen fertilizer, with 4 gradations, namely Classic Urea, Airtek Urea, Ammonium Sulphate, Sulfammo 25 MPPA DUO. The obtained results obtained under water deficit conditions drew attention to the positive effects of Classical Urea on the sunflower grain yield. It resulted that the best fertilizer option is the nitrogen rate of 60 kg/ha incorporated at seedbed preparation.

Key words: sunflower, nitrogen, fertilizer, rate, yield

Sunflower has uses in human nutrition and animal feed, industrial and energy uses, to which are added a number of specific uses (Ion V., 2021).

Sunflower is grown mainly for oil, which is a good quality edible oil with a pleasant color, taste and smell. In terms of caloric value and degree of assimilation by the body, sunflower oil is among the best vegetable oils (Petcu G., Petcu E., 2008). Unshelled sunflower seeds, but mostly the cakes resulting after oil extraction can be used in animal feed. The cakes are primarily used as a source of protein (Bîlteanu G., 2001).

Sunflower is cultivated globally, but it is mainly cultivated in Europe, especially in the Black Sea region. In Romania, in recent years there was cultivated with sunflower over 1 million ha, one of the explanation for this large surface being the farmers orientation towards crops which better tolerate the increasingly frequent droughts of recent years.

The sunflower sector has managed to maintain its competitiveness through continuous innovation in genetics, cultivation practices and value-added research that has led to greater market segmentation (Pilorgé E., 2020). Climate change has, however, led to a significant decrease in sunflower production (Babec B. *et al*, 2021). Agro-meteorological conditions have a significant impact on yield (Nedealcov M. *et al*, 2016). In its traditional production areas, sunflower crop will be exposed to major climate change and potentially impacted by water and temperature stresses (Prodan T. (P.) *et al*, 2021).

The use of fertilizers is essential for plant growth (Negi P. *et al*, 2022). In the modern agriculture, the importance of using chemical fertilizers is undeniable (Leonte A. *et al*, 2023). But it is necessary to optimize the fertilizer use to meet the yielding and environment issues. Optimizing fertilizers leads to the achievement of economic and environmental goals in sustainable agriculture (Mehrparvar M. *et al*, 2021).

Fertilization is one of the major factors that could increase sunflower yield (Shoghi-Kalkhoran S. *et al*, 2013). Nutrient management is one of the main factors that influence sunflower achene yield, achene oil, and fatty acid contents (Mahmood H.N., 2021), its importance being increasing in the actual climate change.

Nitrogen (N) is one of the most important mineral nutrients because of its numerous effects on plant growth and yield (Ahmad R. *et al*, 2014). Nitrogen is one of the major nutrients that enhance the metabolic processes that based on protein,

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leads to increases in vegetative, reproductive growth and yield of the crop (Abd El-Rahman L. A. *et al*, 2016).

Nitrogen is the major nutrient required by sunflowers, and has the greatest impact on seed size, leaf size and number of leaves, test weight and yield (Toosi A.F., Azizi M., 2014). Sunflower reacts well to nitrogen fertilization and nitrogen excess lowers the seed oil content and plant resistance to diseases, while balanced phosphorus and potassium fertilization increase yield and oil content in seeds (Gerassimova I. *et al*, 2023). Two main approaches can be undertaken to enhance nitrogen use efficiency: increasing the use of N during crop growing season and decreasing the losses of N by applying optimum doses (Khanzada A. *et al*, 2016).

The large variation in the response of sunflower to nitrogen fertilization indicates the need for studies to better adjust the optimum levels of this nutrient for production conditions (Coêlho, E.D.S. *et al*, 2022). Choosing the right fertilizer product, rate and time of application are essential decisions for farmers. In this context, the purpose of this paper is to present the results obtained regarding sunflower yield under different nitrogen fertilization conditions as rate and fertilizer product under the specific growing conditions of South-Est Romania.

MATERIAL AND METHOD

The research was carried out in Dobrogea region from South-East Romania, respectively in Cerna commune from Tulcea county, and consisted in field experiments performed in rainfed conditions in the years 2022 and 2023.

The field experiments were organized as subdivided plots with 3 replications being of type 3 x 4 with the following experimental factors:

- Factor A - Nitrogen rate:
  - a1 = 60 kg/ha nitrogen;
  - a2 = 80 kg/ha nitrogen;
  - a3 = 100 kg/ha nitrogen;
- Factor B - Nitrogen fertilizer:
  - b1 = Classic Urea;
  - b2 = Airtek Urea;
  - b3 = Ammonium Sulphate;
  - b4 = Sulfammo 25 MPPA DUO;

The basic fertilization was done with the product DAP 18-46-0 in a dose of 150 kg/ha, a product that provides 27 kg/ha of nitrogen and 69 kg/ha of P_2O_5.

The nitrogen difference up to the studied quantity was applied from each studied product at the preparation of the seedbed.

Classic Urea ($(NH_2)_2CO$) is a product with a high nitrogen content (46% nitrogen) which gives urea a priority place in agricultural use, representing the most economical source of nitrogen available. This is produced by Azomureș company.

Airtek Urea is produced by Belor in partnership with BASF who developed the new range of Airtek fertilizers that use the urease inhibitor Limus. It is a formula that contains 46% nitrogen completely inhibited with Limus. By using this product, the losses of nitrogen through volatilization are completely canceled and the availability of nitrogen is regulated for the efficient increase of fertilization.

Ammonium Sulphate is an inorganic compound with the chemical formula $(NH_4)_2SO_4$. This has a wide range of commercial uses, being an important soil fertilizer. The commercial product contains 21% nitrogen from the ammonium cation and 24% sulfur from the sulfate anion.

Sulfammo 25 MPPA DUO is a product with 25% total nitrogen (N), of which 18% ammonia nitrogen (NH_4^+) and 7% nitric nitrogen (NO_3^-), 2% magnesium oxide (MgO), and 31% sulfuric anhydride (SO3) soluble in water. The product contains MPPA DUO, which is the optimal combination of 2 active compounds: MPPA (Activated Poly-Phenolic Molecules) extracted from organic acids, responsible for the protection of nutrients in the product and the mobilization of nutrients from the soil; XCK (Plant extract) containing a phytohormonal precursor, stimulator of the microbial activity in the rhizosphere and of the metabolic processes of plant growth and development, especially of the roots and absorbing peripheries. Sulfammo 25 MPPA DUO is created by the research department of Timac Agro.

Each experimental variant had a size of 67.2 m^2 consisting of 12 rows of sunflower plants with 70 cm between rows resulting in a width of 8.4 m and a length of 8 m along the rows.

The previous crop was maize. Tillage in the experimental field consisted of harrowing after harvesting the previous crop, and in October plowing was carried out at a depth of 20 cm. The plowing was followed in the fall by harrowing and in the spring the seedbed preparation was carried out before sowing with a cultivator.

Sowing was carried out on April 9, 2022 and May 3, 2023. The ensured plant density was 64,000 plants per hectare.

The sunflower hybrid used in the research was SY Onestar CLP, a hybrid with exceptional production potential, adaptable and stable under different growing conditions.

Weed control was achieved by applying the herbicide Pulsar 40 (Imazamox 40 g/l) in a rate of 1.2 l/ha in the growth stage of 6 leaves of sunflower plants.

For controling sunflower diseases, the fungicide Pictor Active (Boscalid 150 g/l and Pyraclostrobin 250 g/l) was applied in a rate of 1 l/ha in the growth stage of 10 leaves of sunflower plants.

The results that are presented in the present paper are with respect to the grain yield (kg/ha)

reported at 9% moisture content. The calculation and interpretation of the results were made based on the analysis of variance

The geographical coordinates (44°59'15.4"N 28°22'08.0"E) of the research location determine its inclusion in the temperate continental climate zone. So, the climate is characterized by high temperatures in summer and sometimes very low in winter. The average annual temperature is around 10.7 ºC.

Regarding the temperatures registered during the vegetation period of the sunflower plants, compared to the year 2022, in the year 2023 the months March, July and August were warmer, while the months April, May and June were colder (*table 1*). As average values for the period March-August, the year 2023 with 17.2ºC was warmer than the year 2022 with 16.8ºC.

Table 1

Climatic conditions during sunflower plant's vegetative period at Cerna, Tulcea county, Romania

Month	Temperature (ºC)		Rainfall (mm)	
	2022	2023	2022	2023
March	3.4	7.8	32	8
April	11.1	10.2	15	125
May	16.8	15.5	49	36
June	21.8	19.8	34	41
July	23.5	24.7	20	25
August	24.2	25.4	12	15
Average/Sum	***16.8***	***17.2***	***162***	***250***

Regarding the rainfall registered during the vegetation period of the sunflower plants, the year 2022 with 162 mm was drier than the year 2023 with 250 mm. In the year 2023, after a drought month March with 8 mm rainfall, there followed a rainy month April with 125 mm. As a consequence, in 2023 the sowing was significantly delayed compared to the usual sowing period for the studied area, which is between the end of March and the beginning of April. Thus, in 2023 the sowing was performed on May 3. In both experimental years the month July but especially August were characterized by a small amount of rainfall.

In the studied area, the specific soil is carbonate chernozem with 2.5% humus content and pH of 7.8-8.1.

RESULTS AND DISCUSSIONS

Because of the climate, which is constantly changing, in general but especially when it comes to the South-East of Romania, which is one of the poorest areas in the country in terms of precipitation, it is essential to adapt and find the best and most effective solutions of fertilization.

In the research carried out, fertilization with Classic Urea in a rate of 60 kg/ha of nitrogen, incorporated in the soil during the preparation of the seedbed, ensured the highest yields in both experimental years, respectively 2044 kg/ha in 2022 and 2310 kg/ha in 2023 (*table 2*). Also in both experimental years, at the rate of 80 kg/ha of nitrogen, the best results were registered in the case of Airtek Urea, while at the rate of 100 kg/ha of nitrogen, the best results were registered in the case of Sulfammo 25 MPPA DUO.

In the year 2022, increasing the amount of nitrogen to 80 kg/ha had a negative influence on grain yield, compared to control variant with a difference negative distinctly significant (-686 kg/ha) in the variant fertilized with Classic Urea and with a difference negative significant in the variant fertilized with Sulfammo 25 MPPA DUO (-533 kg/ha). The same situation can be found in 2023, when the grain yield difference in the case of the two fertilizers mentioned above was for both of them negative significant.

Table 2

Sunflower grain yield at different nitrogen rates and nitrogen fertilizers in different climatic conditions in South-East of Romania

Experimental factors		Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Rate (kg/ha)	Nitrogen Fertilizer	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
			(kg/ha)	(%)		(kg/ha)	(%)
60	Classic Urea	2044	Control	100	2310	Control	100
	Airtek Urea	1539	-505 °	- 25	1807	-503 °	-22
	Ammonium Sulphate	1561	-483 °	-24	1821	-489	-21
	Sulfammo 25 MPPA DUO	1868	-176	-9	1868	-442	-19
80	Classic Urea	1358	-686 °°	-34	1781	-529 °	-23
	Airtek Urea	1914	-130	-6	1914	-396	-17
	Ammonium Sulphate	1635	-409	20	1896	-414	-18
	Sulfammo 25 MPPA DUO	1511	-533 °	-26	1768	-542 °	-24
100	Classic Urea	1855	-189	-9	2110	-200	-9
	Airtek Urea	1862	-182	-9	2149	-161	-7
	Ammonium Sulphate	1644	-400	-20	1905	-405	-18
	Sulfammo 25 MPPA DUO	2003	-41	-2	2281	-29	-1
Average		*1733*	-	-	*1968*	-	-
		$LSD_{5\%}$ = 473.94 kg $LSD_{1\%}$ = 642.25 kg $LSD_{0.1\%}$ = 859.94 kg			$LSD_{5\%}$ = 493.62 kg $LSD_{1\%}$ = 668.93 kg $LSD_{0.1\%}$ = 895.65 kg		

The average yield obtained in 2023 is higher than in 2022, respectively 1968 kg/ha in 2023 and 1733 kg/ha in 2022, this being the result of higher precipitation in 2023 during the vegetation period of sunflower plants, which have a total of 250 mm, compared to 162 mm in 2022. Therefore, all average yields related to either nitrogen rate or nitrogen product used are higher in 2023 than in 2022. Basically, a better water supply to the sunflower plants gives them the opportunity to use the available nutrients in a more efficient way.

Analyzing the grain yield average values per nitrogen rate, the highest grain yields were obtained at 100 kg/ha of nitrogen (1841 kg/ha in 2022 and 2112 kg/ha in 2023), but with a yield increase compared to the rate of 60 kg/ha of only 5% in 2022, respectively 88 kg/ha, and of 8% in 2023, respectively 160 kg/ha (*table 3*). The grain yield increase obtained at 100 kg/ha of nitrogen compared to the nitrogen rate of 60 kg/ha do not obviously cover the cost of the extra 40 kg/ha of nitrogen.

Table 3

Sunflower grain yields as average values at different nitrogen rates in different climatic conditions in South-East of Romania

Experimental factor	Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Rate	Yield	Differences to control		Yield	Differences to control	
(kg/ha)	(kg/ha)	kg/ha	%	(kg/ha)	kg/ha	%
60	1753	Control	100	1952	Control	100
80	1604	-149	-8	1840	-112	-6
100	1841	+88	+5	2112	+160	+8
	$LSD_{5\%}$ = 510.96 kg/ha $LSD_{1\%}$ = 685.64 kg/ha $LSD_{0.1\%}$ = 903.87 kg/ha			$LSD_{5\%}$ = 487.16 kg/ha $LSD_{1\%}$ = 653.71 kg/ha $LSD_{0.1\%}$ = 861.78kg/ha		

The obtained results are the effect of water deficit registered in both experimental years, which limit the plant use of the available nutrients. In fact, the reduced nutrient availability is one of the most important factors limiting plant growth under drought (Canavar Ö., Kaptan M.A., 2014).

In both experimental years, the smallest grain yields were registered in the case of the nitrogen rate of 80 kg/ha (-149 kg/ha in 2022 and -112 kg/ha in 2023 compared to control variant). It has to be mentioned that compared to control variant which was the nitrogen rate of 60 kg/ha, the differences registered at the nitrogen rates of 80 kg/ha and 100 kg/ha are not statistically significant (*table 3*).

As average values of the grain yield obtained for different nitrogen products, we notice that there are no differences statistically significant compared to control variant represented by Classic Urea for any of them (*table 4*). In 2022, the fertilizer product with the highest grain yield is Sulfammo 25 MPPA DUO, respectively 1794 kg/ha, but only with a grain yield increase of 42 kg/ha compared to control variant. In 2023, compared to control variant, all the other fertilizer products registered negative differences. In both experimental years, the smallest average grain yields were registered in the case of the fertilizer product Ammonium Sulphate.

Table 4

Sunflower grain yields as average values with different nitrogen fertilizers in different climatic conditions in South-East of Romania

Experimental factor	Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Fertilizer	Yield	Differences to control		Yield	Differences to control	
	(kg/ha)	kg/ha	%	(kg/ha)	kg/ha	%
Classic Urea	1752	Control	-	2067	Control	-
Airtek Urea	1771	+19	+1	1957	-111	-5
Ammonium Sulphate	1613	-138	-8	1874	-193	-9
Sulfammo 25 MPPA DUO	1794	+42	+2	1973	-95	-5
	$LSD_{5\%}$ = 535.52 kg/ha $LSD_{1\%}$ = 721.20 kg/ha $LSD_{0.1\%}$ = 956.18 kg/ha			$LSD_{5\%}$ = 521.41 kg/ha $LSD_{1\%}$ = 702.19 kg/ha $LSD_{0.1\%}$ = 930.98 kg/ha		

CONCLUSIONS

Following the research carried out in South-Est Romania in 2022 and 2023 under water deficit conditions it resulted that the best fertilizer option is the nitrogen rate of 60 kg/ha assured through the Classic Urea fertilizer product incorporated at seedbed preparation. Under the experimented conditions, practically there were not registered significant differences in grain yield as average values between the nitrogen rates and nitrogen fertilizer products.

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MAIZE GRAIN YIELD AT DIFFERENT COMPLEX FERTILIZERS AND APPLICATION METHODS UNDER GROWING CONDITIONS OF SOUTH ROMANIA

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Abstract

Complex fertilizers are an important tool to enhance productivity of the maize plants and their ability to support stress factors, especially in the present when climate change has become the biggest global challenge to agriculture and food production. Nowadays, the selection of the right complex fertilizer products, the appropriate rate and time of application are essential for farmers to make efficient management decisions. In this context, the aim of this paper is to present the obtained results regarding the influence of different types of complex fertilizers depending on different method of application on maize grain yield under the specific growing conditions of South Romania. The research was carried out in field experiments located in South Romania (44°22' N latitude and 26°89' E longitude), under rainfed conditions in the years 2022 and 2023. The experimental factors were the following: Factor A – 2 types of fertilizer application method (a1. Banded with sowing; a1. Surface broadcast + incorporation), Factor B – 3 complex fertilizer products (b1. DAP 18:46:0; b2. DAP 18:46:0 treated with AVAIL; b3. Complex fertilizer 14:40:0+7S). The obtained results brought attention to the positive effects on the maize grain yield of the protected product DAP Avail 18:46:0 when it was applied banded with sowing. The effect of the complex fertilizers on the maize grain yield is depended of the climatic conditions of the year. The better water supply of maize plants gives them the possibility to use in more efficient way the nutrients from the soil.

Key words: maize, grain yield, complex fertilizer,

Being one of the most important crops, maize (*Zea mays* L.) is cultivated in many regions of the world (Erenstein O. *et al*, 2013) and also, it is one of the most important crops in Romania, ranking the first place as cultivated area with 2.4-2.7 million hectares in the period 2012-2022. Maize has a special importance at global level, this being given by its food and fodder values, by the several uses as raw material in various industrial sectors, as well as by the agronomic characteristics of the crop. Also, grain maize is an important cash crop for farms without livestock (Finke C. *et al*, 1999). Maize's ecological flexibility makes it "the plant of choice" for grain and feed in climates raging from temperate to tropical as long as there is no frost and mean temperatures are mostly above 10 degrees Celsius (Haraga L.C., Ion V., 2022).

As the human population continues to grow, it is becoming highly challenging to increase food production without exacerbating environmental problems and increasing agricultural acreage (Xu Z. *et al*, 2020). Therefore, the research has to provide practical solutions to increase the yields and to make them less dependent of the environmental conditions.

Fertilizers are essential for providing the necessary nutrients to the soil and promoting plant growth, their efficient use being important to ensure that plants get the right amount of nutrients they need to produce a high yield (Zaib M. *et al*, 2023). Evaluation of long term field studies has shown that fertilizer input is critical to crop production, the average percentage of yield attributable to fertilizer generally ranging from about 40 to 60% in temperate climates and tends to be much higher in the tropics (Stewart W.M., Roberts T.L., 2012). For this particular reason maize has been a subject of study for many researchers. Improving the nutritional status of plants through fertilizer application and maintaining soil fertility has been the critical step in food production since the beginning of the "Green Revolution" in both developed and developing countries (Huang F. *et al*, 2021).

There are many new types of fertilizers (slow-release fertilizers, microbial fertilizers, and organic fertilizers, among others) that are effective in increasing yield and protecting the environment (Du Y.D. *et al*, 2020). Slow or controlled release fertilizers have been researched and used more and more widely, they being effective in reducing nutrients loss and making a better use of the

nutrients. One important type of this kind of fertilizers is coated fertilizers, which are physically prepared by coating granules of conventional fertilizers with various materials that reduce their dissolution rate. The release and dissolution rates of water-soluble fertilizers depend on the coating materials (Wu S.L. *et al*, 2008). The new type of fertilizers implies, as in the case of any new technology, higher costs, and therefore they have to be used in an appropriate way.

Fertilizers play a crucial role in modern agriculture to increase maize yield (Mulyati *et al*, 2021), they increasing maize yields both quantitatively and qualitatively, this being because fertilizers increase the availability of nutrients, plant health and suppress disease growth (Naomi M.R. *et al*, 2021). The nitrogen (N), phosphorus (P) and potassium (K) are the three most widely used elements for improving maize yield (Wu L.Q. *et al*, 2015). The phosphorus plays an important role in the transfer of energy in plant cells. It stimulates root development and increases nitrogen uptake at the beginning of growth. Phosphorus is also known to play a role in the formation of flowers, fruits and seeds. In using of phosphate fertilizer in the field farmers often does not pay attention to the appropriate dosage.

At present, most studies have shown that the application of nitrogen, phosphorus and potassium fertilizers has a significant impact on soil fertility. (Gaudin et al. 2015). Drought is one of the main constraints in maize cultivation in South Romania, which is the most important Romanian growing area for maize (Ion V. *et al*, 2023). In the context of evident climate changes in the maize growing areas from South Romania, the farmers need to adapt and find the best solutions regarding the nitrogen and phosphorus fertilization. It should be noted that not only crop yields (Ray D.K. *et al*, 2015), but also the efficiency of the use of resources, in particular nutrients from soil and fertilizers (Ryan J. *et al*, 2012) are influenced by the weather conditions.

Complex fertilizers can supply crops in several nutrients in appropriate amounts and proportions and their rates are related to soil abundance in available essential nutrients: phosphorus, potassium and magnesium (Nogalska A. *et al*, 2012). Complex fertilizers are an important tool to enhance productivity of the maize plants and their ability to support stress factors, especially in the present when climate change has become the biggest global challenge to agriculture and food production. Nowadays, the selection of the right complex fertilizer products, the appropriate rate and time of application are essential for farmers to make efficient management decisions. In this context, the aim of this paper is to present the obtained results regarding the effects of different complex fertilizers and their application methods at maize under the specific growing conditions of South Romania.

MATERIAL AND METHOD

The research was carried out in field experiments located in South Romania, respectively at Agribest Mânăstirea Farm (44°22' N latitude and 26°89' E longitude) in the area of Mânăstirea commune, Călărași county. The field experiments were performed under rainfed conditions in the years 2022 and 2023. In the studied area, the specific soil is chernozem cambic with a humus content of 3.29% and pH of 6.4.

For the period March-September 2022, the average temperature was 17.8°C, respectively 18.6°C for 2023. For the same period (March - September), the sum of rainfall was 281.7 mm in 2022 and 238.4 mm in 2023 (*table 1*). In both years, the months March, July and August were dry months. The highest rainfall was registered in April, June and September in 2022 and in May and June in 2023. As a conclusion, the year 2023 can be characterized as being warmer and drier than the year 2022.

Table 1

Climatic conditions during maize plant's vegetative period at Mânăstirea, Călărași county, Romania

Month	Temperature (°C)		Rainfall (mm)	
	2022	2023	2022	2022
March	3.7	8.3	15.8	7
April	11.9	10.8	68.8	25.6
May	17.7	16.2	31.9	97
June	22.3	21.6	69.2	52.8
July	25.1	25.9	17.3	14.2
August	25.1	25.7	13.5	30.7
September	18.6	21.4	65.2	11.1
Average/Sum	***17.8***	***18.6***	***281.7***	***238.4***

The studied biological material was the maize hybrid KWS Kashmir from FAO group 370, which is a simple hybrid with kernera quite large, having a high TGW (Thousand Grain Weight) value, which is one of the key elements of a high yield.

The preceding crop was winter wheat in both experimental years. Also, the crop technology was similar in both years. After harvesting the preceding crop, there was performed a harrowing work, and in Autumn (October) there was performed the ploughing at 25 cm depth. The preparation of the seedbed was made with a combinatory one day before sowing. The sowing was performed in the first decade of April, with a sowing density of 70,000 germinal seeds/ha, at a depth of 7 cm and at 70 cm row spacing. The control of the weeds was performed by the application after sowing of the herbicide Adengo (Isoxaflutole 225 g/l + Thiencarbazone-methyl 90 g/l + Cyprosulfamide (safener) 150 g/l), in a rate of 0.35 l/ha.

The field experiments were organized as subdivided plots with 3 replications being of type 2 x 3 with the following experimental factors:

- Factor A – Fertilizer application method, with 2 graduations:
  - a1. Banded with sowing;
  - a2. Surface broadcast + incorporation.
- Factor B – Complex fertilizer product, with 3 graduations:
  - b1. DAP 18:46:0;
  - b2. DAP AVAIL 18:46:0;
  - b3. Complex fertilizer 14:40+7S.

In the variants of surface broadcast, the fertilizers were broadcasted before seedbed preparation and were incorporated by this tillage. In the banded variants, the fertilizers were applied with sowing.

DAP 18:46:0 – Diammonium phosphate [$(NH_4)_2HPO_4$] is one of the most concentrated phosphate-based fertilizer, this being the world's most widely used phosphorus fertilizer. It is perfect for any agriculture crop to provide full phosphorus nutrition throughout crop growth and development, as well as a starter dose of nitrogen. It can be applied in autumn with tilling and in spring during sowing, as well as for pre-sowing cultivation. Dissolving in soil, it provides temporary alkalization of pH of the soil solution around the fertilizer granule, thus stimulating better uptake of phosphorus from the fertilizers on acid soils.

DAP AVAIL 18:46:0 is a DAP fertilizer treated with AVAIL© which is a specific material, designed as a mode of action to attract divalent and trivalent cations, not being affected by temperatures and soil reaction. AVAIL© creates a strongly negatively charged shield in the microenvironment around the granules and once in the soil, minimizes the concentration of potentially reactive cations in the immediate vicinity of the applied phosphorus fertilizers. AVAIL© is soluble in water but very little mobile from its contact area with the fertilizer, being a copolymer (macromolecule composed of several distinct repeating units called monomers, which can be linked together in various forms and through various chemical bonds) with long chain dicarboxylic acid (organic compound containing two carboxyl functional groups).

Complex fertilizer 14:40:0+7S is a fertilizer that also provides an important Sulphur (S) supply.

DAP 18:46:0 and DAP AVAIL 18:46:0 were used in a rate of 200 kg/ha of commercial product, which assured 36 kg/ha of nitrogen and 92 kg/ha of phosphorus (P_2O_5). Complex fertilizer 14:40:0+7S was used in a rate of 230 kg/ha which assured the same rate of P_2O_5, respectively 92 kg/ha, but it assured less nitrogen, respectively the rate of 32.2 kg/ha.

In total, the nitrogen rate assured within the experiments were of 120 kg/ha, the difference of the nitrogen from the complex fertilizer being assured by ammonium nitrate (NH_4NO_3) with 33.5 nitrogen content applied in the growth stage of 8 leaves of the maize plants.

Each experimental variant consisted of 126 m^2 resulting from 18 maize plant rows at 70 cm row spacing, which means 12.6 m, and 10 m of row length. The grain yield was calculated in kg/ha and it was reported at 14% moisture content.

RESULTS AND DISCUSSIONS

Due to the climate changes, in general but especially when it comes to South Romania, there is necessary for farmers to adapt and find the best and most efficient fertilization options.

The experimental variant DAP 18:46:0 applied with sowing was choose as control variant because this fertilizer product and method of application is the most use by farmers growing maize in Romania.

The influence of fertilization with complex fertilizers had an important impact on the maize plant growth at all experimental variants. In both experimental years, the best fertilization variant was those with DAP Avail 18:46:0 applied with sowing, this variant giving the highest grain yields, respectively 12514 kg/ha in 2022 (a yield increase of 16.74% compared to control variant) and 6777 kg/ha in 2023 (a yield increase of 11.7% compared to control variant) (*table 2*).

Except DAP Avail 18:46:0 variant, the other two fertilizer products, respectively DAP 18:46:0 and complex fertilizer 14:40+7S realized better grain yields when they were broadcasted before seedbed preparation and were incorporated by this tillage (*table 2*).

In the year 2022, there were not registered differences statistically significant compared to

control variant, but in 2023 the complex fertilizer DAP Avail 18:46:0 realized a difference very significant when it was applied banded with sowing and a difference distinct significant when it was broadcasted before seedbed preparation and were incorporated by this tillage. In 2023, also the fertilizer product DAP 18:46:0 realized a difference distinct significant when it was broadcasted before seedbed preparation and were incorporated by this tillage.

Table 2

Grain yield at maize at different fertilizer application methods and complex fertilizer products under different climatic conditions in South Romania (2022 and 2023)

Experimental factor		Yields obtained in 2022			Yields obtained in 2023		
Fertilizer application method	Complex fertilizer product	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
			kg/ha	%		kg/ha	%
Banded with sowing	DAP 18:46:0	10720	Control	-	6067	Control	-
	DAP AVAIL 18:46:0	12514	1794	16.74	6777	710 ***	11.70
	14:40:0 + 7S	10291	-429	-4.00	5999	-68	-1.12
Surface broadcast + incorporation	DAP 18:46:0	11100	380	3.54	6587	520 **	8.57
	DAP AVAIL 18:46:0	11124	404	3.77	6635	568 **	9.36
	14:40:0 + 7S	11342	622	5.80	6196	129	2.13
		$DL_{5\%}$ = 2189.93 kg/ha $DL_{1\%}$ = 3070.32 kg/ha $DL_{0.1\%}$ = 4339.65 kg/ha			$DL_{5\%}$ = 325.25 kg/ha $DL_{1\%}$ = 456.01 kg/ha $DL_{0.1\%}$ = 644.54 kg/ha		

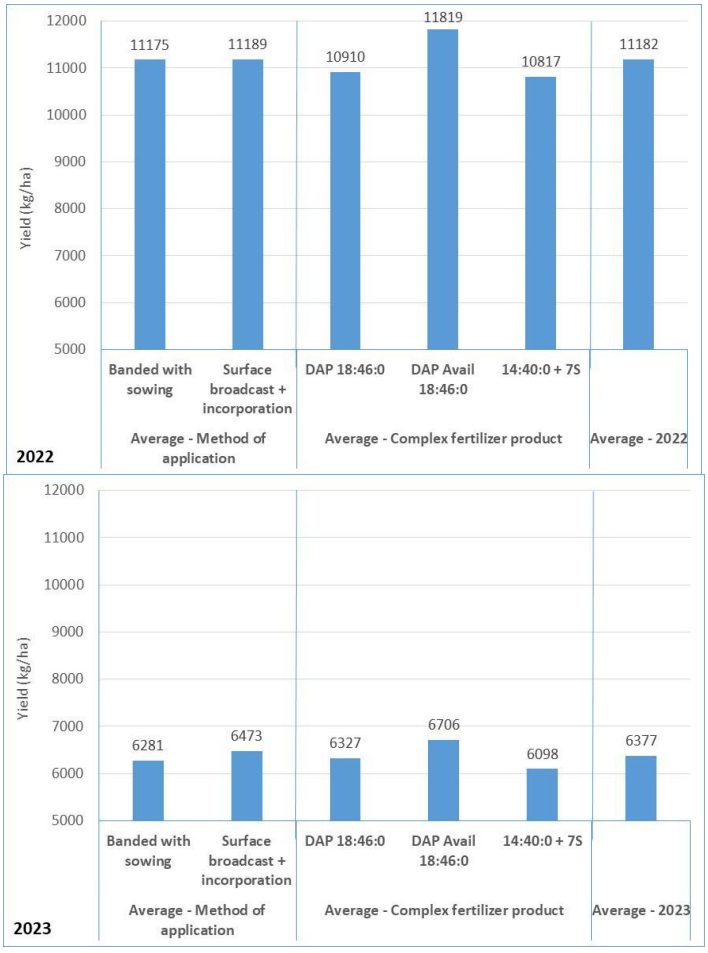

Figure 1 **Average grain yields for fertilizer application methods, complex fertilizer products and years of study in South Romania**

As average values, the grain yields obtained at the two fertilizer application methods were almost equal in 2022 and a bit more evident under the less favorable climatic conditions of the year 2023 (characterized as being warmer and drier than the year 2022) in the favor of surface broadcast before seedbed preparation and incorporation by this tillage (*figure 1*).

The average values for the complex fertilizer products put into evidence the superiority of the protected product DAP AVAIL 18:46:0, but also drew attention to the complex fertilizer 14:40:0 + 7S, which despite the Sulphur supply determined the smallest average grain yield (*figure 1*).

The average yield obtained in 2022 (11182 kg/ha) is much higher than in 2023 (6377 kg/ha) (*figure 1*), this being due to the higher rainfall in 2022 during the vegetation period of the maize plants, which totaled 281.7 mm, compared with 238.4 mm in 2023. In fact, all the average yields either reported to the application method of the fertilizers or the complex fertilizer products are higher in 2022 than in 2023 (*table 2*). Practically, the better water supply of maize plants gives them the possibility to use in more efficient way the nutrients from the soil.

CONCLUSIONS

Following the research carried out on the chernozem cambic soil from South Romania, it resulted that the complex fertilizer product with the best results in maize grain yield was the protected product DAP Avail 8:46:0 in both experimental years of study when it was applied banded with sowing.

The other two fertilizer products, respectively DAP 18:46:0 and complex fertilizer 14:40+7S realized better grain yields when they were broadcasted before seedbed preparation and were incorporated by this tillage.

The effect of the complex fertilizers on the maize grain yield is depended of the climatic conditions of the year.

The better water supply of maize plants gives them the possibility to use in more efficient way the nutrients from the soil.

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THE INFLUENCE OF CROP ROTATION AND FERTILIZATION ON AGRICULTURAL YIELD IN THE CONTEXT OF CLIMATE CHANGE ON SLOPED LANDS IN THE BÂRLAD PLATEAU

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Abstract

In Romania, severe droughts of varying intensities frequently impact large parts of the country, particularly the southern and eastern regions. Sloped agricultural lands, prone to erosion, cover approximately 43% of the country's agricultural area. Due to their extent and productive potential, these lands play a decisive role in Romanian agriculture, including in drought-affected areas. In addition to achieving competitive yields, soil conservation on these lands is essential. In this context, it is necessary to adapt and integrate both traditional and innovative methods to reduce soil erosion to acceptable limits and improve soil fertility. In the Bârlad Plateau, the topographical conditions and lack of water sources prevent the use of irrigation on sloped lands to offset moisture deficits, leaving crop production dependent solely on precipitation. The aridity of the region is exacerbated not only by the lack of rainfall but also by the terrain, which reduces the effectiveness of precipitation through runoff and diminishes the soil's water retention capacity due to surface erosion. This study investigates the role of crop rotation and fertilization in the quality and quantity of the primary agricultural crops on sloped lands in the upper sub-basin of the Țărnii Valley, Bârlad Plateau, over the past 10 years, in the context of climate change. The research highlights how rainfall patterns and surface runoff impact crop yield and emphasizes the importance of efficient soil and water resource management in areas at high risk of erosion.

Key words: drought, slope, rotation, erosion

The global climate evolution manifested by the increase in the average temperature, the change in the regime and the amounts of precipitation, have determined in the last decades, an increase in the areas affected by drought worldwide. The climatic framework of Romania is generally characterized as "moderate continental", but there is a great variability of it, both geographically and from one year to another. The extremely large variation, both in the total amount of precipitation from one year to another, and in its distribution throughout the year, causes water deficits during the vegetation of agricultural crops, in almost all areas of the country. These are accentuated in recent years due to climate change.

Plants are exposed, throughout their life, to numerous stress factors, which produce changes in the normal physiological functioning of all plants, including with important economic effects in crop plants. Due to the sedentary way of life, plants resort to a series of adaptive strategies regarding the response to different types of abiotic stress (drought, salinity, radiation, high or low temperatures, flooding, etc.) and biotic (pathogens, competition with other organisms), which alter the plant-environment balance (Epstein E. *et al*, 1980), reduce the biokinetic capacity of the plant, and cause damage that can kill the plant. Of all these natural stress factors to which plants can be exposed, drought affects 26% of the arable surface of the earth, thus limiting the most the distribution of plants and their productivity, both in natural and agricultural systems (Hanson A.D., Hitz W.D., 1982).

The rational use of sloping agricultural land implies the fulfillment of two major objectives, namely: soil and water conservation; the use of appropriate culture technologies. These objectives refer to the technical and agrotechnical methods of combating soil erosion on agricultural land. Indirectly, however, they also aim at issues related to preventing and combating the effects of drought because through the works of organization, development and soil erosion control exploitation of the lands, the aim is primarily to reduce liquid leakages on the slopes and, implicitly, to increase the water reserve in the soil.

The dry nature of the area is determined not only by the lack of precipitation but also by the relief that reduces their efficiency through surface

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runoff and the reduction of the useful water capacity of the soil, as an effect of surface erosion. The shock of droughts is felt much more strongly by the population in the hilly area. Due primarily to water losses caused by runoff on slopes, the level of agricultural production is lower compared to flat land.

MATERIAL AND METHOD

The experiments are located on the right slope of Tarna Valley on land with a slope of 12-13% on a moderately eroded cambic chernozem type soil, within the S.C.D.C.E.S. "Mircea Moțoc" Perieni. The experience is stationary and was established in 1969. In the present study, only the data obtained during the period 2013-2023 was analyzed.

Wheat and corn crops that are predominant in the research area were studied. The factors studied for both cultures were A – the type of rotation and B – the dose of fertilizers.

For the wheat crop, the A factor comprises 5 gradations:

- Wheat monoculture;
- Two-year wheat / corn rotation;
- Three-year rotation wheat / maize / peas;
- Five-year rotation with spring soil: wheat-maize-peas-sunflower-alfalfa

For the wheat crop, factor B also includes 5 fertilization options:

- Unfertilized (control);
- $N_{32}P_{32}$;
- $N_{96}P_{96}$;
- $N_{128}P_{128}$;
- Manure 50 t / ha (once every 5 years).

Biological material used. During the research, different varieties of wheat from higher biological categories and from those zoned in the Bârlad Plateau were cultivated.

The experiments were located with the length of the plots in the general direction of the contour lines. The soil works in accordance with the agrotechnics specific to each crop depending on the conditions of the year, so that an attempt was made to ensure a germinative bed as well prepared and uniform as possible.

Nitrogen and phosphorus fertilizers were applied fractionally, 1/3 before sowing and 2/3 of the total dose during the growing season of the crops. Fermented manure was applied once every 5 years under the basic plowing. Weed control was carried out with the recommended herbicides, aiming at the optimal application period. The experiments were laid out according to the method of subdivided plots in five repetitions.

Grain production in kg per plot, weighed to two decimal places, was recorded for each repetition. Grain moisture was determined with a moisture meter immediately after harvest and weighing was also recorded for each repetition.

The samples taken from the field were determined in the laboratory, consisting of: the weight of 1000 grains and the hectoliter weight.

RESULTS AND DISCUSSIONS

Climatic data

The values of the meteorological elements (temperatures, precipitation) indicate the presence of a temperate-continental climate of excessive nuance, with hot, dry summers and cold winters.

The data used were recorded at the weather station at the Perieni Research Station.

The rainfall regime is of particular importance because the production is directly dependent on the amount of precipitation and its distribution over time, and on sloping lands the volume of liquid runoff and erosion largely depends on the torrential nature of the rain.

More than 47% of the annual volume of precipitation falls in the critical season of erosion, which explains the high values that erosion registers in the Bârlad Plateau. Also, about 18% of the annual volume of precipitation occurs when the soil is bare, freshly tilled and easily erodible.

The analysis of the annual rainfall amounts recorded between 1941-2023 (*figure 1*) reveals a cyclical tendency of approximately 40 years, in which the rainy interval alternates with the dry one. The 5-year moving average, which conclusively expresses the climate evolution trend, suggests that in the period 1942-1957 the phenomenon of drought was specific and in the interval 1958-1984 the precipitation exceeded the multiannual average of 493.1 mm. Since 1985, the drought phenomenon has re-established itself, tending to continue even today.

The average annual temperature varies between 8.0°C and 13.0°C, the coldest month being January (-2.7 0C) and the warmest July (21.8°C). The transition between these limits is done gradually.

The analysis of monthly values from the interval 1941-2023 (*figure 2*) highlights a multi-year average of 10.1°C, a minimum of -11.5°C in January 1942 and a maximum of 26.2°C in July 2012. Temperature records the absolute maximum was 39.7°C and was recorded on July 25, 1942.

Influence of crop rotation and fertilizers on wheat production

In the long-term experiments with rotations and fertilizers, the influence of rotation and fertilizers on production was followed by the method of analysis of variance independently for each type of rotation. Statistical analysis of production data on each type of rotation revealed the effect of chemical and organic fertilization on wheat production.

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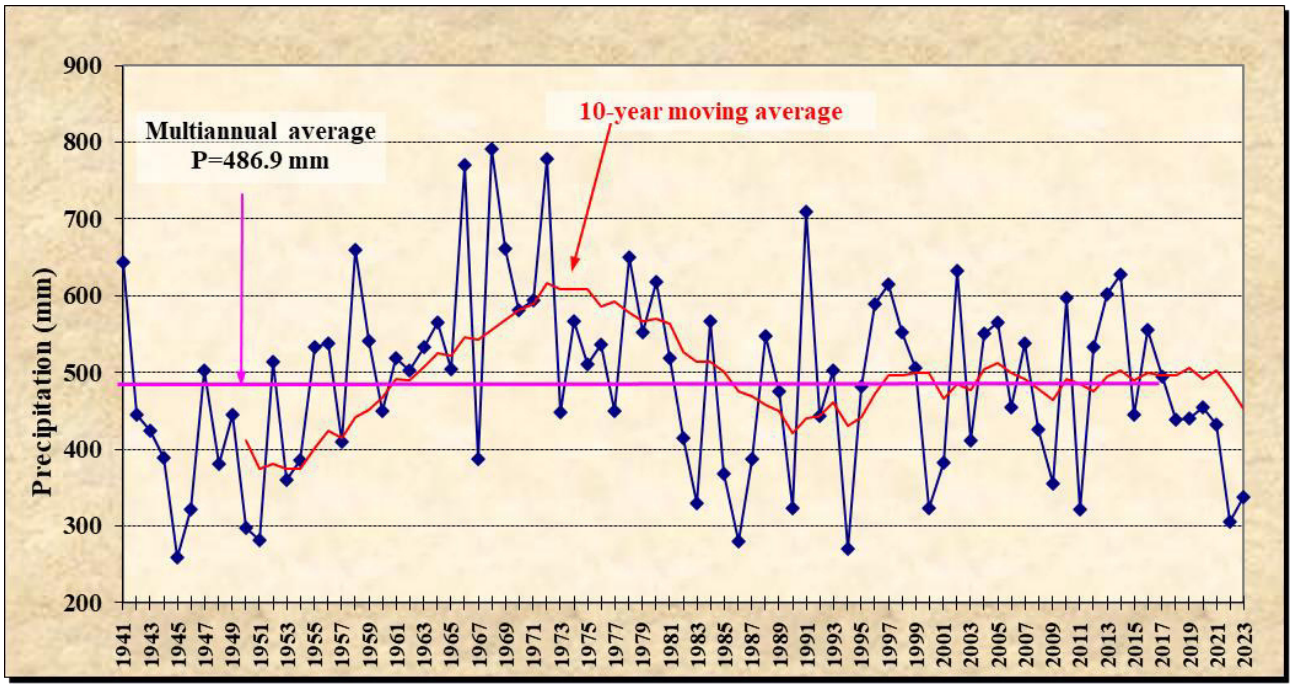

Figure 1 **Distribution of multiannual average precipitation in the period 1941-2023**

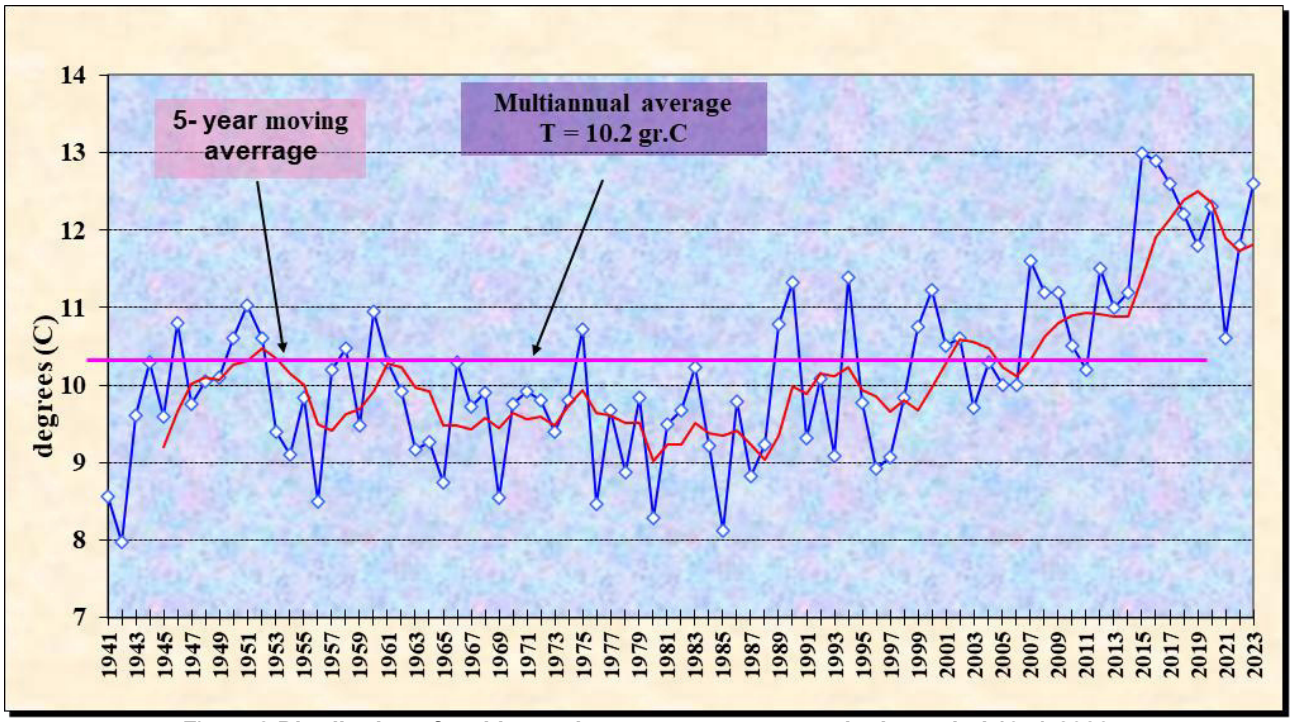

Figure 2 **Distribution of multiannual average temperatures in the period 1941-2023**

In order to have an overview of the evolution of wheat production, *table 1* presents the results obtained during the period 2013-2023.

In the monoculture of wheat, fertilizers are the only added factor, their influence was decisive in determining the production, so if in the non-fertilized variant an average production of 1478kg/ha was obtained, in the other variants the production recorded increases between 286 kg/ha and 1326 kg/ha. Statistically very significant assured production increases were recorded in the $N_{96}P_{96}$ and $N_{128}P_{128}$ variants.

The average production of wheat following the application of manure was 1764 kg/ha higher than the control 119%.

In the two-year wheat-maize rotation, the production differences between the non-fertilized and fertilized variants were higher than those obtained in monoculture. The average production obtained in the non-fertilized version was 1200

kg/ha, approximately 247 kg/ha lower than in the monoculture.

Average productions over the analyzed years in the fertilized variants were between 1441 kg/ha and 3869 kg/ha, 120%-322% higher than the unfertilized control. Statistically very significant assured production increases were recorded in the $N_{96}P_{96}$ and $N_{128}P_{128}$ variants.

In the three-year rotation, where wheat follows after peas, it is found that fertilizers, both chemical and organic, increase production with amounts between 155% and 285% higher than the unfertilized control. The average production, obtained in the non-fertilized variant was 1200 kg/ha, approximately 247 kg/ha lower than in the monoculture, it should be noted that the $N_{128}P_{128}$ variant had the highest increase (4591 kg/ha). It should be noted that all variants registered very significant production increases, statistically ensured both with respect to the error and the interaction with the years.

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Table 1

The effect of the interaction of the wheat crop and the level of fertilization on the production obtained in the years 2013 -2023

Crop rotation	Variant	Production/repetitive (kg / ha)					Average kg/ha	Difference as compared to the control variant	Significance
		1	2	3	4	5			
A1- Monoculture	b_1 (N_0P_0)	596	1597	3460	1399	1766	1478	0	
	b_2 ($N_{32}P_{32}$)	1083	2358	2443	1894	1838	1923	445	***
	b_3 ($N_{96}P_{96}$)	1888	2212	3634	3379	2901	2803	1325	* * *
	b_4 ($N_{128}P_{128}$)	2158	3780	3160	3065	1859	2804	1326	* * *
	b_5 (g.g)	543	1876	1854	1138	1981	1764	286	*
A2- 2 year rotation	b_1 (N_0P_0)	1205	890	1176	1277	1454	1200	0	
	b_2 ($N_{32}P_{32}$)	2473	2555	1990	2235	2744	2399	1199	* * *
	b3($N_{96}P_{96}$)	3961	3790	3573	3448	3625	3679	2479	* * *
	b_4 ($N_{128}P_{128}$)	4274	4432	3838	4006	2797	3869	2669	* * *
	b_5 (g.g)	1191	1418	1436	1404	1754	1441	240	*
A3- 3 year rotation	b_1 (N_0P_0)	1429	1776	1633	1373	1854	1613	0	
	b_2 ($N_{32}P_{32}$)	2937	3205	2144	2542	2825	2731	1118	* * *
	b_3 ($N_{96}P_{96}$)	4559	5151	4722	3659	4242	4467	2854	* * *
	b_4 ($N_{128}P_{128}$)	4789	5176	5042	3977	3972	4591	2978	* * *
	b_5 (g.g)	2076	2809	2378	2021	3255	2508	895	* * *
A5- 5 year rotation	b_1 (N_0P_0)	2126	1772	1632	2149	1485	1833	0	
	b_2 ($N_{32}P_{32}$)	3591	2890	2785	3344	2867	3095	1263	* * *
	b_3 ($N_{96}P_{96}$)	5259	4286	4559	4875	4895	4775	2942	* * *
	b_4 ($N_{128}P_{128}$)	5202	5244	4804	5781	5333	5273	3440	* * *
	b_5 (g.g)	2413	2818	2184	2595	1920	2386	553	* * *

DL 5 % 228 (kg / ha)
DL 1 % 308 (kg / ha)
DL 0,1 % 390 (kg / ha)

Cultivation of wheat in a five-year rotation with spring soil, where pea is the precursor in the rotation, led to productions between 2386 kg/ha and 5273 kg/ha, with increases compared to the control between 130%-288 %. The most significant increase in production was recorded in the version with $N_{128}P_{128}$. The influence of the preceding crop (leguminous for grains) combined with the long period after which wheat returns to the same surface, determined the obtaining of yields clearly superior to the other types of rotation, which means that the wheat crop, as expected, responds with significant increases in production, the employment in which it is included.

The influence of the interaction between crop rotation and fertilization (as a multi-year average over all five fertilization levels) on wheat production can be distinguished from the data in *table 2*, where it is observed that the gains obtained vary between 117%-161%.

Cultivation of wheat in simple rotation with maize brings an increase of 240 kg/ha, in the two-year rotation when wheat follows maize, the average production is higher than in monoculture. Only the five-year rotation brings an increase in production (3472 kg/ha, respectively 161% more than the two-year rotation, *figure 3*).

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Table 2

The influence of crop rotation on wheat production 2013-2023

Crop rotation	Average	Difference as compared to the control variant		Significance	Limit difference	
	kg/ha	%	kg/ha			
Monoculture	2154	100	0			
2 year rotation	2518	117	363	**	DL5%	546
3 year rotation	3182	148	1027	* *	DL1%	766
5 year rotation	3472	161	1318	* * *	DL0.1%	1081

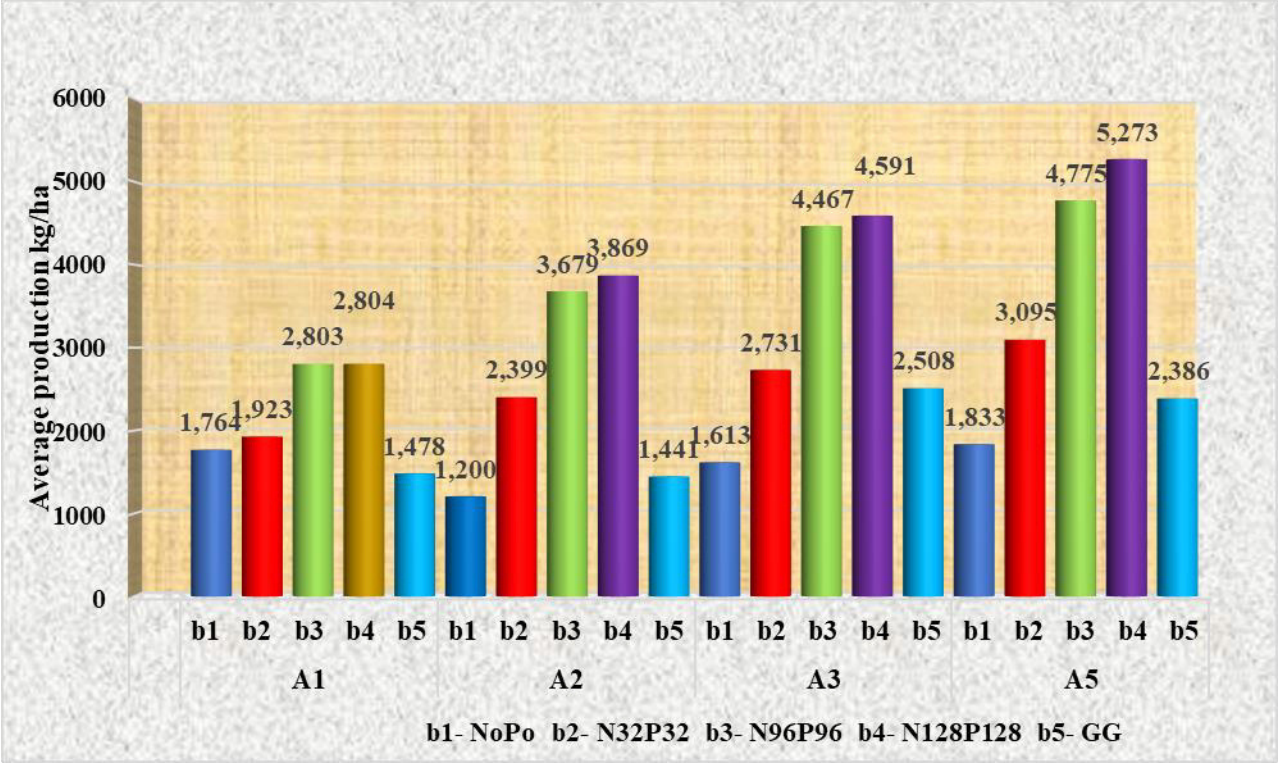

Figure 3 **Dynamics of average wheat production 2013-2023**

CONCLUSIONS

The change in the regime and amounts of precipitation, as well as the increase in the average annual temperature, influenced the level of wheat production in the last 10 years, on the sloping lands, located in the studied area. The uneven distribution in time and space of precipitation during the growing season of crops greatly influenced the growth and development of plants, but also the quality and quantity of production.

Wheat production was also affected due to high temperatures over a long period of time, which led to a prolonged atmospheric drought.

Analyzing the average productions of the wheat crop in crop rotations, in the last 10 years the following was found:

In the wheat crop:

- in monoculture the average production recorded was 2804 kg/ha in the $N_{128}P_{128}$ variant compared to the control variant where a production of 1478 kg/ha was recorded;

- in the 2-year rotation, the average production recorded was 3869 kg/ha in the $N_{128}P_{128}$ variant compared to the control variant where a production of 1200 kg/ha was recorded;

- in the 3-year rotation, the average production recorded was 4591 kg/ha in the N128P128 variant compared to the control variant where a production of 1613 kg/ha was recorded;

- in the 5-year rotation, the average production recorded was 5273 kg/ha in the $N_{96}P_{96}$ variant compared to the control variant where a production of 1833 kg/ha was recorded.

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THE COMPACTNESS STATE OF THE SALINE SOILS ON THE WESTERN SLOPE OF THE BEJENEASA FARM – COTNARI

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Abstract

The state of compactness is a complex characteristic of soil resulting from its textural characteristics and bulk density values. It is influenced both by the natural processes that contributed to the formation of the soil and by the agricultural works carried out. Our studies concern the compactness state of saline soils on the Bejeneasa Farm, Cotnari Vineyard, from the northeast part of Romania. The studied area is about 11.6 hectares in six vineyard plots. It is situated on the upper part of the slope. The absolute altitude ranges between 152 m and 172.5 m. The average annual precipitation and annual temperature values are 508.9 mm and 10.9°C, respectively. To highlight the causes of weak growth of the vine on the slope with a slope of 8% and with the western exposure, five soil profiles were made in representative locations following the cutting clearing of the vine plantation. The soil profiles were made after cutting the vine stems due to the growing stagnation and the small yields obtained from the grapes. The soil profiles were located in the upper and lower parts of the slope, both in the part with a uniform slope and on the diluvial–colluvial glacis located in the contact area with the land with a lower slope. From each soil horizon, soil samples were collected for laboratory analysis. The analytical data showed that the state of compactness of the saline soils was influenced by both soil formation processes and agriculture during the growing season and in the cold season. The range of values of the bulk density for the tracks of the wheels of agricultural machines was wider compared to those recorded on the row of vines.

Keywords: compactness, saline soils, vines

INTRODUCTION. The modernisation of viticulture to increase productivity and increase the quantities of wine products for consumption has led to a multitude of worrying negative effects on the environment and especially on the soil, influencing the production and quality parameters of the vine (*Vitis vinifera* L.).

Recently established vineyards require more agricultural operations than older ones. These practices, which are necessary for the growth and development of the vines (e.g., application of pesticides, fertilisers, installation of the support system), involve the continuous use of heavy machinery and consequently cause changes in the physical properties of the soil. Intensive agricultural activities cause the degradation of soil structure, compaction and the formation of surface crusting, which in turn reduces water infiltration. If soil infiltration capacity is lower than rainfall intensity, the potential risks of runoff and soil erosion are increased (Alagna V. *et al,* 2018).

Due to the intensification and extension of degradation processes, it is necessary to study agricultural activities in vine plantations because these activities lead to soil quality changes. The soil in vineyard plantations under vine training is subject to frequent tractor traffic associated with tillage, carrying out phytosanitary treatments, mechanised grape harvesting, manual dry, and green tillage works throughout the viticultural year. The increase in the number of mechanical works on the soil, as well as the use of heavy machinery and equipment, lead to soil compaction and partial destruction of the soil's structure (Robescu Valentina-Ofelia *et al,* 2008). These processes also decrease the soil's fertility by reducing the amount of organic matter in the soil and increasing the risk of erosion. Increased tillage also leads to damage to vine roots and the directional spread of pests and pathogens (Buesa I. *et al,* 2021). Compactness is a complex property of soil resulting from its textural characteristics and bulk density values.

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Soil degradation directly affects agroecosystems through high losses of soil and water, depletion of organic matter, and reduction of soil biota. The use of modern machinery in highly mechanised viticulture can influence soil compaction, which is also dependent on the amount of soil water.

Soil compaction is also relevant for understanding the life cycle in the soil system so that sustainable farming systems can be adopted, systems for soil improvement can be developed and adopted, and soil can be conserved and utilised in a superior way by establishing sustainable cropping technologies and adopting conservative tillage systems (Jităreanu G., 2015).

Soil management practices of vineyard plantations with sustainable objectives can be considered a first step to establishing a protective strategy to improve grape quality and reduce the effects of climate change (Cataldo Eleonora *et al,* 2020).

Soil compaction is one of the major causes of soil degradation in modern agriculture, and when operations are carried out in wet soil conditions, the risk of soil compaction is amplified (Marinello F. *et al,* 2017).

Unfavourable soil compaction in the path of tractors and machinery can be eliminated by using tillers appropriate to the wheel gauge. Controlled traffic practices, deep ripping and conservation tillage are recommended to increase the soil's physical condition. Another suggestion would be the application of organic mulch to reduce erosion without decreasing yields (Țopa D. *et al,* 2013).

MATERIALS AND METHODS

The study regarding the state of compaction of dewatered soils was carried out on the slope of Bejeneasa Farm, Cotnari Vineyard, in northeastern Romania. The studied area is about six vineyard plots. It is located in the upper part of the slope (*figure 1*).

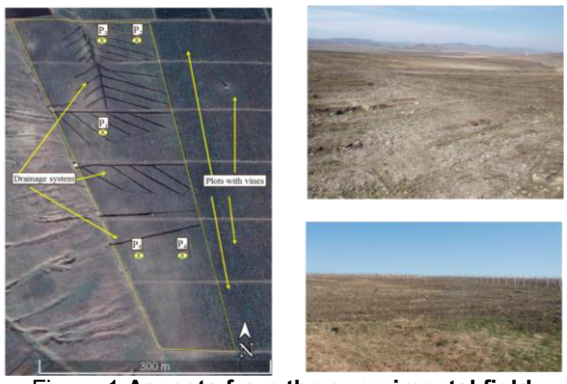

Figure 1 **Aspects from the experimental field**

To determine the main physical properties of the soil from the five soil profiles, soil samples were collected using numbered stainless-steel cylinders with dimensions of 5.1 cm in height and 5 cm in diameter (volume of 100 cm³), with walls 0.8–1 mm thick and pointed at one end. To determine the moisture regime, samples with a mass of about 20–25 g were placed in ampoules of aluminium.

The soil samples taken from the vine plantation were processed and analysed in the laboratory of the Research Institute for Agriculture and the Environment, Iași, according to the standardised methodology developed by the National Research Development Institute for Pedology, Agrochemistry and Environmental Protection (ICPA).

Several soil profiles were opened in the field, and the soil samples were analysed in the laboratory, where both the physical and chemical properties of the soil were determined *(figure 2)*.

Figure 2 **Aspects from soil profiles in the field**

RESULTS AND DISCUSSIONS

The soil within the studied area was formed on texturally inhomogeneous diluvial and diluvial–colluvial deposits. The clay content ranged between 36% and 55%. The highest content was recorded in the middle part of the soil profile, which constituted a barrier for water infiltration into deeper layers.

The bulk density values in the soil profile on the vine row ranged from 1.21 to 1.66 g/cm^3. It is worth noting that bulk density values were higher than those on the vine row only in the 0–80 cm depth interval between rows *(figure 3)*.

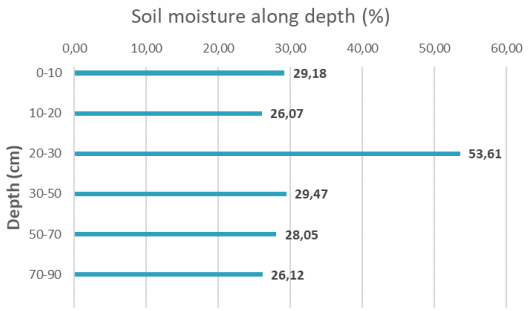

Figure 3 **Soil moisture along depth**

The soil was heavily loamy, starting from a depth of 60 cm, both on the vine row and on the tractor wheel tracks. The high DA values recorded at the base of the soil profile were due to natural soil compaction processes. The moderately compacted soil layer on the tractor wheel tracks was thicker than that on the plant row.

The compaction of the middle part of the soil profiles was due to pedogenetic processes of CTSS salinisation, which was also noted by pH values close to 9 and weak and moderate alkalinisation within the soil profile. The more pronounced compaction of the upper part of the soil on the tractor wheel tracks was a limiting factor for the lateral development of the root system of the vine. The lack of vine roots at depths greater than 35–40 cm was another indicator of severe limitations for vine growth due to salinisation and salinisation processes.

The determination for the same soil profile of the values of momentary moisture content and bulk density (Figure 4) revealed that the salty soil layer, with a clay content of approximately 55%, prevented water infiltration into the soil. The soil layer located above the clay layer recorded a high water content of 50% and approached flow consistency. Lower values of bulk density recorded on the depth interval of 30–65 cm, compared to those determined in the previous year, highlighted the presence of smectitic clay minerals that increase their volume greatly in the presence of water.

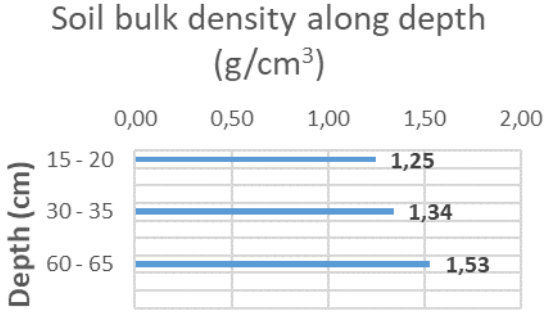

Figure 4 **Soil bulk density along depth**

The presence of these minerals was evidenced in the field by the oblique-slip faces in the layer with maximum clay content.

Penetration resistance values of more than 3 MPa were recorded starting from a depth of 45 cm, which confirmed the existence of other chemical limitations for root penetration (*figure 5).*

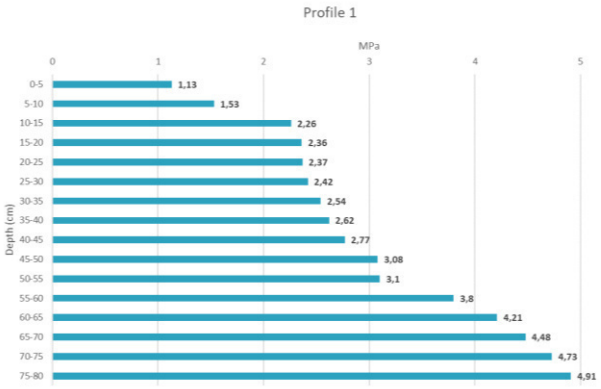

Figure 5 **Soil penetration resistance long depth**

The results obtained on soil compaction and other soil profiles confirmed that the development of the root system of the grapevine was restricted both by moderate or strong soil compaction and soil salinisation.

CONCLUSIONS

The state of compaction of depleted soils was influenced by both pedogenetic processes and the agricultural works carried out.

The range of variation of bulk density values was wider in the tracks of agricultural machinery than in the vine rows

The extension of the root system of the vine was limited due to both soil compaction as a result of the maintenance works carried out on the plantation and pedogenetic processes of depletion (salinisation and sodisation).

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INFLUENCE OF TILLAGE SYSTEMS AND COVER CROPS ON SOIL PHYSICO-CHEMICAL PROPERTIES

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Abstract

Tillage systems influence all soil properties and have different effects on plant growth and development. Adopting conservation farming practices brings benefits by improving soil quality, reducing soil erosion and can have synergistic effects on crop productivity over time. Cover crops are one of the most effective methods of improving the quality of agricultural soils, retaining soil moisture and combating nutrient pollution. Studies have been carried out from 2022 to 2023 to determine the influence of different tillage systems and cover crops on soil quality indicators. The research was carried out in an experimental polygon belonging to the Ezăreni Didactic Station, occupying an area of 0.50 ha, where in autumn 2022, autumn forage pea crop was sown in conventional and no-tillage system. In order to determine the moisture regime, immediately after sowing and during the whole growing period, soil samples were taken from 0-90 cm depth from both tillage systems. In terms of bulk density, it increased steadily over the 0-40 cm soil profile in both tillage systems. Penetration resistance was determined using the Eijkelkamp penetrologist in both tillage systems, with soil samples taken from three points in each system. The highest values were obtained in the conventional system at a depth of 25-30 cm. Phosphorus and mobile potassium were determined by the Egner-Rhiem-Domingo method, and the resulting values on the 0-40 depth of mobile phosphorus (17-53 ppm) place the soil in the medium and good category of the assurance status of this element in both tillage systems. Also, the values obtained for mobile potassium (184-259 ppm) in both tillage systems place the soil in the good and very good category of mobile potassium status. The nitrogen index was calculated according to the humus content and the degree of saturation in the bases, and the recorded values place the soil in a good supply of nitrogen content in both the conventional and no-tillage systems.

Key words: moisture, bulk density, phosphorus, potassium, nitrogen index

Soil tillage is one of the fundamental agrotechnical operations in agriculture because of its influence on soil proprietes, environment and crop production in general.

Tillage is a primary field operation that has been part of most agricultural systems throughout the years (Busari M.A. *et al*, 2015). Among the available tillage systems, conventional tillage (CT) played a key role in the evolution of modern agriculture, by promoting high yielding crops and weed control (Ashapure A. *et al*, 2019). Basically, the CT is characterized by the complete inversion of soil through ploughing. Conversely, conservation systems (minimum tillage, MT) include non-inversion tillage practices and no-tillage (NT). These systems consist of planting crops with minimal or none soil disturbance leaving at least 30% mulch cover (Giller K.E. *et al*, 2015).

In comparison to CT, the MT and NT systems have gained popularity worldwide due to reduction in fossil fuel consumption, and improvement of soil carbon content, soil structure, and water infiltration, which can increase farm sustainability and potentially optimize productivity over time (Deubel A. *et al*, 2011; Ćirić V. *et al*, 2012).

Minimum tillage improves the physico-chemical characteristics of the soil. Thus, the content of mobile phosphorus and potassium is higher in chisel tillage compared to conventional tillage (Jităreanu G. *et al,* 2008).

Soil tillage with chisel and paraplow determined the increase by 5.5 mg/kg (12%) and 16.0 mg/kg (7.0%), respectively, in mobile phosphorus and potassium content from soil, in comparison with ploughing to a depth of 20 cm, due to improved soil physical characteristics (Jităreanu G. *et al,* 2009).

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The assimilation of residues, moisture retention, microorganisms, pH, structure, and bulk density are all factors that tillage can affect positively or negatively (Bekele D., 2020). Thus, by reducing the turnover rate of macro-aggregates, enhancing the physical protection of particulate organic material, and minimizing soil to residue contact, reducing tillage or introducing no-tillage (NT) has the potential to reduce the amount of soil organic carbon (SOC) lost (Page (Mitchell J.P. *et al*, 2016). According to, how sustainably soil resources are used depends on the properties of the soil, which are influenced by soil tillage (ST) (Adaugna O., 2019). Using tillage properly might reduce soil-related restrictions; however, doing so incorrectly can result in a number of unfavorable processes. Compaction-related soil degradation is a growing issue as agricultural machinery's power and mass continue to rise, which has been a trend for the past 30 years (Antille D.L. *et al,* 2015).

The soil compaction indicators as compression degree (CD) and bulk density (BD) had the lowest value in the variant with ploughing, a medium value in the variant without turning the furrow, and the minimum values in no-till (Răus L. *et al,* 2016). The intensity of anthropogenic compaction can be amplified by some soil characteristics, machinery systems and farming technologies (Jităreanu G. *et al,* 2020).

Soil penetration resistance depends on soil characteristics and soil tillage. Thus, it is influenced by some soil properties such as bulk density, texture, aggregation, cementation, organic matter content, mineralogy, and soil water content, which has led some authors to propose empirical models to describe penetration resistance (Tavares F. *et al*., 2012).

In agricultural soils, several studies point to a reduction in productivity due to increased compaction, especially in areas under intense mechanization or grazing activities (Carvalho A.P.V. *et al*, 2012).

Although many soil properties affect penetration resistance, bulk density and, in particular, soil water content have the largest short-term impacts on penetration resistance. Some studies have reported a direct relationship between penetration resistance and these variables, which is often described by an exponential model (Vaz C.M.P. *et al*, 2011, Vaz C.M.P. *et al*, 2013, Imhoff S. *et al*, 2016).

In water-controlled environments, rainfall and its seasonality and interannual variability are the primary drivers of soil physical processes, and impose limitations on vegetation growth which

K.L. *et al*, 2020). The adoption of no-tillage systems has grown throughout the world due to the desire to cut costs, to plant winter crops quickly, and the alleged environmental advantages. However, the primary goal of using no-plowing tillage is to lower production costs while maintaining or increasing yields and reducing costs by up to 20% in the form of time and equipment savings (Mitchell J.P. *et al*, 2016)

reduces crop yields (Feng X. *et al,* 2013, Porporato A. *et al,* 2015, Souza E.S *et al*, 2014).

Bulk density values are required for converting gravimetric soil water content to volumetric and to calculate soil porosity which is the amount pore space in the soil (Blake G.R., Hartge K.H, 1986).

The assessment of soil conditions is still carried out only by chemical indicators, despite the growing awareness of the importance of soil biodiversity (Lehmann J. *et al*, 2020).

Agrochemicals improve crop productivity via protecting crops from insects, weeds, and other pathogens that impact crop yield and, at the same time, replenish soils deficient in plant nutrients. The conclusions on the nexus between agrochemical use and crop productivity among existing studies indicate that agrochemical use has conditional effects on crop yield. Since agrochemicals increase crop productivity, applying agrochemicals is stimulated by economics, though they also come with significant environmental costs that are always internalized. For this reason, knowing the determinants and optimal levels of agrochemical usage is important. Additionally, focusing on the distribution of the impact and the average treatment effects could provide a more precise depiction of how adoption of agrochemicals affects productivity (Kwabena N.A. *et al,* 2022).

Nitrogen is the main factor in growth and development of plants, with positive influence on rooting, tillering, leaf system development and photosynthesis process, the elements of productivity and also quality (Matei G., 2014). Nitrogen plays a major role in increasing plant production and its deficiency is believed to be the most frequent factor restricting plant growth (Zotarelli L. *et al,* 2008).

A study conducted by Misbah in Ethiopia found that short-term deep tillage significantly reduced soil bulk density and penetration resistance, significantly increased soil infiltration rates, and effectively countered soil degradation (Misban A.H. *et al*, 2019).

Rotary tillage can decrease soil bulk density in the 0–20 cm soil layer, increase the field's

water-holding capacity and soil porosity, and significantly enhance seedling plant height, stem diameter, leaf area, and dry weight per plant (Dong J.X. *et al*, 2021).

MATERIAL AND METHOD

The experiment was conducted at the Didactic Station of the from University Life Sciences of Iasi (IULS), Ezareni Farm. The experimental polygon has an area of 5000 square meters and is located on a slope between 5 and 7 %, on a type of cambic cernoziom soil. Two tillage systems are practised on this area - the conventional system (CT) and the no-tillage system (NT), where in october 2022, autumn fodder pea was sown in both tillage systems (*figure 1*).

Figure 1 **The experimental plot – Ezareni farm**

Sowing was carried out on the same day in both tillage systems, in the conventional system the seeding was done with SUP-29 DK seeders and in the no-tillage system the seeding was done with FABIMAG FG-01 seeders.

The specific climate of the area is temperate-continental, with an average precipitation of 436,4 mm and 354,8 mm, in 2022 and 2023, and an average annual temperature of 10,8°C, data recorded by Ezăreni weather station. During the growing season of the autumn fodder pea crop a total rainfall of 329.6 mm was recorded (*figure 2*).

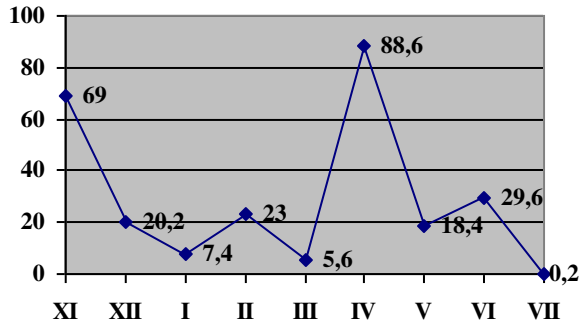


Figure 2 **Rainfall recorded during the growing season**

In the field stage, samples were determined throughout the growing season to determine the degree of compaction by analyzing the following indicators - bulk density, penetration resistance and soil moisture. Samples were also taken to analyse some soil chemical properties.

In order to determine the bulk density, undisturbed soil samples were taken, using cylinders (5 cm diameter, 5.1 cm height) with a volume of 100 cm^3 and a bottom cut at an angle of 15°.

In each plot, samples were taken from 3 points on the diagonal at 4 depth intervals: 0– 10 cm, 10–20 cm, 20–30 cm, and 30–40 cm. The chosen samples were taken a long way from the areas' external edges in order to avoid border effects.

The soil surface from which samples were taken was cleared of plant debris and gently levelled to ensure a sufficient surface area to sample 3 replicates at each depth. Soil samples were then dried to a constant weight in a 105°C oven in the lab.

The soil's weight was noted, and the bulk density was computed using *Equation 1*: Bulk density (g/cm^3) = (weight of oven dried soil) / (volume of the soil) (1) The bulk density values are interpreted according to *table 1*.

Table 1

Characterisation of bulk density (according to ICPA Bucharest, 1987)

Characterisation	Values (clay-loam texture)
Extremely low	<1.05
Very low	1.06-1.18
Low	1.19-1.31
Medium	1.32-1.45
High	1.46-1.58
Very high	>1.59

In order to determine the gravimetric soil moisture regime in the experimental field, soil samples were taken in six intervals down to 90 cm depths (0–10, 10–20, 20–30, 30–50, 50–70, and 70–90 cm) with three replicates at each interval. Soil from five points were collected individually from each plot in aluminum vials.

Moisture content was determined in the laboratory by the gravimetric method, which is considered the standard method for calibrating moisture tools due to its high accuracy.

The soil resistance to penetration was determined using the Eijkelkamp penetrologger in 10 replicates on each plot to a depth of 80 cm to obtain a representative value (expressed in MPa).

Soil pH in the conventional system is between 7.9 and 8.2, and in the NT it varies between 7.2 and 7.4 depending on sampling depth and slope. Soil pH was determined by potentiometric method in soil solution (aqueous or

saline) with different ratios of soil:liquid phase (mass: volume) (*table 2*).

Table 2

Soil reaction characterization limits (ICPA Bucureşti, 1981)

pH	Soil reaction status
< 5.0	strongly acid
5.01 – 5.80	moderately acid
5.81 – 6.80	slightly acid
6.81 – 7.20	neutral
7.21 – 8.40	slightly alkaline

Spectrometric determination of phosphorus (P) and mobile potassium (K) in ammonium acetate solution was carried out by the Egner-Riehm-Domingo method. The soil phosphorus and potassium status are presented in *table 3* and *table 4*.

Table 3

Status of soil phosphorus supply

Value range P-AL P ppm	Characterisation of insurance status with P
< 8.0	very weak
8.1 – 18.0	weak
18.1 – 36.0	middle
36.1 – 72.0	good
72.0 – 144.0	very good

Table 4

Appraisal of the soil's condition with accessible K

Accessible K value ppm	Characterisation of insurance status with K
< 66.0	weak
66.1 – 132.0	middle
132.1 – 200.0	good
200.1 – 265.0	very good
265.1 - 400	-

RESULTS AND DISCUSSIONS

Influence of tillage systems on soil compaction

Bulk density increased steadily in both tillage systems over the 0-40 cm depth. In the CT the bulk density values ranged between 1.07 and 1.24 g/cm^3 over the sampling depth, while in the NT the values recorded ranged between 1.26 and 1.42 g/cm^3 (*table 5*).

Table 5

Influence of tillage systems on soil compaction indices

Depth (cm)	Bulk density (g/cm^3)	
	Conventional system	No-tillage system
0-10	1,07 ± 0,03 a	1,26 ± 0,03 bc
10-20	1,14 ± 0,02 ab	1,35 ± 0,03 cd
20-30	1,23 ± 0,02 bc	1,37 ± 0,05 cd
30-40	1,24 ± 0,04 bc	1,42 ± 0,03 d

Note: CT – conventional system; NT – No-tillage system. Mean ± standard error of each column is reported in correspondence with each experimental treatment. Within each column: values associated with the same lower-case letters are not statistically different at $p \leq 0.05$ according to Tukey's test.

Influence of tillage systems on penetration resistance

Penetration resistance was sampled to a depth of 80 cm for both tillage systems. The

highest value in the CT was recorded at a depth of 30-40 cm where the hardpan layer occurs (3.52 MPa). Also, the highest values were recorded in the CT compared to the NT, where root system development is limited. In the NT, penetration resistance values ranged from 0.4 to 2.1 MPa. These values recorded in the NT system indicate a low penetration resistance, which is optimal for plant development (*figure 3*).

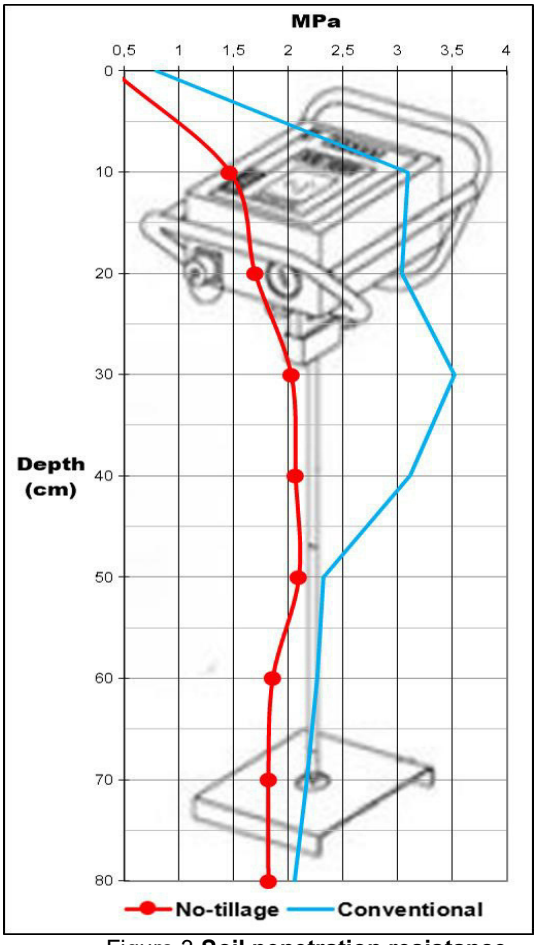


Figure 3 **Soil penetration resistance**

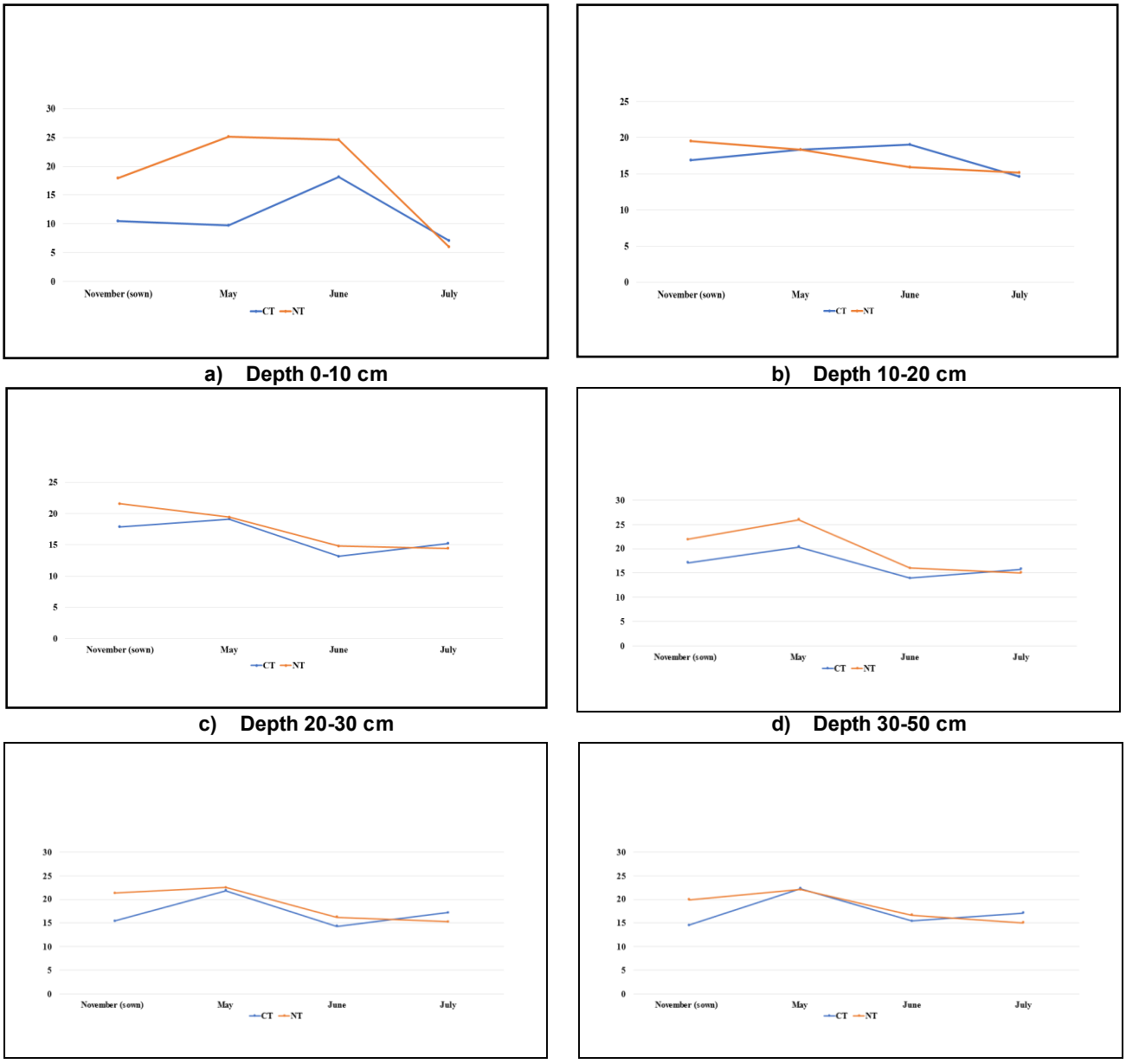
Influence of tillage systems on the soil moisture regime

Soil moisture was directly influenced by the tillage system used. Considering that NT is a conservative system, soil moisture had higher values in NT compared to CT throughout the growing season (*figure 4*).

After sowing the forage pea crop, samples were taken to determine the moisture regime and

the values obtained in NT were higher than the values recorded in CT. Also, in vegetation, the higher values were in NT. For example, in May, on the soil surface depth of 0-10 cm in the NT, soil moisture recorded a value of 25.14%, while in the CT a value of only 9.71% was obtained.

Similar results were obtained in a study by Budu M. *et al,* (2022) where the NT system had a higher moisture level compared to the conventional system on the 0 - 30 cm depth soil layer and after harvested. It was indicated by Slawinski C. *et al.,* (2012), that the no-till system is essential for conserving soil moisture content.



a) Depth 0-10 cm

b) Depth 10-20 cm

c) Depth 20-30 cm

d) Depth 30-50 cm

e) Depth 50-70 cm

f) Depth 70-90 cm

Figure 4 **Influence of tillage systems on the soil moisture regime (% g/g)**

Influence of tillage systems on soil pH

Soil pH was determined from both tillage systems over four depths from 0 to 40 cm, which was slightly influenced by the slope of the soil.

The values obtained in the conventional system were between 7.9 and 8.2, depending on the sampling depth, while in the no-tillage system, the values were lower and ranged between 7.2 and 7.2.

Both the values obtained in the conventional system and those recorded in the no-tillage system place the soil in the weak alkaline category (*figure 5*).

In deeper layers, the soil reaction is neutral to slight alkaline (7.1), influenced by the presence of CaCO3 from the C horizon.

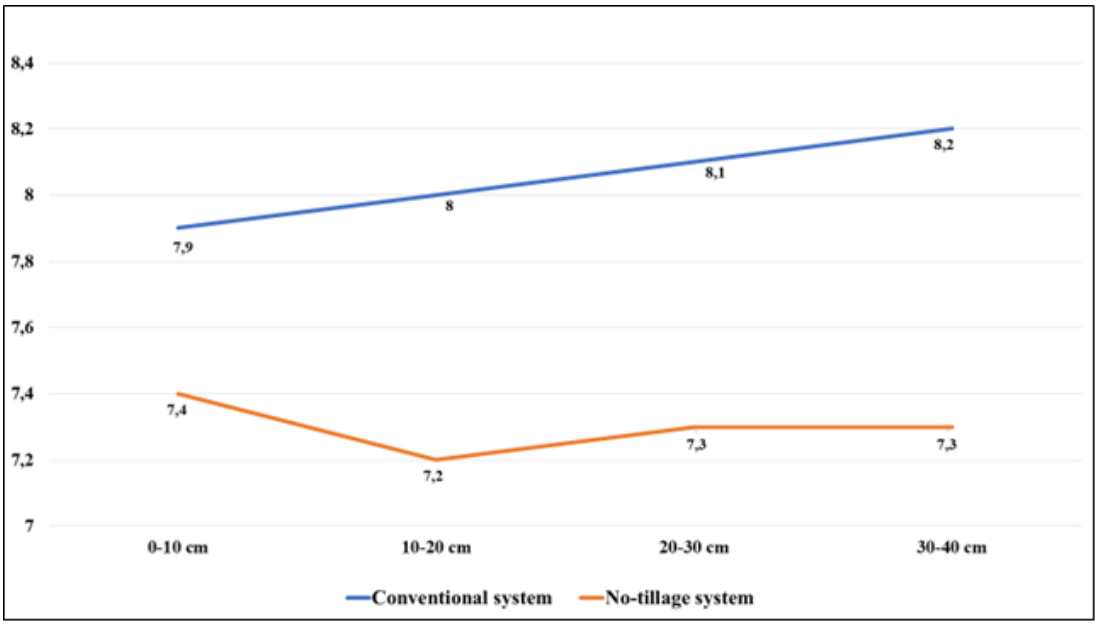


Figure 5 **Soil pH**

Mobile phosphorus content

Following agrochemical sampling, it was found that phosphorus in the soil surface depth of 0-10 cm falls into the good category of soil supply of this element. In the conventional system, phosphorus values ranged from 53 to 26 ppm, while in the no-tillage system, mobile phosphorus values ranged from 38 to 17 ppm (*figure 6*). The lower phosphorus content in the no-tillage system is due to the lack of deep soil tillage and non-incorporation of applied chemical fertilizers.

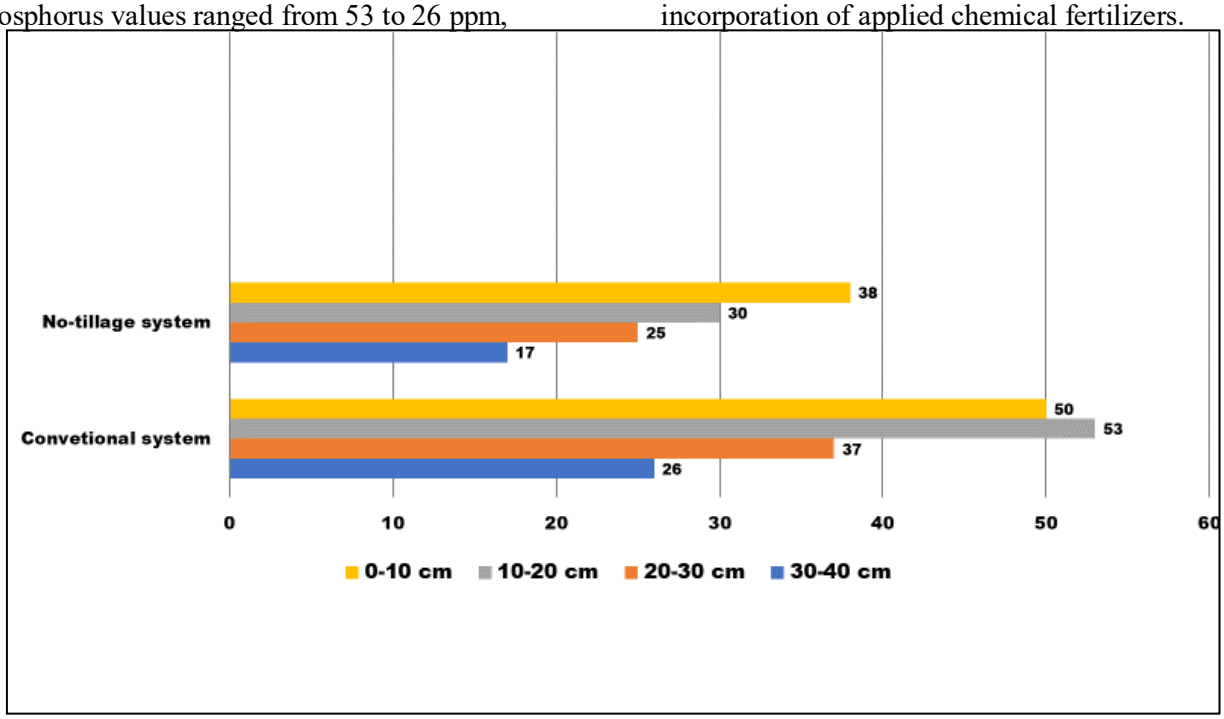


Figure 6 **Mobile P content (ppm)**

Mobile potassium content

Potassium is the most important cation for living organisms, performing numerous physiological and biological functions. After sampling for potassium determination, it was found that on the 0-20 cm depth, in both tillage systems, the resulting values fall into the very good category of soil supply of mobile potassium. Also, the resulting values on the 0-40 cm sampling depth fall into the good and very good category of supply of this element (*figure 7*).

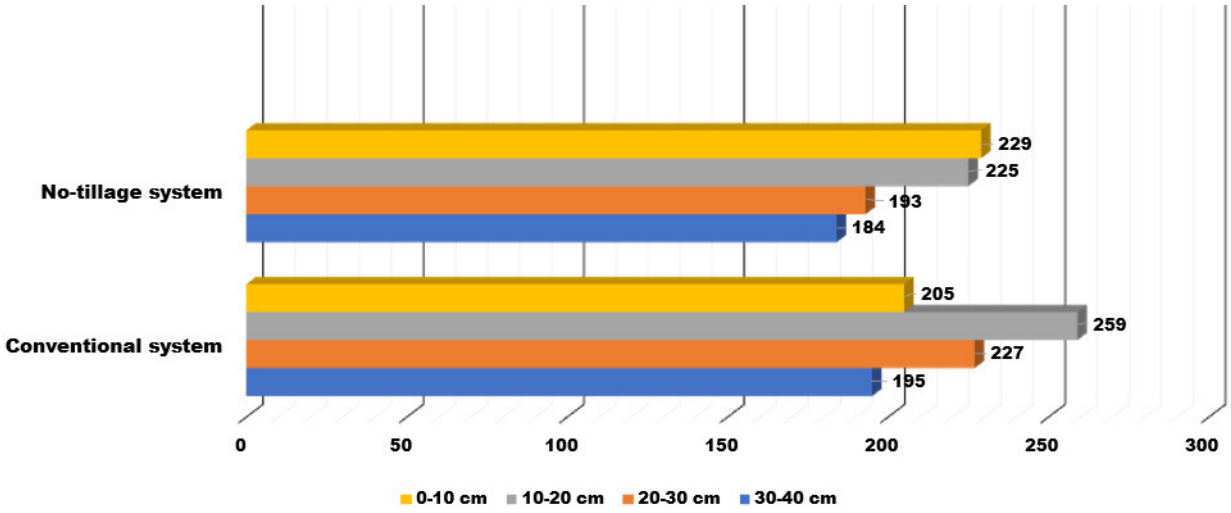


Figure 7 **Mobile K content (ppm)**

CONCLUSIONS

In this study, the values of physico-chemical soil properties of the studied tillage systems were determined during the agricultural year 2022-2023.

Among the physical properties studied we mention bulk density, penetration resistance and soil moisture, and among the chemical properties analysed we list soil pH, phosphorus and mobile potassium content.

Bulk density increased steadily over the 0-40 cm depth in both tillage systems. In CT, bulk density values ranged from 1.07 to 1.24 g/cm^3 indicating that this soil is very loose, and in NT, values ranged from 1.26 to 1.42 g/cm^3.

In terms of penetration resistance, the highest values were recorded in the NT at a depth of 30-40 cm where the hardpan layer appears.

Soil moisture regime was higher throughout the growing season in NT compared to CT. The soil pH values obtained in both tillage systems place the soil in the slightly alkaline category.

Mobile phosphorus content is lower in NT due to lack of deep tillage and non-incorporation of applied chemical fertilizers.

After soil sampling, it was found that on the 0-20 cm depth, in both tillage systems, the resulting values fall into the very good category of soil supply of mobile potassium.

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DETERMINING THE ENERGY INVOLVED IN THE INSTALLATION OF PEHD PIPES. APPLICATIONS OF DETERMINING THE ECONOMIC DIAMETER OF PRESSURE PIPES IN IRRIGATION SYSTEMS

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Abstract

The main purpose of the paper is the economic evaluation of the construction of pipeline networks under pressure, within irrigation systems. In this sense, the following stages were completed: (1) the technology for the execution of the pipeline network was established; (2) the phases related to the execution technology were established, respectively, grouped by categories of work, are as follows; (3) category of earthworks: mechanized excavation when making a trench related to the pipeline network; manual excavation when making a trench related to the pipeline network; mechanized filling when making the pipe network; (4) manual filling when making the pipeline network; mechanized compaction when making the pipe network; manual compaction when making the pipe network; making (manual filling) the sand bed; the mechanized spreading of the surplus earth resulting from the excavation; (5) category of construction and assembly works: preparation for joining pipes (tubes); joining by welding the pipeline (tubes); laying of pipes (tubes); (6) corresponding to the technological phases of the construction of the pipeline network, estimate items were allocated using WindevRO version 7.3 quotation preparation software, with the price catalog related to the semester preceding the preparation of this paper; (7) going through the above stages, the price per linear meter of pipeline executed in the field, equipped with PEHD, PE 100, PN 10 pipes and the range of diameters DN 90...DN630, was evaluated. By using these prices a mathematical model was established and the accuracy of determining the economic diameter for pressure pipe networks within irrigation systems has been improved.

Key words: execution technology, economic diameter, pipeline network

The main objective of the paper is to develop an algorithm for the economic evaluation of the execution works of pipeline networks under pressure, within irrigation systems.

The use of the costs devised in this way will allow us to establish an optimal and objective technical-economic-energy efficiency of the irrigation systems.

MATERIAL AND METHOD

In order to achieve the object proposed in this paper, we went through the following stages:

- establishing the pipeline network execution technology;
- establishing the phases related to the adopted execution technology;
- corresponding to these pipeline network execution phases, the quote items were allocated using the software for preparing quotes (Softeh Plus, 2023 - WindevRO V.7.3), with the related price catalog;
- going through the above stages, the price per linear meter of pipeline executed in the field, equipped with PEHD, PE 100, PN 10 pipes and the range of diameters DN 90...DN 630, was evaluated.

Next, detailing the stages presented above will allow us to solve the proposed objective.

Regarding the execution technology of the pipeline network, a mixed technology was adopted, respectively, mechanized supplemented with manual technology. Regarding the phases related to the execution technology, we have established work groups and related work categories, as follows:

- the group of mechanized and manual earthworks;
- group of construction and installation works.

Within the first group of works, we established the categories of works/technological phases of execution (NP 133, 2022), respectively:

- mechanized excavation when making a trench related to the pipeline network;
- mechanized compaction when making the pipeline network;
- mechanized filling when making the pipe network;

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- manual excavation when making a trench related to the pipeline network;
- manual filling when making the pipeline network;
- making (manual filling) the sand bed;
- the mechanized spreading of the surplus earth, resulting from the excavation

Within the group of construction and assembly works, we established the categories of works/technological phases of execution, respectively:preparation for joining pipes (tubes);joining by welding the pipeline (tubes); and laying of pipes (tubes).

With regard to the allocation of quotation items, using software for the preparation of quotations, for the financial evaluation of the technological phases of execution, the following stages were completed:

- we carefully analysed all the technological phases of execution that must be completed, presented above;
- we analysed the concrete conditions in which the technological phases must be carried out, according to the specialized technical legislation (NP 133, 2022, SR 4163-3, 1996);
- regarding the technological phases related to embankments - which are carried out at ground level and in its depth - indicated at current numbers 1, 2, 3 and up to 8 (*table 1)*, all these works are carried out in the conditions of light, non-cohesive soils (from the point of view of land category I and II), from a pedological aspect, they are similar to arable, loose land, land in general, suspended current agricultural/agrotechnical works, specific to the growing season (we considered the pipelines located with the upper generator at a depth of 0.90 m);
- corresponding to the technological phases and specialised technical restrictions (standards, technical regulations), we allocated, to all the technological phases of execution, the estimate items using specialised software (Softeh Plus, 2023; *table 1*).

We mention the fact that in column 3 of *table 1*, the suggestive name of the technological phase related to the estimate item in column 2 is inserted; in reality, the definition of the article is much broader, specifying all the concrete conditions for the realisation of the technological phase. In this sense, for example, *figure 3* shows the technological phase from current position 25, from *table 1* in detail.

When running the quotation software, simultaneously with the creation of the financial entity structure related to the works presented above, the list of recapitulation coefficients was established. *Figure 1* shows the coefficients in the default version. For the analysed case study, we departed from the default variant, with the addition of the recapitulation coefficients related to "Direct expenses" (10%) and, respectively, "Profit" (5%), to the value indicated in *figure 2*, with the adopted version.

RESULTS AND DISCUSSIONS

Going through all the stages presented above, in *table 2*, below, the costs are centralised - expressed in lei, euros and kWh - for one linear meter of pipe, equipped with PEHD, PE 100, PN 10 pipes and the range of diameters DN 90...DN 630, executed in the field.

The series of nominal diameters chosen, from the diameter of 90 mm to the nominal diameter of 630 mm, is in concordance with the level of the secondary infrastructure in our country; the nominal pressure of 10 bar is also optimal at the level of the infrastructure specified above.

We mention the fact that the price in lei, corresponds to the pricing catalog, where the price database related to the software is updated every six months.

The energy value (kWh) was obtained by converting the currency, leu, into electricity, respectively 1,004 lei/kWh, with a VAT of 19%; is the price of active energy, at the level of August 2024, which was applied to the supply of water for the irrigation of the secondary irrigation infrastructure (the irrigation systems of the Albița-Fălciu Complex for Hidroameliorative Development) from Vaslui county, an area administered at the macro level, by ANIF, in case, by the Territorial Branch of Vaslui Land Improvements.

Taking as a reference the price of electricity at the level of August 2024, the lei/euro exchange rate was adopted, from the end of the same month, namely 1euro = 4.9769 lei, 30.08.2024, BNR bank.

The centralised costs in *table 2* were applied within an original mathematical model to determine the optimal technical-economic diameter, D_{opt}, of a pipe in the network of an irrigation plot, which transports the Q_C flow.

To simplify the exposition, without affecting the generality of the results, we will consider a pipe section executed in the field, of unit length, and all related expenses will be expressed in the unit of electricity, kWh.

The performance criterion, considered in determining the diameter D_{opt}, consists in minimizing the amount of annual expenses G_{c_E}, (*equation 1*).

$$\min(G_{c\_E}) = \min(C_{ac} + C_E) \quad (1)$$

where:

C_{ac} are the expenses related to the amortization of the investment in the pipeline section, of diameter D_{opt}, and C_E the electricity consumed by the pressurization station to cover the load losses on said section, when transporting the QC flow.

Table1

The quoted items assigned to the technological phases of the execution of the pipeline network under pressure

No.	*Quoted items*	*The suggestive name of the technological phase of execution, related to the estimate of the item*
1	TSC03XB(93)	Mechanized pipe network excavation
2	TSA02E1(82)	Manual excavation of the pipe network
3	TSD02XB(93)	Mechanized filling of pipe network
4	TSD01XB(93)	Manual filling of the pipe network
5	TSD05XA(93)	Mechanized compaction at the pipe network
6	TSD04XC(93)	Manual compaction at the pipe network
7	ACF03A(99)	Manual sand filling (sand bed) at the pipe network
8	TSD03XA(93)	Mechanized spreading of the excavation surplus on the surface of the land
9	00601A03(02)	Tub PEHD PE 100, PN10, DN90, preparation for jointing and laying in the ground after jointing
10	00601A04(02)	Tub PEHD PE 100, PN10, DN110, preparation for jointing and laying in the ground after jointing
11	00601C01(02)	Tub PEHD PE 100, PN10, DN125, preparation for jointing and laying in the ground after jointing
12	00601C02(02)	Tub PEHD PE 100, PN10, DN140, preparation for jointing and laying in the ground after jointing
13	00601C03(02)	Tub PEHD PE 100, PN10, DN160, preparation for jointing and laying in the ground after jointing
14	00601C04(02)	Tub PEHD PE 100, PN10, DN180, preparation for jointing and laying in the ground after jointing
15	00601C05(02)	Tub PEHD PE 100, PN10, DN200, preparation for jointing and laying in the ground after jointing
16	00601C06(02)	Tub PEHD PE 100, PN10, DN225, preparation for jointing and laying in the ground after jointing
17	00601C07(02)	Tub PEHD PE 100, PN10, DN250, preparation for jointing and laying in the ground after jointing
18	00601C08(02)	Tub PEHD PE 100, PN10, DN280, preparation for jointing and laying in the ground after jointing
19	00601C09(02)	Tub PEHD PE 100, PN10, DN315, preparation for jointing and laying in the ground after jointing
20	00601C10(02)	Tub PEHD PE 100, PN10, DN355, preparation for jointing and laying in the ground after jointing
21	00601C11(02)	Tub PEHD PE 100, PN10, DN400, preparation for jointing and laying in the ground after jointing
22	00601C12(02)	Tub PEHD PE 100, PN10, DN450, preparation for jointing and laying in the ground after jointing
23	00601C13(02)	Tub PEHD PE 100, PN10, DN500, preparation for jointing and laying in the ground after jointing
24	00601C14(02)	Tub PEHD PE 100, PN10, DN560, preparation for jointing and laying in the ground after jointing
25	00601C15(02)	Tub PEHD PE 100, PN10, DN630, preparation for jointing and laying in the ground after jointing
26	00602D04(02)	Pipeline welding PEHD PE 100, PN 10, DN90
27	00602D05(02)	Pipeline welding PEHD PE 100, PN 10, DN110
28	00602D06(02)	Pipeline welding PEHD PE 100, PN 10, DN125
29	00602D07(02)	Pipeline welding PEHD PE 100, PN 10, DN140
30	00602D08(02)	Pipeline welding PEHD PE 100, PN 10, DN160
31	00602D09(02)	Pipeline welding PEHD PE 100, PN 10, DN180
32	00602D10(02)	Pipeline welding PEHD PE 100, PN 10, DN200
33	00602D11(02)	Pipeline welding PEHD PE 100, PN 10, DN225
34	00602D12(02)	Pipeline welding PEHD PE 100, PN 10, DN250
35	00602D13(02)	Pipeline welding PEHD PE 100, PN 10, DN280
36	00602D14(02)	Pipeline welding PEHD PE 100, PN 10, DN315
37	00602D15(02)	Pipeline welding PEHD PE 100, PN 10, DN355
38	00602D16(02)	Pipeline welding PEHD PE 100, PN 10, DN400
39	00602D17(02)	Pipeline welding PEHD PE 100, PN 10, DN450
40	00602D18(02)	Pipeline welding PEHD PE 100, PN 10, DN500
41	00602D19(02)	Pipeline welding PEHD PE 100, PN 10, DN560
42	00602D20(02)	Pipeline welding PEHD PE 100, PN 10, DN630

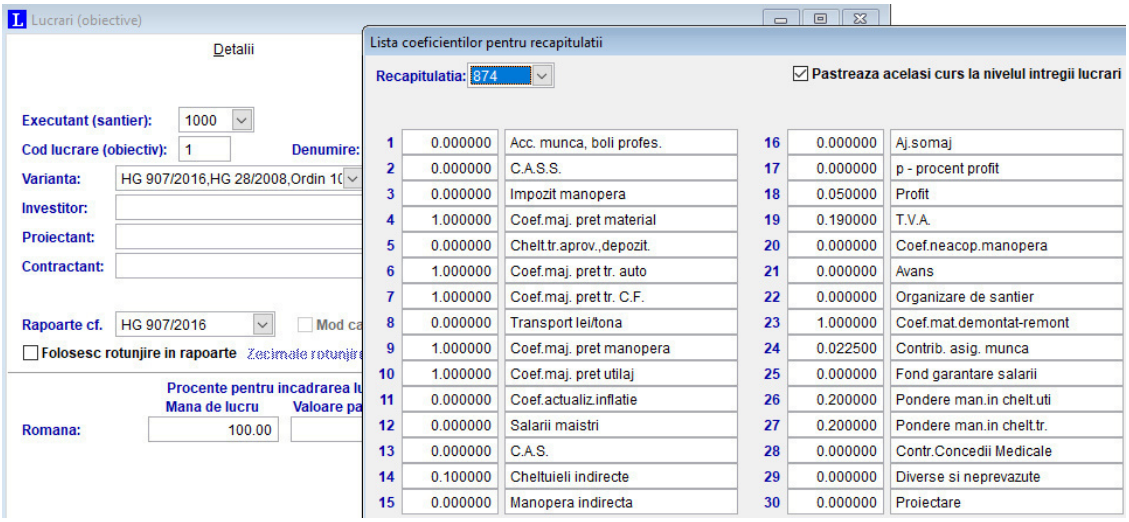

Figure 1 **List of calculated software recapitulation coefficients, default version**

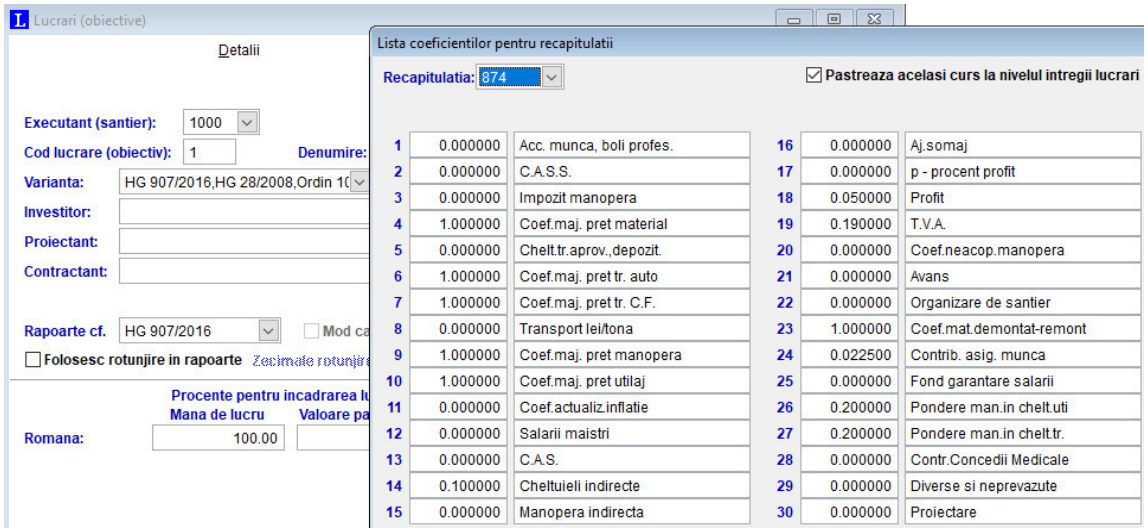

Figure 2 **List of calculated software recapitulation coefficients, adopted version**

Articolul 00601C15 02 Rețeta pentru 1m

Pregătirea pentru îmbinarea tuburilor din PEHD cu D = 630 mm în bare L = 12 m și poziția în pământ după îmbinare

Cod resursa	Tip resursa / Denumire resursa	U/M	Cantitate	Pret	Valoare
1	2		3	4	5
2901118	Material BILE, MANELE RASINOASE D = 15-18 CM	M CUB	0.003600	1152.37	4.15
8815165	Material BANDA AVERTIZARE GAZ 15,0CM X 0,09MM Componenta listei anexa LA006A2	M	1.100000	1.10	1.21
8815544	Material TUB PEHD APA PE100 SDR17 PN10 D.630 X37,4 MM Componenta listei anexa LA006A1	M	1.015000	1690.02	1715.37
0019900	Manopera MUNCITOR DESERV.CTII MONTJ.	ORE	0.330000	30.42	10.04
0025000	Manopera MONTATOR CONDUCTE	ORE	0.680000	35.10	23.87
1935	Utilaj MACARA PE PNEURI	ORE	0.033000	294.00	9.70
Greutate	0.000	Total ore	1.01	Total	1764.34

Figure 3 **Detailed execution technological phase, related to estimate item 00601C15**

C_{ac} expenses are assessed with the following (*equation 2)*:

$$C_{ac} = \frac{p_{Ad} + (1 - p_{Ad})(1 + N_{l-r} r_I)}{T_a} e_C \qquad (2)$$

where:
r_I = bank interest rate;
N_{l_r}= number of years for bank loan repayment;
p_{Ad} = advance amount for the investment;
e_C = energy embedded in the pipe section;
T_a = the amortization period of the investment.

E_C expenses are evaluated with the following (*equation 3)*:

$$C_E = \frac{8}{\pi^2} \frac{T_0}{\eta_P \cdot \eta_m \cdot \eta_{TS}} \frac{\lambda Q_C^3}{D_{opt}^5} \qquad (3)$$

where:
T_0 = number of operating hours of the pumping units within a year;
η_P = pump efficiency;
η_m = efficiency of the electric motor;
η_{TS} = the global performance of electromotor-pump transmission systems;
λ = the Darcy Weissbach resistance coefficient, calculated with the Colebrook White formula.

Next, the above mathematical model was customized for the following numerical data:
r_I = 0.07, N_{l_r} =10 years, p_{Ad} =0.25, e_C = according to Table 2, columns 1, 2 and 5, T_a =25 years;
T_0 = 1798 (hours/year); η_P =0,87, η_m =0,954; η_{TS} =1 (direct coupling).

The evaluation of the resistance coefficient λ, we considered the kinematic viscosity υ =1.006·10^{-6} m^2/s and the equivalent absolute roughness k=7.0·10^{-6} m.

The results, obtained with MATLAB, are presented synthetically in (*figure 4)* and *(figure 5).*

Table 2

The cost of running pressure pipes in irrigation systems

No.	Pipeline specifications	lei/ml, without VAT	euro/ml without VAT	kWh/ml
1	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 90	217.73	43.75	258.07
2	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 110	250.64	50.36	297.07
3	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 125	241.65	48.55	286.42
4	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 140	271.72	54.60	322.06
5	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 160	309.60	62.21	366.96
6	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 180	357.95	71.92	424.26
7	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 200	402.71	80.91	477.31
8	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 225	469.61	94.36	556.61
9	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 250	541.99	108.90	642.39
10	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 280	711.89	143.04	843.77
11	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 315	835.63	167.90	990.43
12	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 355	999.43	200.81	1184.59
13	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 400	1240.54	249.26	1470.37
14	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 450	1425.12	286.35	1689.14
15	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 500	1716.51	344.90	2034.51
16	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 560	2091.49	420.24	2478.96
17	Pressure pipe network made of tubing din PEHD PE 100, PN 10, DN 630	2558.42	514.06	3032.39

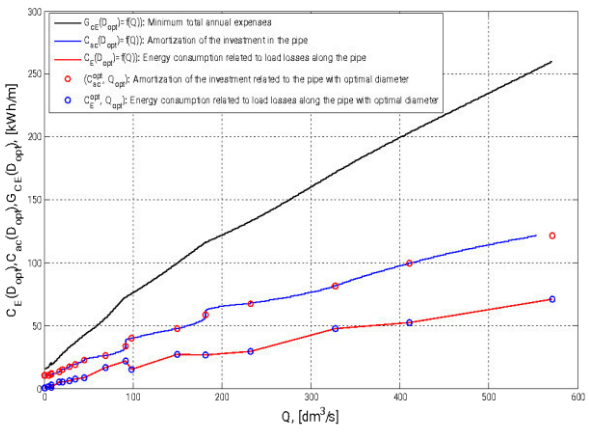

Figure 4 **Variance of optimal annual expenditure (related to minimum total expenditure, G_{CE}), by debit**

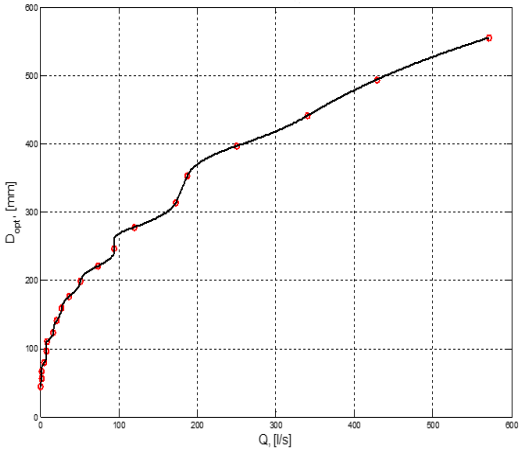

Figure 5 **Variance of optimal diameter, D_{opt}, as a function of flow rate**

CONCLUSIONS AND RECOMMENDATIONS

The obtained results, respectively, the energy value involved in the execution of pipe networks made of tubes/pipes with the range of diameters specified in *table 2*, will/can be used in an already established mathematical model, improving the precision of determining the economic diameter for pressure pipe networks within irrigation systems.

The optimal economic design of pipeline networks under pressure, related to irrigation systems, based on the energy quantification established by this paper, will allow the successful development of the economic-energy efficiency analysis of total investments in new irrigation systems. In the calculation of economic-energy efficiency, it is possible to energetically quantify all the investments made in the irrigation system, with its effect translating into an increase in agricultural production obtained by farmers, agricultural production that is easy to quantify energetically (Logigan I., 2003*;* Logigan I., 2005); thus, in the end, we obtain the economic-energetic effect of the investment in an irrigation system, objectively, eliminating the controversies that appear when analysing the classic economic efficiency, financially evaluated (lei/euro).

We mention that in the work (Pricop A. *et al*, 2000) when determining the optimal diameter for pipe sections of water distribution networks, the energy embedded in the pipe section, e_C, consists only of the expenses related to the amortisation of the cost of purchasing the pipes, but not those relating to the actual execution of the network.

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RESEARCH ON WATER LOSSES AT BRANCHES IN THE MAINS OF WATER SUPPLY SYSTEMS

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Abstract

Losses from the pipeline network constitute one of the main problems in their operation. The amount of losses in a water supply system varies from 8-10% to 60-74% of the volume of water taken from the source depending on the technical condition of the system. A large water loss is recorded at the consumer's connections. Water losses at the branches are caused by the breakdown of the branching installation, the absence of metering and by the theft of water. The paper presents the modern technologies for detecting water losses at branches in the urban pipe network. The case study carried out used modern acoustic detection equipment for hidden water leaks. By mounting 20 noise loggers on a distribution pipe with Dn 100 mm and in the branch housing, several losses were detected, among them an important one at a branch. The analysis of the data showed that the noise-to-signal logger correlation ratio had a 90% ratio in case of loss at the connection. Thus, the rate of water loss at the connection was about 0.5 m³/h (12m³/day or 360 m³/month). After fixing the connection, the appearance of new losses was verified with the help of noise loggers through the captured acoustic signal. The applied rehabilitation works determined the reduction of water losses by about 85% at the branch.

Key words: breakdowns, detection, measurement, pipe connection,

The loss of water from the structural components of water supply systems located in localities is a permanent reality with negative effects on the social and economic environment. The "water loss" phenomenon is studied and researched on a national and international level, especially in the last period of time. At the same time, the current climate changes have determined the decrease of drinking water sources, a situation that has required a drastic reduction of these losses. From the analysis of the degree of development of each state entity, it emerged that the value of water losses from pipeline networks can be from 5-10% to 75-80% of the volume of water introduced into the system depending on the level of economic development (Chirica S., 2019).

In a study carried out by the United Nations (UN), it is shown that a person needs an average value of 110 litre of water daily to cover the needs for consumption and hygiene. The value is variable worldwide, from 575 l/day in the USA, to 200 l/day in Brazil and up to 15 l/d in Ethiopia and others (Chirica S., 2019). The value of water losses is influenced by the structural state of the components of the water supply system (intakes, pipe network, reservoirs, treatment stations, hydraulic installations and others) and their mode of operation (Mănescu A., 2010, Chirica S., 2019). Also, loss monitoring and quick intervention in damage can limit this phenomenon (ARA, 2022, Boulos P.F., Aboujaoude A.S., 2011, Chirica S., 2019, Thorton J. *et al*, 2008). The volumes of water lost at the national level register values with changes over time, but an average of 48.3% is accepted (ARA, 2022).

In a statistic made in 2021 regarding water losses in European states, Romania ranks second with 42% of the volume taken from the source; Bulgaria was first with 59% and Italy was third with 50%. The lowest water losses are in the Netherlands and Denmark (about 4-5%). Worldwide, the reduced losses in technologically developed countries with values of 5-15% are noted, (for example, Australia has a percentage of up to 11% (Danilenko A. *et al*, 2014)).

Real-time pressure monitoring in the pipe network is one of the oldest methods used in water loss analysis (Chirica S., 2019, Lambert A.O., Thorton J., 2006, Walski T. *et al*, 2006). Metering the volumes of water distributed to consumers is one of the most effective measures to limit water losses (ARA, 2022, Apavital, 2019, Luca M.,

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Alexandrescu A., 2010). The research of the last 30 years in the field of water losses, many initiated by the International Water Association (IWA), as well as those developed in Romania, have highlighted the initiation and development of the phenomenon (Chirica S., 2019, Chirica S. *et al*, 2019), controlling the phenomenon through detection and metering (Thorton J. *et al*, 2008, Hamilton S., Charalambous B., 2020, Rizzo E.B. *et al*, 2021), but also increasing the efficiency of water transport and distribution (ARA, 2022, Apavital, 2019, Lambert A.O. *et al*, 1999).

The lack of adequate remedial and maintenance measures of the pipeline network leads to its degradation over time and shortening its life span. The studies carried out show how the lifetime of a pipeline installed in 1920 is reduced by up to 5 years after 75 years of operation, if only the detectable damages on the surface were repaired. In this case, undetected damage led to an increase in the supply pressure of the pipeline network (Chirica S., 2019, Chirica S., Luca M., 2017).

Water losses at branches are important in the water balance, although their value is small compared to the losses produced by breakdowns. The losses are present during the entire operation period of the branch and have the characteristic of hidden and background losses. The research carried out highlights the contrast between developed countries, where losses are at 0.5 m^3/h,km and underdeveloped or developing countries, where losses can reach up to 4.0 m^3/h,km (Chirica S., 2019).

Exact knowledge of consumption is the solution to introduce modern water meters, which have the possibility of real-time metering of the volume of water taken (Rizzo E.B. *et al*, 2021). At the same time, the measurement value is quickly transmitted to the operator for recording. The user can read the volume consumed directly on the smartphone by using a specialized application.

The reduction of water losses has become a priority direction of action in the management of water - canal companies at the national level (ARA, 2022, Apavital, 2019) and worldwide. Water losses are present from the design phase of the water supply system and are generated by the solutions adopted in the design, the materials selected for the system components and the technologies used in the execution. Water losses are reduced, but can also be amplified by the type of management of the canal water operator. Limiting water losses contributes to the effective utilization of drinking water sources, their protection, as well as the surrounding environment (Chirica S., Luca M, 2017).

The aim of the paper is to present a series of results regarding the detection and determination of water losses from the branches to the distribution network by using modern equipment and technologies.

MATERIAL AND METHOD

The research material consists of the constructive structure of the branches currently used in Romania and their influence on the initiation and development of water losses in various exploitation situations. The research area was located in a sector of the water supply system of the city of Iasi. The research used devices and installations for acoustic detection of water losses applicable to pipes with small diameters. The research stages were the following:

- the analysis of the volumes of water taken by consumers on a pipeline section and the highlighting of water losses following data processing over a determined time interval;
- defining the analysis section by using a number of acoustic sensors and data processing to highlight water losses;
- selection of pipeline sectors with significant water losses and detailed analysis by locating the acoustic sensors on the objective to be monitored; taking data and processing it using the calculation programs specific to this case;
- repairing the damage within the monitored objective;
- relocation of the acoustic sensors on the objective to verify the absence or reduction of water loss and processing of the obtained data;
- comparative analysis of the data taken before the accident and after the remedial work and entering it into a database.

Data processing was carried out through statistical calculation programs and the use of water loss interpretation programs specific to the acoustic detection technique (e.g. the PermaNET Web processing program).

Water losses at connections and their detection

The number of branches existing in the year 2022 on the pipeline networks for the water supply of the towns in Romania was 2,790,966. Of these, a number of 2,638,402 were counted. It should be noted that in 2009 the number of branches was 1,291,467, of which 1,151,126 were metered (ARA, 2024). In the Iasi Regional Water Supply System there were 115,805 branches of which 51,885 were located in the city of Iasi (Apavital, 2019).

The water branch to a consumer is composed of two constructive structures depending on the ownership of an owner. The first structure belongs to the water operator and is located on the public domain. It is composed of the following structural components (*figure 1*): the connection to the water distribution pipe, the

branch pipe, the concession valve, the housing for the hydraulic installation of the device for measuring the volume of water or the supplied flow, shut-off valves, valve drain and other installation elements.

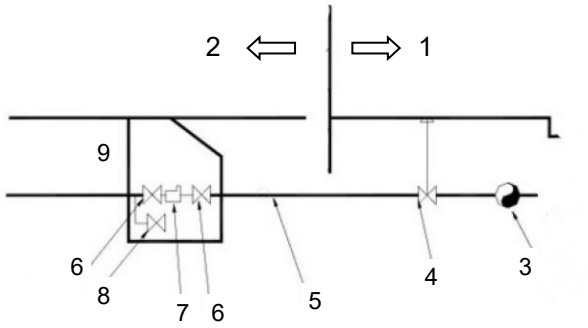

Figure 1 **Structural scheme of a water branch: 1 – public domain; 2 – private domain; 3 – the distribution pipe with the branch connection; 4 – concession valve; 6 – branch pipe; 6 – shut-off valve; 7 – flow meter; 8 – drain valve; 9 – manhole.**

The second branch structure belongs to the consumer and is located on the private domain. This contains the connection pipe to the water supply system of the objective and the hydraulic system for adjusting the hydraulic parameters. Water losses can occur on both structures and their management is carried out by the two owners. The water operator must involve the owner in reducing water loss through training and control actions.

Water losses at the branches are produced by the component elements made of different materials, by the large number of joints and the common mode of operation given by the distributor-consumer partnership. The branch generally consists of a construction (the branch manhole) and the hydraulic branching and metering installation (the branch pipe, the hydraulic installation in the manhole and the connection to the internal installation of the consumer).

Water losses in the components of the branch are generally detected only after a certain period of time, when there is a greater increase in the bill for the consumed water. At the same time, a series of degradations of the branching and sometimes of the building's infrastructure can be noticed.

The feature of water losses at the branches can be visible, hidden and background. In the area of the home with the water meter and on the pipe connecting to the consumer, it can be admitted that the water losses are hidden and at the bottom, because the water pressure is lower. Studies and research worldwide have shown that the maximum value of water losses is 0.07 m^3/h, branch. A series of researches carried out on water losses at branches (Lambert A.O. *et al,* 1999) highlight a series of values correlated with the supply pressure value (*table 1*).

The International Water Association (IWA) indicated a series of standard values for unavoidable annual water losses (UARL) along the branch route (*table 2*) (Chirica S., 2019). UARL type losses are differentiated on the components of the branch and depend on the supply pressure of the consumer

Table 1

Evaluation of systems based on the ILI indicator (Lambert A.O. *et al*, 1999)

Technical performance category		ILI	Flow rate (litres/ connection / day for) at an average pressure of:				
			10 m	20 m	30 m	40 m	50 m
Developed countries	A	1 – 2		< 50	< 75	< 100	< 125
	B	2 – 4		50 – 100	75 – 150	100 – 200	125 – 250
	C	4 – 8		100 – 200	150 – 300	200 – 400	250 – 500
	D	> 8		> 200	> 300	> 400	> 500
Developing countries	A	1 – 4	< 50	< 100	< 150	< 200	< 250
	B	4 – 8	50 – 100	100 – 200	150 – 300	200 – 400	250 – 500
	C	8 – 16	100 – 200	200 – 400	300 – 600	400 – 800	500 – 1000
	D	> 16	> 200	> 400	> 600	> 800	> 1000

Table 2

Standard specific values* for the calculation of unavoidable annual losses (UARL) (Chirica S., 2019)

Infrastructure component	U.M.	WL1	WL2	WL1	TOTAL UARL
Pipes	l/km/day/m pressure	9,60	5,80	2,60	18,0
Branch 1	l/branch/day/m pressure	0,60	0,04	0,016	0,80
Branch 2	*l/branch/day/m pressure*	16,0	1,90	7,10	25,0
* For the average service pressure 50 mca; Branch 1 - connections up to the concession valve; Branch 2 - branching to the water meter; WL1 - fund losses; WL2 - reported losses and damages; WL3 - Leaks and unreported damage					

The performance categories in which the water supply systems mentioned in table 1 fall have the meaning (Lambert A.O. *et al*, 1999):

- category A represents the systems where the further reduction of water losses is not considered economical;
- category B represents the systems that can be improved through pressure management, control and management of pipe losses;
- category C represents systems with poor water loss control management;
- category D represents inefficient water loss control systems; this situation requires a set of urgent measures to control and limit water losses.

Branch metering must be stepped up to reduce water losses through real-time control of distributed water volumes.

An anthropogenic factor increasing water losses is represented by illegal branches to transport and distribution networks. This situation is highlighted both in the rural and urban areas of Romania. The presence of illegal branches is determined by the inefficient management of the operator, the absence of comparative measurements over time, the use of modern means of detecting fraudulent consumption, etc. Illegal branches are made on main pipes (*figure 2*) and even upstream of the meter flow (*figures 3*).

Figure 2 **Illegal connections on the main water transport pipe**

Monitoring flows and pressures on a sector of a locality's pipe network allows the identification of water losses. Pressure management has a series of approaches on a national level (Mănescu A., 2010, Chirica S. *et al*, 2019) but also internationally (Hamilton S., Charalambos B., 2020, Thorton J., Lambert A.O., 2005, Walski T. *et al*, 2006, Lambert A.O., Thorton J., 2006) and is considered the "quintessential preventive method" in water loss management.

Illegal branches with a buried position and the water losses produced by them can be detected with specialized detection equipment for the underground investigation of the land.

Figure 3 **Illegal connection made upstream of the flow meter**

Illegal branches with a buried position and the water losses produced by them can be detected with specialized detection equipment for the underground investigation of the land.

Effective technologies for detecting water leaks at branches are acoustic and non-acoustic. Acoustic technologies use noise loggers (*figure 4*), noise correlator, ground microphones, which record the sound of water flow in the network, but also the emission through the fault.

Figure 4 **Acoustic equipment (noise loggers) for flow monitoring in the pipeline network** (Chirica S., 2018).

Non-acoustic technologies use geo-radar, drone and satellite imagery and others.

Pressure and flow loggers are devices mounted on the pipeline network and which transmit flow rates and pressures over time intervals. They can have alarm systems in case of large changes in the measured values.

RESULTS AND DISCUSSIONS

Monitoring during the night of flows and pressures on a sector of the pipe network of the city of Iasi DMA (District Metered Areas) Breazu Inferior revealed a series of variable flow values. These values are specific to water losses from pipes. In order to define the areas with water losses, a research program was organized in this district. The detection and control of water losses

was achieved through four work stages, respectively:

A – Analysis of the pipeline network parameters by taking them from the GIS (Geographic Information System) database. A distribution pipeline made of ductile iron with a diameter of 100 mm is positioned in the research area. The research area included a length of 400 m of the pipeline and related installations (hydrants, branches, derivations and others). Hydrants and water branches are mounted on it. The history of the pipeline regarding its behaviour over time was also analyzed.

B – Pre-location of damage to detect areas with water loss. For this purpose, 20 noise loggers were installed on the pipeline route and in the distribution areas (branches, junction box, hydrants, derivations, etc.). The measurements were carried out at night between 01-04 hours, in order not to influence the results with other collateral noises. The recorded water loss values were in the range of 18 - 22 m^3/h. The data obtained from the measurements indicated the presence of four areas with important water losses (*figure 5*). They were located at two branches, at a hydrant and at the analyzed pipe section and section. The data were entered into a water loss map and into the GIS system allocated to the water supply system of the city of Iasi.

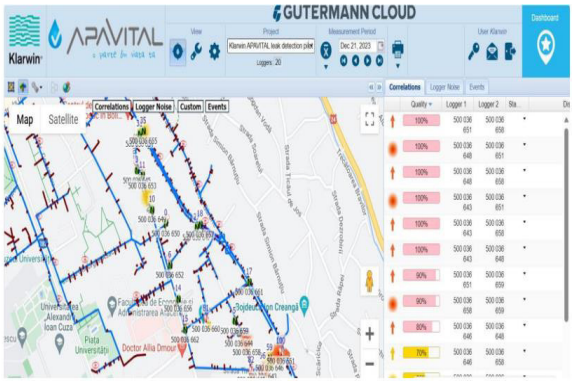

Figure 5 **Detail of the water loss detection area**

C - The location of water losses is achieved by using acoustic and non-acoustic equipment. Four noise loggers and correlators were used to precisely locate the leaky branch. The branch pipe was made of PEHD with an outer diameter of 32 mm. The water loss rate recorded over a 10-day measurement interval was 0.5 m^3/h, respectively 12 m^3/day. The noise-to-signal logger correlation ratio showed a value of 90%. The measured values indicate a significant damage to the branch. Through the intervention at the connection, it was revealed that the connection pipe made of PEHD was cracked, and the coupling to the distribution pipe was degraded (*figure 6*). The fault was remedied by using a modern branch.

Figure 6 **Detail of water loss at the branch**

D – After the rehabilitation of the branches, the presence of water losses was checked. Four noise loggers, correlators and a listening ground microphone were used to verify the patched wiring. The results of the measurements indicated a reduction of water losses to 0.2 m^3/h after the application of the rehabilitation works, and these are considered background losses.

ZoneScan.net Cloud Software was used for water loss analysis. The data obtained at the damaged branches and after their rehabilitation were entered into the database of the GIS monitoring system for the pipeline network of the water supply district.

CONCLUSIONS

1. An important direction in the current management of water supply systems is represented by the phenomenon of the value of water losses. They appear in all the components of the water supply system and mainly manifest themselves at the branch of the consumer to the pipe network.

2. The detection of water losses at the connections can be achieved by monitoring the consumption recorded by the volumetric meter, by using acoustic detection devices for non-compliant emissions and time tracking programs of pressure and flow variations on the distribution pipes. At the same time, the acoustic method can detect illegal branches to the distribution pipes.

3. The quick results obtained with the help of modern detection equipment limit the amount of water losses, with favourable implications on the functional, economic and environmental protection factors in the area where the branches are located.

4. Water losses can be significantly reduced by modernizing and typifying the constructions and installations that structure the branch to the consumer, as well as by using modern flow meters that are monitored from a distance.

5. The use of acoustic water leak detection devices at branches is effective considering their small size, the possibility of placement in small spaces, their mobility, fast data retrieval and processing, as well as the use of a variable number depending on monitoring area.

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ASSESSMENT OF EROSION FACTORS AND CONTROL MEASURES IN THE CĂLINA HYDROGRAPHIC BASIN

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Abstract

The Călina hydrographic basin, located in the Central Moldavian Plateau, presents a complex natural framework shaped by geological, geomorphological, hydrological, and climatic factors. This study aims to analyze the basin's structure, relief, hydrography, and ecological processes that influence its current landscape. Data on sedimentary layers, tectonic influences, erosion dynamics, and land use provide insights into the region's environmental sustainability. The findings highlight the importance of monitoring geomorphological processes and implementing conservation strategies to mitigate erosion and enhance agricultural productivity. The study further examines the role of slope inclination, precipitation patterns, and human activities in accelerating soil degradation. By analyzing erosion-prone areas, this research proposes targeted soil conservation techniques, such as afforestation and contour farming, to improve land stability. The conclusions emphasize the need for sustainable land management practices to preserve the basin's natural balance and ensure long-term agricultural productivity. Furthermore, comparative analysis with similar studies on soil fertility and erosion control from other regions provides a broader context for assessing the effectiveness of proposed measures.

Keywords: Călina Basin, hydrography, geomorphology, erosion, environmental

The Călina hydrographic basin is situated in the Central Moldavian Plateau, extending between latitudes 46°6' and 46°50' N and longitudes 27°5' and 27°25' E. As a tributary of the Şacovăţ River, the basin is characterized by a diverse geological structure, active geomorphological processes, and significant hydrological features.

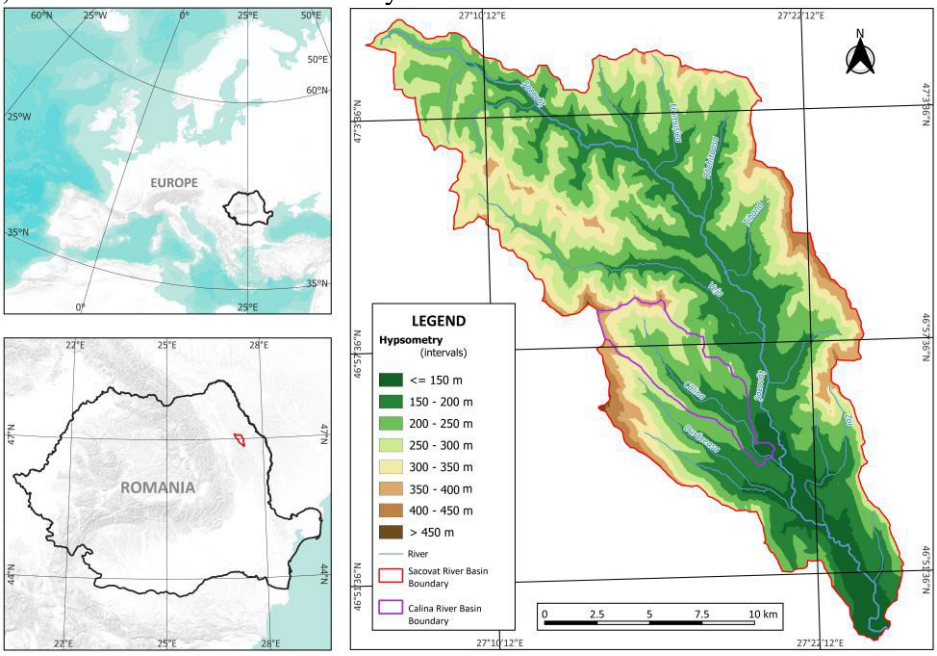

Figure 1. Location map of the Călina Basin, illustrating its geographical position within the Central Moldavian Plateau

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Understanding its physical geography is essential for effective land management and environmental conservation (*fig. 1*).

One of the key concerns within this region is soil erosion, a process influenced by multiple natural and anthropogenic factors. Erosion can be accelerated by steep slopes, intense precipitation, deforestation, and improper agricultural practices. The agents of erosion, including water, wind, and gravitational forces, contribute to the degradation of soil and impact both agricultural productivity and water quality.

The objective of this study is to evaluate the environmental characteristics of the Călina Basin, with a particular focus on the factors and agents contributing to soil erosion. The findings will serve as a foundation for assessing soil degradation risks and proposing sustainable management solutions.

MATERIAL AND METHOD

The research involved field obsevations, eological and topographic mapping, and hydrological data collection. Stratigraphic analysis was conducted to determine sedimentary deposition cycles, while GIS tools were employed to assess spatial distribution patterns of relief and erosion-prone areas. Climatic data, including temperature variations and precipitation levels, were integrated to evaluate their impact on soil degradation and land use (*Ciocan et al., 2021; Dai et al., 2020*).

The slope map was generated using GIS software, specifically ArcGIS and QGIS, by processing a Digital Elevation Model (DEM) with a resolution suitable for hydrological and erosion studies. The analysis applied spatial interpolation methods to accurately delineate terrain inclination classes, providing a detailed representation of the basin's topographical variations.

RESULTS AND DISCUSSIONS

Soil erosion in the Călina Basin is primarily driven by water and wind forces, with precipitation being the main trigger for hydric erosion. The intensity of erosion is further influenced by terrain characteristics, soil properties, vegetation cover, and land use patterns.

Relief and Its Impact on Erosion

Relief plays a basic role in water runoff and sediment transport. The key metric for assessing terrain impact is hypsometry, which represents the distribution of elevations (*table 1*).

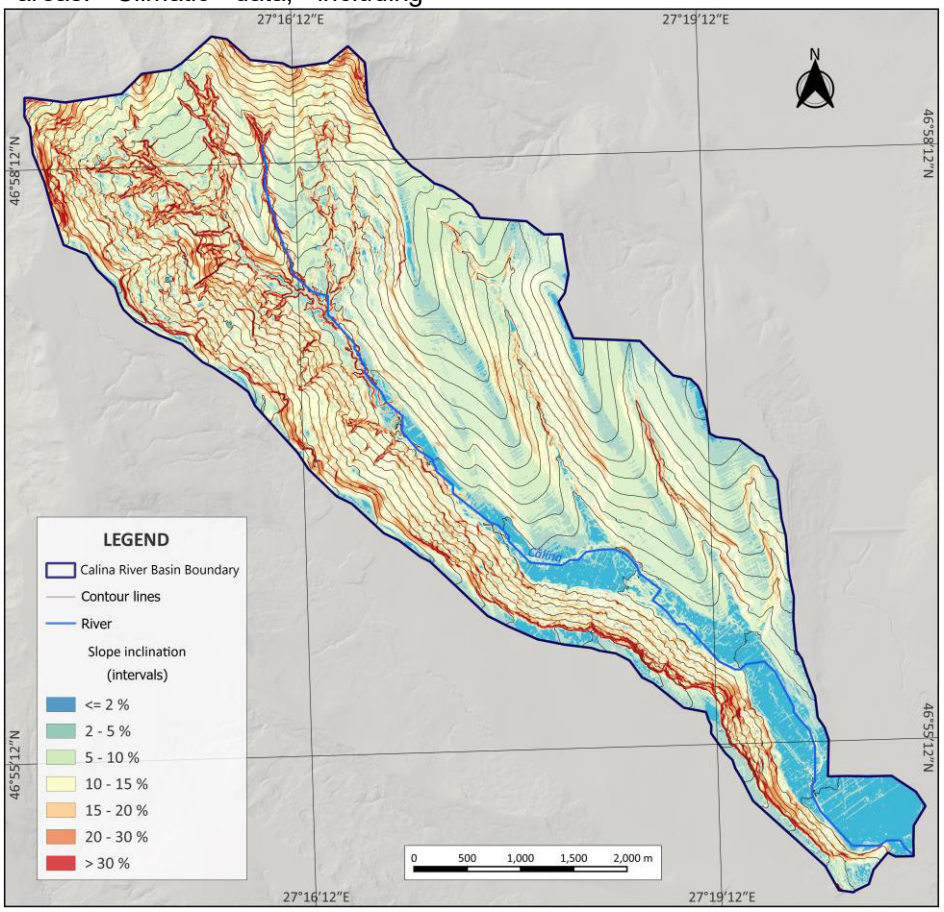

Figure 2. Slope inclination map of the Călina Basin, showing terrain classification based on GIS analysis

Table 1. Hypsometric Classification of the Călina Basin provides the classification of the basin based on elevation

Hypsometric Class	Surface Area (ha)	Percentage (%)
< 150 m	60.39	2.60
150 - 200 m	538.58	23.23
200 - 250 m	851.21	36.71
250 - 300 m	497.09	21.44
300 - 350 m	269.14	11.61
350 - 400 m	92.71	4.00
> 400 m	7.73	0.33

Slope Distribution Analysis

The distribution of slopes within the Călina Basin plays a basic role in understanding erosion risks. The slope analysis reveals that over 63% of the total area has slopes greater than 7%, indicating a significant susceptibility to erosion (*fig. 2*).

The highest percentages are recorded in the 7-12% (27.81%) and 12-18% (21.48%) slope categories, which correspond to interfluves and cuesta landforms (*table 2)*.

These areas are prone to sheet and rill erosion, requiring targeted soil conservation strategies. The steepest slopes (>35%) account for only 1.67% of the area, but they represent the highest risk zones for landslides and severe erosion, especially in regions with deforested or cultivated land.

The majority of the basin (over 36%) lies between 200 and 250 m, indicating a predominantly hilly landscape. Lower elevations below 150 m are mainly found along the Călina River floodplain, whereas higher elevations above 300 m exhibit more fragmented terrain with higher erosion risks.

Geological Structure

The geological structure of the Călina basin consists of a crystalline basement overlaid by sedimentary deposits, including Proterozoic, Cretaceous, Badenian, Sarmatian, and Pleistocene formations.

The region is influenced by tectonic movements that have contributed to the structural formations and transgressions over geological time.

The seismicity of the Vrancea zone affects the basin, requiring continuous monitoring.

Relief Characteristics

The relief is shaped by fluvio-denudational processes, resulting in valleys, terraces, cuesta landforms, and sculpted slopes. The basin exhibits a high degree of fragmentation, with altitudes ranging from 180 m to 422 m in the Măgura Gârbești region.

Hydrographic Network

Hydrologically, the basin is drained by the Călina River and its tributaries, with a hydrographic density of 0.5 km/km². The main water supply sources include precipitation (65-70%) and groundwater (30-35%).

Seasonal variations influence river discharge, and water quality is occasionally compromised by agricultural activities and livestock farming (*Dumitrașcu et al., 2003; Liu et al., 2023*). The Şacovăţ River serves as the primary drainage outlet.

Erosion and Geomorphological Processes

Erosion is a significant environmental concern, with approximately 35% of the basin affected by strong erosion and 10% by severe erosion processes.

The main factors contributing to these dynamics include steep slopes, tectonic activity, and climatic variations. The presence of cuesta landscapes and unstable slopes further exacerbates soil degradation and mass movements. Anthropogenic influences, such as deforestation and unsustainable agricultural practices, contribute to increased rates of land degradation (*Năstasă et al., 2008; Rusu et al., 2001*).

Microregions within the Basin

The basin is divided into several micro-regions:

- Floodplains: These are fertile but prone to periodic flooding, necessitating drainage and embankment measures.
- Interfluves and structural platforms: These host agricultural activities and settlements, benefiting from stable geomorphological conditions.
- Cuesta landforms and steep slopes: These regions exhibit high erosion rates and require targeted conservation measures (*Deac et al., 2009; Zhao et al., 2022*).
- Forested regions: These play a crucial role in stabilizing slopes, preventing excessive erosion, and supporting biodiversity.

Slope Influence on Erosion

Slope inclination significantly impacts water flow velocity and soil stability. The steeper the slope, the more susceptible it is to erosion (*table 2*).

Table 2. Slope Distribution and Erosion Implications in the Călina Basin presents slope distribution and its implications

Slope Category (%)	Surface Area (ha)	Percentage (%)	Impact on Erosion
0-2	191.38	8.25	Minimal erosion risk
2-7	609.01	26.27	Low risk, potential sheet erosion
7-12	644.84	27.81	Moderate erosion, rill formation possible
12-18	497.93	21.48	High erosion risk, gully formation likely
18-25	221.75	9.56	Severe erosion, high conservation needs
25-35	103.06	4.45	Extreme erosion risk, urgent stabilization needed
> 35	38.73	1.67	Landslide-prone, highest conservation priority

The analysis highlights that approximately 58.85% of the basin features moderate to high slopes (>7%), necessitating effective land management measures (*table 3*).

Table 3. Statistical Analysis of Slope Data

Slope Parameter	Value (%)	Interpretation
Maximum Slope	123.02	Highly unstable terrain, prone to landslides
Minimum Slope	0	Flat areas, limited erosion risk
Mean Slope	11.20	Moderate overall erosion risk
Median Slope	9.61	Balanced terrain distribution

These findings underscore the need for targeted interventions, including afforestation, terracing, and controlled land use, to mitigate erosion risks in vulnerable areas.

CONCLUSIONS

The Călina hydrographic basin demonstrates a diverse and dynamic environmental framework shaped by geological and climatic interactions. The high erosion rates and increasing human activities necessitate targeted conservation measures, such as afforestation, soil stabilization techniques, and controlled land use. Proper management of hydrographic resources and erosion control strategies will enhance environmental sustainability (*Petcu et al., 2003*). Future research should focus on long-term monitoring of hydro-geomorphological processes and the implementation of sustainable management practices to preserve the region's ecological integrity and agricultural productivity.

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RESEARCH ON THE EFFECT OF GROWTH REGULATORS ON THE MORPHOLOGICAL DEVELOPMENT OF SOYBEAN PLANTS UNDER CLIMATIC STRESS CONDITIONS

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Abstract

The earliest mentions of soybean cultivation are found in a botanical work dating from 2838 B.C., written by the chinese emperor Sheng-Nung Later, it is described in several other works and is considered the most important legume, while also being mentioned as one of the five sacred plants: rice, soybean, wheat, barley, and millet, which were essential for the existence of ancient chinese civilization. The entire biomass of the soybean plant can be utilized, but the seeds, rich in proteins (36-50%) and lipids (13-27%), are the most valuable part. Growth is the process of a stable and irreversible increase in the volume and weight of plant cells, tissues, and organs due to the continuous accumulation of dry matter resulting from biosynthetic processes, transformation, and deposition of the plant's own organic substances. Knowing the importance of the growth process, this paper presents the results obtained from a bifactorial experiment aimed at analyzing the influence of several growth regulators on the morphological development (plant height, number of leaves) of soybean plants under climatic stress conditions. The research was conducted in 2024 at A.R.D.S. Secuieni. According to the results obtained, the values of the morphological characteristics varied depending on both the variety and the treatment applied. Thus, the highest average plant height was 80.4 cm (Eugen variety, untreated), while the lowest was 62.6 cm (Eugen variety, treated with Ormet). The average number of leaves per plant ranged between 8.82 leaves per plant (Eugen variety, treated with Toprex) and 11.77 leaves per plant (Iris TD variety, untreated).

Key words: growth, drought, soybean

Soybean is a cultivated herbaceous plant belonging to the botanical family *Fabaceae*, subfamily *Faboideae*, genus *Glycine* L.. The most important and widely cultivated species of this plant is *Glycine max* L., synonymous with *Glycine hispida* (*Moench*.) *Maxim* (Mogârzan A., 2012).

The earliest references to soybean cultivation can be found in a botanical work dating back to 2838 B.C., written by the Chinese emperor Sheng-Nung. Later, it was described in several other works and was considered the most important legume, being mentioned as one of the five sacred plants: rice, soybean, wheat, barley, and millet, which were of essential importance for the existence of ancient Chinese civilization. The entire biomass of the soybean plant can be used, but the seeds are the most valuable, being rich in proteins (36-50%) and lipids (13-27%). The specific protein of soybeans is glycinin, a complex substance with a high degree of digestibility, with a water solubility index ranging from 61-92%. Soybean seeds are rich in proteins with very high nutritional value due to their high content of essential amino acids (Roman G. V. *et al,* 2011).

Growth is the process of stable and irreversible increase in the volume and weight of plant cells, tissues, and organs, due to the continuous accumulation of dry matter, resulting from biosynthetic processes, transformation, and deposition of organic substances (Jităreanu C. D., Toma L. D., 2007).

For plants to grow, they need adequate resources and conditions for these resources to be transformed into biomass. The photosynthetic absorption of CO2 is paramount, above any other factors in the morphological development of plants. Carbon can only be converted into biomass to the extent that chemical elements, temperature, or cell turgidity allow (Körner C., 2015).

The modification of cell turgor can be seen as a physical process governed by the mechanical properties of the cell wall and the osmotic properties of the protoplasm. Irreversible cell expansion is produced by creating a driving force

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for water absorption, decreasing turgor by reducing pressure in the cell wall. The biochemical mechanisms of these changes are controlled by internal factors (e.g., hormones) and external factors (e.g., light, drought stress) (Schopfer P., 2006).

Aiken R. M. and Smucker A. J. M. (1996) state that signals sent from the roots to the aerial parts of the plant, including abscisic acid, nitrogen flux, and cytokinins, modify the growth processes of the entire plant, including leaf expansion, stomatal behavior, and the biosynthesis of photosynthetic enzymes. It is believed that the signals from the roots reflect the water and nutrient supply conditions and soil characteristics, as perceived by the roots.

To meet the increasing demand for soybean cultivation, it is essential to introduce agrotechnical methods that enhance plant adaptability to various environmental conditions, improve resistance to abiotic stress, and increase productivity. Plant growth regulators play a crucial role in achieving soybean growth and development objectives, having a significant impact on yield, quality, and the plant's responses to stress conditions. The application of such products at optimal concentrations and stages of development can mitigate abiotic stress, contributing to an increase in both the quantity and quality of soybean yields. Recent studies suggest that growth regulators positively influence the morphology, physiology, and quality of soybean production, offering new insights into improving the morphological characteristics of the plants (Hanna Amoanimaa-Dede *et al,* 2022).

MATERIAL AND METHOD

The present paper includes the partial results of an experiment conducted in the experimental field of A.R.D.S. Secuieni in 2024, with the aim of analyzing the influence of certain growth regulators on the morphological traits of soybean plants. The experiment was bifactorial, where factor A was represented by the soybean variety, and factor B by the growth regulator. Factor A had two levels, represented by the Eugen and Iris TD varieties, while factor B had four levels: the untreated control and the products Moddus Evo, Ormet, and Toprex.

Both Eugen and Iris TD are Romanian soybean varieties patented by A.R.D.S. Turda. These varieties are early-maturing and belong to the OO maturity group. In terms of productivity and quality, the varieties have a production potential of over 4500 kg/ha, protein content of over 40%, and oil content of over 20%. Additionally, these varieties exhibit very good resistance to lodging, shattering, and downy mildew.

To achieve the research objectives, both soybean varieties were subjected to treatments using three commercial products with specific action as growth regulators.

The physiological action of these products consists in modifying the morpho-physiological traits. The length growth of the stem is reduced, particularly by limiting the elongation of the internodes. In contrast, they stimulate and accelerate the processes of flowering, fruiting, and fruit maturation. Additionally, they increase the plants' tolerance to unfavorable conditions (drought, salinity, diseases, and pests) by reducing cell extension and promoting tissue differentiation (Jităreanu C. D., Toma L. D., 2007).

Moddus Evo – a plant growth regulator containing 250 g/l of Trinexapac-ethyl. Applied to crops during the growth phase, it contributes to obtaining shorter, more robust plants with improved root systems. It is primarily absorbed through the leaves and stems, being translocated to the meristematic growth zones where it inhibits the elongation of the internodes

Ormet a growth regulator containing 480 g/l of Ethephon. This product is rapidly absorbed by plants and distributed to the meristematic areas, optimizing internode elongation and reducing the risk of lodging. It also promotes stem thickening, increases leaf area, and facilitates harvest

Toprex – a product that combines the benefits of a fungicide with those of a growth regulator. It contains two active substances: 125 g/l of Paclobutrazol (growth regulator) and 20 g/l of Difenoconazole (fungicide). These substances are rapidly absorbed by the plants and transported through the xylem, contributing to height control, healthy root system development for better stability, and crop uniformity

The experiment was set up using the split-plot method in 3 repetitions on a faeoziom soil (typical cambic chernozem), characterized by very good phosphorus and potassium availability, moderate active humus content, and low nitrogen availability (*table 1*). The experiment was established by adhering to all the technological stages specific to soybean cultivation, with the treatments applied during the flowering phenophase (BBCH 51 - 55) being the differentiating factor. Measurements regarding the morpho-physiological traits were carried out seven days after the treatment was applied, by harvesting five whole plants from each variant in the field.

To highlight the influence of the applied products, measurements were taken on the plant height and weight, the number and weight of leaves, and the number of inflorescences per plant.

Table 1

Characterization of the soil type on which the experiments were located

Characterization of the soil type	A.R.D.S. Secuieni	
	phaeozem (chernozem) cambic	
	Value	Interpretation
pH_2O	7,29	neutral
Texture	40	muddy
$CaCO_3$ (%)	0,91	slightly chalky
Humus Content	2.3 %	well
Total Nitrogen Content (mg/kg)	9,4	poorly supplied with nitrogen
Phosphorus Content (mg/kg)	189	very well supplied with mobile phosphorus
Potassium Content (mg/kg)	304	very well supplied with mobile potassium

RESULTS AND DISCUSSIONS

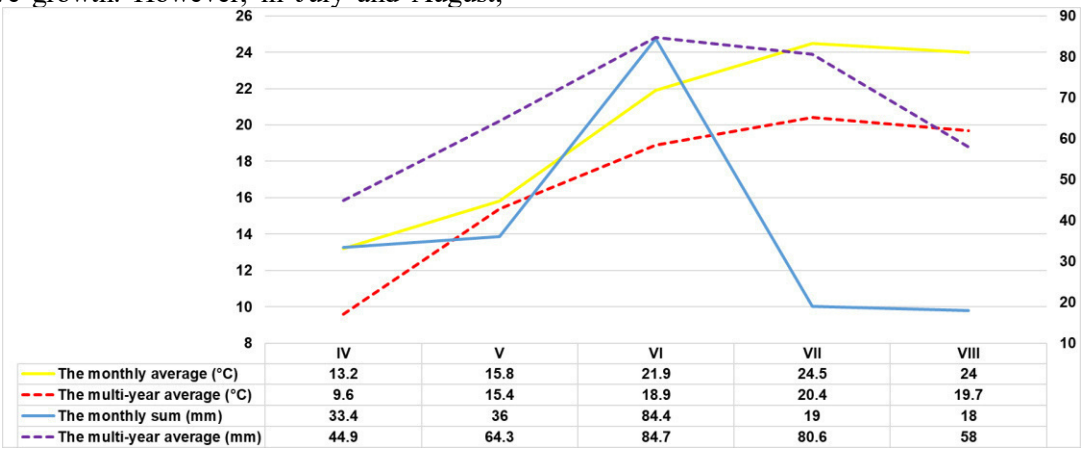
The agricultural year 2023-2024 was highly atypical for field crops, especially for soybeans, which experienced a growing season characterized by unusually warm and very dry conditions (*figure 1).*

In April and May, temperatures were above the multi-annual average, which favored rapid germination and an accelerated development cycle during the initial growth phase.

In June, both temperature and precipitation were close to optimal values for soybeans, positively influencing flower formation and vegetative growth. However, in July and August, the high temperatures and extremely low rainfall created a stressful environment for the soybean crop. This water deficit, combined with temperatures above 24°C, led to flower abortion and poor pod formation, limiting fruiting.

Throughout the growing season, rainfall was unevenly distributed, and the total amount was below the multi-annual average, with the exception of August.

A characterization of the growing season from a pluviometric perspective, as shown in *figure 1*, reveals that the period was very dry, having significant negative effects on the growth and development of soybean plants.



	IV	V	VI	VII	VIII
The monthly average (°C)	13.2	15.8	21.9	24.5	24
The multi-year average (°C)	9.6	15.4	18.9	20.4	19.7
The monthly sum (mm)	33.4	36	84.4	19	18
The multi-year average (mm)	44.9	64.3	84.7	80.6	58

Figure 1 **The climatic conditions recorded at A.R.D.S. Secuieni, 2024**

The growth of plant organs occurs due to the expansion of cells and tissues. The entire process begins at an embryonic stage, located in the meristems (called meresis), continues with the elongation of the formed cells (called auxesis), and ends with the differentiation of the typical anatomical structure. Plant organs grow both in length and thickness.

The growth process of plants or their different organs can be measured through biometric methods (measuring changes in organ size over time) and gravimetric methods (measuring changes in the fresh or dry weight of different plant organs over time).

By conducting assessments of the morphological development of soybean plants, we can understand how plants adapt to different environments and how growing conditions can be optimized to maximize agricultural production.

Growth regulators can significantly influence morphological and physiological characteristics, preventing excessive growth or

stem elongation, promoting the formation of an optimal foliage system, improving the synchronization of flowering, and promoting uniform fruiting.

Analyzing some morphological aspects during the soybean flowering phenophase, it can be seen from figures 2-4 that the average values varied significantly depending on both the cultivated variety and the applied treatment.

Figure 2 highlights that the applied growth regulators had a clear impact on the morphological characteristics of the plants.

For the Eugen variety, the tallest plants were recorded in the untreated variant (80.4 cm), with a similar value observed in the Moddus Evo-treated variant (79.07 cm); at the opposite end, the shortest plants measured 62.6 cm (Ormet). The total plant weight followed the same trend, with values ranging from 73.73 g (untreated control) to 55.58 g (Ormet).

The influence of treatments on the average number of leaves per plant was positive. In two variants (Moddus Evo and Ormet), where commercial products were applied, values exceeded that of the control (9.07), with the highest average value being 10.47 (Ormet).

Additionally, the average leaf weight per plant was influenced by the applied treatments, with average values ranging from 40.22 g (control) to 28 g (Ormet).

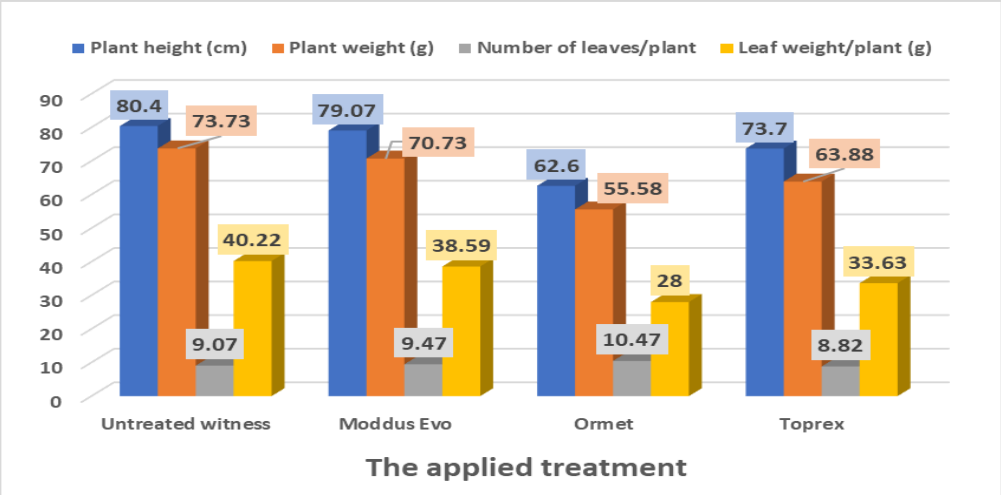


Figure 2 **The influence of treatment on the morphological characteristics of the Eugen variety**

For the Iris TD variety, the applied commercial products exhibited similar effects as those observed in the Eugen variety. The tallest plants were recorded in the control group, measuring 73.6 cm. In the treated variants, height was slightly reduced by Moddus Evo (70.27 cm), followed by Toprex (67.67 cm) and Ormet (66.13 cm), suggesting that the treatments reduced height growth, which is a common effect of growth regulators.

The plant weight remained relatively constant, with values exceeding 70 g, except for the variant treated with Ormet (64.47 g). The control group had the highest weight (73.6 g), closely followed by the Toprex-treated variant (72.61 g).

The average number of leaves per plant varied within narrow limits, ranging from 11.77 leaves/plant (control) to 10.4 leaves/plant (Ormet). Similar to the Eugen variety, the highest leaf weight per plant was also recorded in the control group for the Iris TD variety (36.47 g), while the lowest value was obtained in the Ormet-treated variant (28.41 g) (*figure 3*). Growth regulators had different effects on the average number of inflorescences per plant, depending on the soybean variety. The control group recorded an average of 13.87 inflorescences per plant for the Eugen variety, while the Iris TD variety had a slightly higher value of 14.4 inflorescences per plant.

Moddus Evo had a favorable effect on inflorescences in both varieties compared to the control. For the Iris TD variety, the highest average number of inflorescences per plant (15.57) was recorded among all variants, indicating a strong stimulation of the flowering process for this variety.

Ormet was also effective in increasing the number of inflorescences, with average values of 14.2 for the Eugen variety and 15.53 inflorescences per plant for the Iris TD variety.

The commercial product Toprex showed a contrasting effect, as it reduced the average number of inflorescences in the Eugen variety (12.45) but stimulated it in the Iris TD variety (15.47) compared to the untreated variants (*figure 4*).

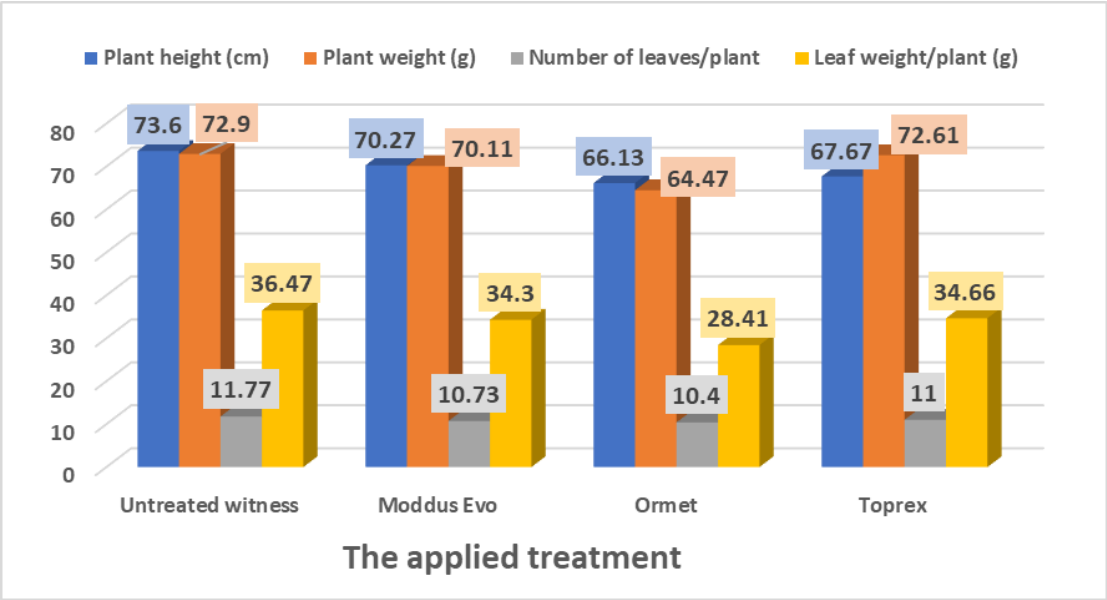


Figure 3 **The influence of treatment on the morphological characteristics of the Iris TD variety**

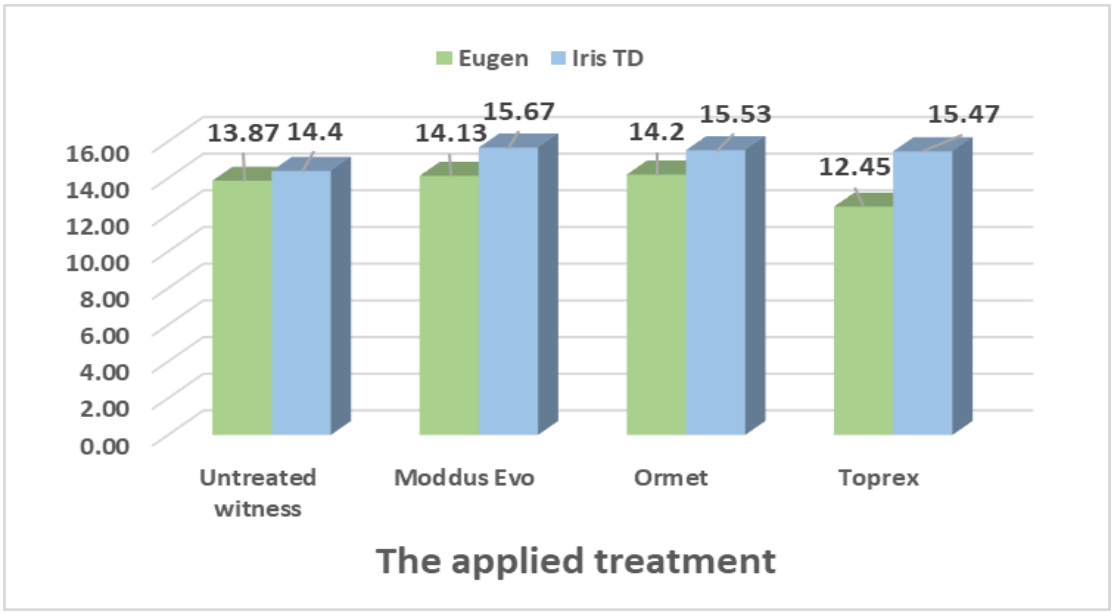


Figure 4 **Influence of treatment on the average number of inflorescences per plant.**

CONCLUSIONS

From a climatic perspective, the agricultural year 2023-2024 was completely atypical for field crops, and the growing period for soybeans was characterized by warmer and very dry conditions.

Treatments with Moddus Evo and Toprex resulted in a slight reduction in plant height compared to the untreated control; however, this decrease did not significantly affect the overall development of the plants. Thus, the highest average plant height was 80.4 cm (control for the Eugen variety), while the lowest was 62.6 cm (Ormet for the Eugen variety).

The weight of the plants was relatively close to the untreated control in the variants sprayed with Moddus Evo and Toprex, suggesting that these products allowed for balanced biomass development. In the Iris TD variety, although the decrease in height was more pronounced, the weight of the plants increased to 72.61 g, and the average number of leaves (11 leaves per plant) remained fairly close to the control (11.77 leaves per plant).

The application of growth regulators led to a moderate reduction in height; however, this was compensated by a slight increase in the average number of leaves, from 9.07 (control for the Eugen variety) to 9.47 leaves per plant (Moddus Evo for the Eugen variety), indicating denser vegetative development.

Leaf weight varied within a limit of 12.22 g, with average values ranging from 40.22 g (control for the Eugen variety) to 28 g (Ormet for the Eugen variety).

The results clearly show a positive effect of growth regulators on the formation of inflorescences. The greatest impact on the average number of inflorescences for both varieties was observed with Moddus Evo and Ormet, with maximum values of 15.67 (Moddus Evo for the Iris TD variety) and 15.53 inflorescences per plant (Ormet for the Iris TD variety).

This increase in the number of inflorescences indicates an optimization of resources towards fruiting, which can enhance the production potential of soybean plants.

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FUNGAL LOAD ASSESSMENT OF WHEAT KERNELS UNDER THE ACTION OF SOME PHYTOSANITARY PRODUCTS

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Abstract

The quality of the wheat seeds determine the production and quality of the grains final agricultural product. Crop losses due to fungal contamination represent a significant problem for many cereals all over the world. Especially for cereals like wheat, at wich for example different toxigenic *Fusarium* spp. are frequently found as contaminants. Thus, in order to obtain the production of crops free from fungal infections it is necessary a permanent evaluation of the seeds before and after harvest but especially before sowing, even if it is mandatory the treatment of the seeds. Tested material was represented by kernels of Miranda wheat variety to which were applied a number of 14 variant treatments. Therefore, identified fungi genera on Miranda wheat variety kernels were *Alternaria, Aspergillus, Fusarium, Penicillium*, and *Rhizopus*. The incidence and percentage of the identified micromycetes was different for each treatment variant that was applied to the kernels.

Key words: fungi, wheat, treatment, kernel

Seed healthy testing is vital to have good germination, healthy seedlings and plant population. Early identification of unhealthy seeds is important for timely management of diseases control. The objective of seed testing is to identify the quality of material seeds that can be sown in the field, which ultimately results in production of healthy food, healthy seed crops, and improved yields in terms of quality and quantity.

The wheat crop is considered one of the most important worldwide in the world. Wheat plants are susceptible to a variety of diseases throughout the growth season and storage period, resulting in a drop in productivity and grain quality. One of the significant risks associated with cereal is consumption in the presence of mycotoxins produced by the development of fungi (Richard J. L. and Payne J. A., 2003).

Fungicides and insecticides, polymers and micronutrients can improve the agronomic performance of crops through seed treatment. The use of polymers improves seed adhesion, distribution, and coloration without impairing its quality and performance (Bays *et al.,* 2007).

MATERIAL AND METHOD

The study were conducted on "Ion Ionescu de la Brad" Iasi University of Life Sciences (IULS), Plant Protection Department.

The investigations carried out focused on testing the biological efficacy of fungicidal treatments on the autumn wheat variety/genotype Miranda, provided from a single location, harvested in 2023, on which were applied a number of 12 variant treatments and untreated. For the effective determination of the efficacy of the products, 8 fungicides, 1 insecticide, and 1 biostimulator were studied, constituting 13 treatments.

Evidence of the effectiveness of treatments applied to the seed or conducted analyses in 2 control variants, the first uncleaned and the second cleaned 5 minute with KOH 10%.

The data were processed using the ARMdata (Agriculture Research Management). The function for efficacy determining had the following form:

$$E.b.\% = \frac{I.m. - I.e.}{I.m.} * 100, were:$$

E.b. – biological efficacy.
I. m. – Intensity of the disease in untreated.
I. m. – Intensity of the disease in treatment (Dospehov, B.A.1979).

The function for frecvency analysis had the following form (Naqvi *et al*., 2013):

$$PF\% = \frac{.No.of\ seeds\ on\ which\ \ fungus\ appears}{Total\ number\ of\ seeds} * 100$$

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The treatments were: Difend[2], Redingo 100FS[3], Bariton Super[4], Redigo Pro 170FS[5], Difend Extra[6], Orius 6WG[7], Celest Extra[8], Orius 6WG + Signal 300ES[9], Rancona[10], Rancona + Signal 300ES[11], Ympact + Redigo 100FS[12] and Ympact + Redigo Pro 170FS[13] (table 1). The treatment were applied with laboratory seed treated Hege 11. The fungicides products have different active substances difenoconazole, protioconazol, tebuconazole, fludioxonil and ipconazole. Insecticide is cipermetrin and biostimulator composition is Cu, Mn, Mo, and Zn (table 1).

To determinate the percenatge (%) of seed infected the moist chamber method was used. (Mathur S. B, Kongsdal O., 2003). Each sample of 300 seeds was put on filter paper, moistened with distilled water, incubated at 22°C for 7 days (Hatman M. *et al,* 1986). After that, the micromycetes identification was done based on microscopic preparations that were analyzed under the optical microscope. The fungal load determination from the surface of the seeds was based on the showed morphological characteristics and some specialized scientific guides (Ellis M. B., Ellis P. J., 1985).

Table 1

Experimental schema regarding the testing of the effectiveness of seed treatment products

Nr. Treat.	Product	Composition s.a	Dose u.m.
1	UNTREATED	-	-
1	UNTREATED STERIL	-	-
2	DIFEND	*30 g/l difenoconazol*	2,00 l/t
3	REDIGO 100 FS	*100 g/l protioconazol*	1,00 l/t
4	BARITON SUPER 97,5 FS	*37.5 g/l fludioxonil*	1,00 l/t
		50 g/l protioconazol	
		10 g/l tebuconazol	
5	REDIGO PRO 170 FS	*150 g/l protioconazol*	0,50 l/t
		20 g/l tebuconazol	
6	DIDEND EXTRA	*25 g/l difenoconazol*	2,00 l/t
		25 g/l fludioxonil	
7	ORIUS 6 WG	*60 g/l tebuconazol*	0,15 l/t
8	CELEST EXTRA	*25 g/l fludioxonil*	1,50 l/t
		25 g/l difenoconazol	
9	ORIUS 6 WG + SIGNAL 300 ES	*60 g/l tebuconazol*	0,15 l/t
		300 g/l cipermetrin	2,00 l/t
10	RANCONA	*15 g/l ipconazol*	1,00 l/t
11	RANCONA + SIGNAL 300 ES	*15 g/l ipconazol*	1,00 l/t
		300 g/l cipermetrin	2,00 l/t
12	YMPACT + REDIGO 100 FS	*5,782 % Cu, Mn, Mo, Zn*	10,00 l/t
		100 g/l protioconazol	1,00 l/t
13	YMPACT + REDIGO PRO 170 FS	*150 g/l protioconazol*	0,50 l/t
		20 g/l tebuconazol	
		5,782 % Cu, Mn, Mo, Zn	10,00 l/t

RESULTS AND DISCUSSIONS

Each treatment variant was analyzed separately and were isolated from the seeds of 12 treatment including untreated. Following the observations and identification of micromycetes made, the next genus of fungi were determined: *Aspergillus, Penicillium, Fusarium, Alternaria,* and *Rhizopus* (table 2).

According to untreated treatment, high values were identified by genus *Alternaria* by 21,00%. Medium values on genus *Penicillium* by 8,00%, *Rhizopus* by 6,33%, and *Aspergillus* by 5,00%. The lowest value was recorded in the genus *Fusarium* by 1,67% (table 2).

Alternaria genus is not harmful for wheat seed because it does not greatly harm the germination (Morar O.A., 2009). It was identified by the large conidia, oval or ellipsoidal in shape,

their color varying from light brown to dark brown, multicellular, with longitudinal, transverse, and sometimes oblique septa. They were identified in all samples, the highest value being recorded in the untreated sample, by 21,00%, while the value of the treated samples differs with 20,67% and 11,67% respectively.

The *Aspergillus* genus was identified with a frequency range of 5,00% on the untreated and 4,33% on the sterilized untreated. The fungi of the genus *Penicillium* are commonly found in grain storage and develop aflatoxins, ochratoxins, and patuline. This fungus forms conidiophores from digitally branching hyphae, with large verticies resembling a skeleton hand. The value on the fungus frequency was recorded at 8,00%. High levels of seed infection can significantly reduce seed germination

Fusarium produces a number of mycotoxins of diverse chemical structures. The infections can start in the field and develop even in grain deposits. It produces mycotoxins classified into two chemical classes: trichothecenes and zearalenone. Among trichothecenes, we mention vomitoxin (deoxynivalenol / DON) toxic in the diet of humans and animals. The mycelium of the genus *Fusarium* fungi has been identified only on untreated sample 1,67%.

The most common species of the genus *Rhizopus* in cereals contaminated by aflatoxin are *Rhizopus nigricans* and *Rhizopus stolonifer*. *Rhizopus* sp. was identified and the highest percentage 6,33%

High levels of seed infection with fungi from the genera *Aspergillus, Fusarium*, and *Penicillium* can significantly reduce seed germination.

According to treatments applied to seed, comparing to the control, we observe a reduction of biological frequency in the case of all agents.

We encounter a high frequency in the case of 2 treatments, Rancona[10] 15,33% with 4 species of fungi, and Difend[2] 13,33% with 3 species. The highest frequency is attributed to the genus *Alternaria,* Rancona[10] 8,67% and Difend[2] 9,33% and medium frequency on *Aspergillus*, and *Penicillium* fungi. It also evident from the result that treatment with one active substance have a higher biological frequency of fungi development. This may be due to the widespread use of applied products and the beginning of the emergence of resistant strains.

Table 2

Biological frequency (%) of phytopathogenic agents

Nr. Treat	Product	Biological frequency (%)					Average frequency %
		Aspergillus	*Penicillium*	*Alternaria*	*Fusarium*	*Rhizopus*	
1	UNTREATED	5,00	8,00	21,00	1,67	6,33	42,00
1	UNTREATED STERIL	4,33	2,33	18,33	1,33	3,33	29,67
2	DIFEND	1,67	2,33	9,33	0,00	0,00	13,33
3	REDIGO 100 FS	2,33	1,33	2,33	0,00	0,00	6,00
4	BARITON SUPER 97,5 FS	1,67	0,67	0,33	0,00	0,00	2,67
5	REDIGO PRO 170 FS	1,67	1,00	1,33	0,00	0,00	4,00
6	DIFEND EXTRA	1,67	1,67	0,00	0,00	0,00	3,33
7	ORIUS 6 WG	1,33	0,33	1,33	0,00	0,00	3,00
8	CELEST EXTRA	1,67	1,33	1,67	0,00	0,00	4,67
9	ORIUS 6 WG + SIGNAL 300 ES	0,33	1,00	3,67	0,00	0,00	5,00
10	RANCONA	2,00	2,33	8,67	0,00	2,33	15,33
11	RANCONA + SIGNAL 300 ES	1,33	4,33	2,33	0,00	0,00	8,00
12	YMPACT + REDIGO 100 FS	0,67	0,00	1,00	0,00	4,67	6,33
13	YMPACT + REDIGO PRO 170 FS	0,67	0,00	1,00	0,00	0,67	2,33

Table 3

Efficacy (%) of seed tretament on phytopathogenic agents

Nr. Treat	Product	Efficacy %					Average efficacy%
		Aspergillus	*Penicillium*	*Alternaria*	*Fusarium*	*Rhizopus*	
1	UNTREATED	-	-	-	-	-	-
1	UNTREATED STERIL	-	-	-	-	-	-
2	DIFEND	66,67	70,83	55,56	100,00	100,00	68,25
3	REDIGO 100 FS	53,33	83,33	88,89	100,00	100,00	85,71
4	BARITON SUPER 97,5 FS	66,67	91,67	98,41	100,00	100,00	93,65
5	REDIGO PRO 170 FS	66,67	87,50	93,65	100,00	100,00	90,48
6	DIFEND EXTRA	66,67	79,17	100,00	100,00	100,00	92,06
7	ORIUS 6 WG	73,33	95,83	93,65	100,00	100,00	92,86
8	CELEST EXTRA	66,67	83,33	92,06	100,00	100,00	88,89
9	ORIUS 6 WG + SIGNAL 300 ES	93,33	87,50	82,54	100,00	100,00	88,10
10	RANCONA	60,00	70,83	58,73	100,00	63,14	63,49
11	RANCONA + SIGNAL 300 ES	73,33	45,83	88,89	100,00	100,00	80,95
12	YMPACT + REDIGO 100 FS	86,67	100,00	95,24	100,00	26,28	84,92
13	YMPACT + REDIGO PRO 170 FS	86,67	100,00	95,24	100,00	89,47	94,44

Reporting on the biological frequency of the agents, the highest efficacy is recorded by the micromycetes *Alternaria* followed by *Penicillium* and *Aspergillus*.

CONCLUSIONS

Poor management of seeds can lead to rapid degradation, resulting in reduced germination and nutritional value. During storage, wheat seeds are subjected to different fungi. The most common are *Penicillium* and *Aspergillus*, but because of climatic influence occurring during the vegetable period, also *Alternaria, Fusarium* and *Rhizopus* can appear. From an agronomic perspective, the most important are temperature, water, interaction with insects, harvest time and storage conditions.

The high frequency was recorded at treatment Rancona[10] 15,33% and Difend[2] 13,33% The highest frequency is attributed to the genus *Alternaria* 8,67%[10] – 9,33%[2] and medium frequency on *Aspergillus*, and *Penicillium* fungi.

The analyses performed show the health status of the wheat seeds intended for sowing as well as the importance of using phytosanitary products.

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AGRAS T30 DRONE SPRAYING EFFICIENCY AND COST ANALYSIS ON SUNFLOWER FUNGICIDE APPLICATION

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Abstract

This study presents a comparative analysis of the application of Orius fungicide on a 200-hectare sunflower field using the DJI Agras T30 drone for 100 ha and the John Deere 4630 sprayer for 100 ha. The research evaluates both methods in terms of resource consumption, operational costs, application efficiency, and environmental impact. The analysis focuses on application efficiency, dosage, and economic aspects to identify the advantages and limitations of each method. The results indicate that drone application achieves superior precision with reduced chemical and water usage, while the tractor-based sprayer offers speed advantages for large-scale operations. These findings provide actionable insights for sunflower farmers aiming to optimize crop protection practices. Results indicate that the Agras T30 drone, employing ultra-low-volume spraying, required significantly less spray solution (1,100 liters) compared to the John Deere 4630 sprayer (15,100 liters), thereby demonstrating greater resource efficiency. Furthermore, the drone exhibited superior precision, minimizing chemical drift and promoting sustainable agricultural practices. However, the John Deere 4630 sprayer completed the application in half the time (3.5 hours compared to 7 hours), highlighting its suitability for time-sensitive, large-scale operations. This study underscores the advantages and limitations of each method, offering critical insights for optimizing fungicide application strategies based on specific agronomic and operational requirements.

Key words: drone spraying efficiency, precision agriculture

The application of agrochemicals, such as fungicides, is a vital practice in modern agriculture to protect crops from diseases and enhance yield. Traditionally, this has been achieved using ground-based machinery such as tractor-mounted sprayers. However, the advent of unmanned aerial vehicles (UAVs), commonly known as drones, has introduced a transformative approach to agricultural spraying (Patel V. et al, 2023). Drones have gained significant attention in precision agriculture due to their ability to provide targeted applications, reduce input waste, and minimize environmental impact.

Drone spraying systems, such as the DJI Agras T30, are equipped with advanced technologies, including GPS-guided navigation, automated flight paths, and variable-rate nozzles. These features enable drones to achieve highly precise spraying, reducing overspraying and chemical drift compared to conventional methods. Drones are particularly useful in challenging terrains or small, irregularly shaped fields where large machinery cannot operate efficiently. Additionally, their ability to apply ultra-low volumes (ULV) of chemicals makes them a resource-efficient choice, using significantly less water compared to traditional sprayers (Ahmed K. et al., 2022).

The adoption of drone technology also aligns with the growing demand for sustainable farming practices. By minimizing chemical runoff and optimizing input use, drones help mitigate the environmental impact of agricultural activities. Moreover, drones offer a level of flexibility and speed in operations, allowing farmers to respond quickly to emerging pest or disease outbreaks.

Despite these advantages, drone spraying also presents challenges, including limited tank capacity, battery life constraints, and regulatory considerations in some regions. Comparing this innovative approach with established methods, such as tractor-mounted sprayers, is essential to understand its practical benefits and limitations (Rodríguez F., Pérez C., 2021). This study contributes to this understanding by comparing the Agras T30 drone and the John Deere 4630 sprayer in the context of sunflower fungicide application, focusing on key parameters such as efficiency, cost, and environmental sustainability.

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Traditional tractor-mounted sprayers, such as the John Deere 4630, have been widely adopted for their ability to cover large areas quickly (Media N., 2018). However, recent advances in agricultural technology have introduced drones like the DJI Agras T30, offering a more precise and environmentally friendly alternative. This paper compares the use of the Agras T30 and the John Deere 4630 for applying Orius fungicide on sunflowers over 100 hectares each. The study evaluates the two methods in terms of fungicide dosage, water consumption, cost-effectiveness, and operational efficiency.

MATERIAL AND METHOD

The study was conducted on a 200-hectare sunflower field located in a temperate climate zone from NE Romania. The sunflowers were at the early flowering stage, a critical period for fungicide application to prevent common diseases. Orius fungicide, containing the active ingredient tebuconazole, was chosen due to its effectiveness against fungal infections in sunflowers. The recommended dosage was 1 liter per hectare.

Two spraying systems were evaluated: the DJI Agras T30 drone and the John Deere 4630 tractor-mounted sprayer. The Agras T30 drone has a 30-liter tank capacity and operates at an application rate of 10 liters per hectare, including water and fungicide. It covers approximately 15 hectares per hour at a flight speed of 6 m/s. The John Deere 4630 has a tank capacity of 3,000 liters and applies at a rate of 150 liters per hectare. It covers about 30 hectares per hour at a speed of 12-15 km/h. The drone required a total application time of 7 hours for the field, including refilling and battery charging, while the sprayer completed the task in 3.5 hours, including refilling intervals.

Data collection focused on operational costs, fungicide and water usage, application efficiency, and environmental impact. Costs included labor, fuel or electricity, and maintenance. Efficiency was evaluated by comparing chemical drift, precision, and coverage rates.

The DJI Agras T30 (*figure 1*) is an advanced agricultural drone designed to enhance the efficiency and precision of crop spraying operations. Equipped with a 30-liter spraying tank, it facilitates extensive coverage, making it suitable for large-scale farming activities. The drone features 16 nozzles and a high-flow plunger pump, enabling a maximum spray rate of 7.2 liters per minute. This configuration ensures uniform distribution of pesticides or fertilizers across the field.

One of the standout features of the Agras T30 is its spherical omnidirectional obstacle avoidance radar. This system provides comprehensive detection in horizontal and overhead directions, enhancing operational safety by allowing the drone to navigate complex terrains and avoid obstacles effectively.

The drone's design includes adjustable arms and branch-targeting technology, which improve penetration in dense canopies, ensuring thorough application of agrochemicals.

This capability is particularly beneficial for crops like fruit trees, where even coverage is crucial.

Figure 1 **Agras T30 drone**

In terms of efficiency, the Agras T30 can cover up to 40 acres per hour, operating at a flight speed of up to 15.6 miles per hour. Its flight time extends up to 20.5 minutes per battery charge, depending on load and environmental conditions.

The drone is built to withstand harsh agricultural environments, featuring an IP67 rating for water and dust resistance. Its foldable design enhances portability, allowing it to be easily transported between fields.

Overall, the DJI Agras T30 represents a significant advancement in agricultural drone technology, offering farmers a reliable and efficient tool for modern farming practices.

The John Deere 4630 Sprayer (*figure 2*) is engineered to deliver efficient and precise agrochemical applications across extensive agricultural fields. It is powered by a 6.8-liter John Deere PowerTech Plus engine, producing 165 horsepower, which enables effective operation in diverse field conditions.

Equipped with an 80-foot (24-meter) boom, the sprayer features a five-section configuration with polypropylene plumbing, ensuring durability and chemical resistance.

The solution tank has a capacity of 600 gallons (2,271 liters), complemented by a 70-gallon (265-liter) rinse tank, facilitating extensive coverage and efficient cleaning between applications.

The 4630 Sprayer incorporates advanced precision agriculture technologies, including the GreenStar™ 2 system with the GS2 1800 Display. This system integrates functions such as SprayStar, Swath Control Pro, and AutoTrac, enabling operators to manage application rates, reduce overlap, and enhance steering accuracy.

Figure 2 **John Deere 4630 Sprayer**

Designed for operator comfort and safety, the sprayer features a spacious cab with climate control and ergonomic controls, reducing fatigue during prolonged operations.

The machine's full-time four-wheel drive and optional traction control provide enhanced maneuverability and stability across various terrains.

Overall, the John Deere 4630 Sprayer combines robust performance with advanced technological features, making it a reliable choice for large-scale farming operations seeking efficiency and precision in crop protection practices.

RESULTS AND DISCUSSIONS

The drone required significantly less water than the sprayer due to its ultra-low-volume (ULV) spraying capability. For 100 hectares, the drone used 100 liters of Orius fungicide diluted in 1,000 liters of water, totaling 1,100 liters. In contrast, the sprayer used the same 100 liters of fungicide but required 15,000 liters of water for dilution, totaling 15,100 liters (*table 1*).

This difference highlights the drone's efficiency in resource usage, reducing the overall environmental footprint.

The total operational costs for the Agras T30 drone were €1,380, compared to €1,950 for the John Deere 4630 (*table 2*). Labor costs were higher for the drone (€200) due to the need for frequent refilling and battery management.

However, the drone incurred significantly lower costs in fuel (€30 vs. €400) and water (€50 vs. €150). Maintenance costs were also lower for the drone (€100 vs. €300), making it the more economical option despite its longer operation time.

Table 1

Results regarding the dosage and water consumption

Machine	Fungicide (liters)	Water (liters)	Total Volume (liters)
Agras T30 Drone	100	1,000	1,100
John Deere 4630	100	15,000	15,100

The drone demonstrated superior precision in fungicide application, minimizing chemical drift and ensuring even coverage across the field. This precision reduces overspraying and potential environmental contamination. The sprayer, while faster, was less precise, increasing the likelihood of chemical wastage and uneven application. The drone's ability to operate in hard-to-reach areas further enhances its versatility compared to the tractor-mounted sprayer.

Table 2

Results regarding the economical analysis

Cost Component	Agras T30 Drone (€)	John Deere 4630 (€)
Labor	200	100
Fungicide	1,000	1,000
Water	50	150
Fuel/Electricity	30	400
Maintenance	100	300
Total Cost	1,380	1,950

The sprayer completed the task in 3.5 hours, making it twice as fast as the drone, which required 7 hours due to smaller tank capacity and battery recharge intervals, meaning also a lot of traveling patterns (*figure 3*). This speed advantage makes the sprayer more suitable for large-scale operations where time is a critical factor. However, the trade-off in precision and environmental impact should be considered.

The drone's reduced water usage and lower chemical drift contribute to a smaller environmental footprint. It is particularly advantageous in areas where water conservation is a priority. The sprayer, while efficient in time, presents higher risks of chemical runoff and environmental damage due to its high water usage and potential for overspraying.

Figure 3 **T30 drone map pattern**

CONCLUSIONS

The comparison between the Agras T30 drone and the John Deere 4630 sprayer for applying Orius fungicide on a 100-hectare sunflower field highlights distinct advantages and limitations for each method. The drone offers precision, reduced chemical and water usage, and lower operational costs, making it ideal for resource-conscious and environmentally sustainable farming practices. In contrast, the sprayer excels in speed and efficiency for large-scale operations but incurs higher costs and environmental risks. Farmers should consider their specific operational needs, field conditions, and sustainability goals when selecting a spraying method. For precision and resource conservation, the Agras T30 is recommended, whereas the John Deere 4630 is preferable for time-sensitive, large-scale applications.

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THE ROLE OF GPS TECHNOLOGY IN ENHANCING SOIL PREPARATION EFFICIENCY AND SUSTAINABILITY

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Abstract

This research investigates the impact of GPS guidance on the operational efficiency of the Horsch Tiger 3 MT across a 10-hectare field, with a specific focus on fuel consumption and time management. The study reveals that GPS technology significantly enhances efficiency, reducing operational time by 23.5% (5.2 hours with GPS versus 6.8 hours without GPS) and fuel consumption by 20.8% (14.5 liters per hectare with GPS versus 18.3 liters per hectare without GPS). Moreover, GPS eliminated field overlaps entirely (0%), in contrast to an 8% overlap observed during non-GPS operations, thereby ensuring precise and uniform field coverage. These improvements translate into measurable cost savings, with a reduction in fuel expenses, alongside environmental benefits from decreased fuel usage. The findings underscore the critical role of GPS technology in optimizing agricultural operations, promoting sustainable resource utilization, enhancing productivity, and supporting the economic viability of modern farming practices. This study underscores the importance of adopting precision agriculture practices to enhance farm profitability and sustainability.

Key words: GPS, precision agriculture, soil cultivation

Enhancing soil preparation efficiency and sustainability through the integration of GPS technology represents a transformative shift in modern agriculture. This approach, known as precision agriculture, leverages advanced technological tools to optimize farming practices, promoting soil health while minimizing environmental impacts. As global agricultural demands grow, the significance of adopting efficient and sustainable methods becomes increasingly critical in addressing food security and ecological challenges (Smith J., Robinson L., 2021).

Notably, precision agriculture enhances soil health and fertility by employing variable rate technology (VRT) that enables farmers to apply fertilizers and nutrients with precision. This targeted application, supported by extensive data from soil sensors and satellite imagery, not only boosts productivity but also prevents erosion and promotes carbon sequestration essential in mitigating climate change effects (Bora G.C. *et al,* 2012).

The importance of healthy soils is further underscored by their role in increasing organic matter, which contributes to greater agricultural resilience and sustainability.

In addition to promoting soil health, precision agriculture significantly reduces chemical usage, thereby fostering environmentally sustainable practices. By accurately analyzing soil moisture and crop needs, farmers can optimize irrigation and minimize chemical runoff into water bodies, protecting aquatic ecosystems.

These technologies enable more precise delivery of water and nutrients, thereby maintaining biodiversity and supporting beneficial species while effectively managing pests and weeds through targeted application of pesticides and herbicides.

The incorporation of GPS technology has also revolutionized resource management and machinery efficiency in agriculture. GPS-guided equipment streamlines field operations, reducing fuel consumption and lowering the overall environmental foot- print of farming practices (D'Antonio P. *et al,* 2023). Predictive modeling enhances planning, which leads to better crop management and minimizes risks associated with crop loss. Ultimately, by optimizing crop production, precision agriculture not only preserves surrounding biodiversity but also reduces the need for deforestation, thereby promoting a sustainable farming ecosystem (D'Antonio P. *et al,* 2023).

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Efficient soil preparation is critical in modern agriculture, as it directly impacts crop yield and farm sustainability (Grisso R.D. *et al,* 2022).

The Horsch Tiger 3 MT, a heavy-duty cultivator, is widely used for tillage on large fields. Integrating GPS guidance with such equipment is a hallmark of precision agriculture, offering potential benefits in reducing overlap, optimizing coverage, and minimizing resource wastage. This study aims to compare the performance of the Horsch Tiger 3 MT over 10 hectares with and without GPS guidance. The results provide actionable insights for farmers considering investments in GPS technology.

This paper presents the advantages of using GPS technology, even for soil-related works. This technology ensures that tractors and other machinery follow precise paths, minimizing overlap and missed areas, reduces the time required for soil preparation by guiding machinery efficiently, more efficient operations that lead to less wear on machinery and reduces over-tilling, which can lead to soil erosion and degradation.

This study evaluates the operational efficiency of the Horsch Tiger 3 MT over a 10-hectare field with and without GPS guidance. The analysis focuses on fuel consumption and time requirements as performance indicators. Results demonstrate that GPS significantly improves resource efficiency, reducing both fuel consumption and operational time. These findings underscore the utility of precision agriculture tools in modern farming practices.

MATERIAL AND METHOD

The study was conducted in two phases. In Phase 1, the Horsch Tiger 3 MT was operated over a 10-hectare plot equipped with a GPS guidance system. The operator was trained to ensure effective use of the GPS for optimal coverage and minimal overlap.Time and fuel consumption data were meticulously recorded during this phase. In Phase 2, the same equipment was used on another 10-hectare plot, but without GPS assistance. Manual guidance relied on the operator's skill and experience to ensure the field was covered adequately.

Data on time and fuel consumption were collected under the same conditions as in Phase 1, with variables such as soil type, equipment settings, and ambient conditions held constant to ensure comparability.

The research was conducted using a 930 Fendt vario tractor with 300 hp and an implement for soil preparation, Horsch Tiger 3 MT with a work width of 3 m (*figure 1*).

The work depth of the implement was 25 cm and the average speed was 11 km/h. The research was conducted on a 20 ha field from which 10 ha were done without GPS and 10 ha using GPS with RTK signal and 2.5 cm precision.

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Figure 1 **Fendt vario 930 working with Horsch Tiger 3 MT**

The Fendt 930 Vario is powered by a robust MAN 6-cylinder, turbocharged, intercooled diesel engine with a displacement of 9.037 liters, delivering a rated power of 296 hp (220.7 kW) and a maximum power of 305 hp (227.4 kW) at 1,700 rpm, with a peak torque of 1,550 Nm. It features a fuel tank capacity of 625 liters and a DEF (AdBlue) tank capacity of 70 liters. The tractor is equipped with a Continuously Variable Transmission (CVT) that offers a forward speed range from 0.02 to 60 km/h and a reverse speed range of 0.02 to 33 km/h. Its advanced load-sensing hydraulic system provides a standard pump flow of 165 liters per minute, with an optional upgrade to 430 liters per minute using dual pumps, supporting rear and front hitch lift capacities of 12,410 daN and 5,584 daN,

respectively. Dimensionally, the tractor has a wheelbase of 3,150 mm, an overall width of 2,710 mm, a cab height of 3,335 mm (without VarioGuide), and a ground clearance of 553 mm. It weighs 11,300 kg unladen and has a maximum permissible weight of 17,000 kg. The PTO system offers rear speeds of 540E/1000 rpm as standard, with an optional 1000/1000E rpm, and a front PTO speed of 1000 rpm. Fitted with 650/65R34 front tires and 710/70R42 rear tires, the Fendt 930 Vario is a high-performing, versatile tractor designed to meet the demands of modern agricultural operations.

The HORSCH Tiger 3 MT is a versatile cultivator designed for intensive soil preparation, particularly effective in incorporating substantial crop residues and performing deep loosening up to 35 cm. It features a combination of a two-row disc system with 68 cm diameter discs and a two-row tine system equipped with TerraGrip tines, each providing a release force of 770 kg. The machine's working width is 3.00 meters, with a transport width of 3.00 meters and a transport height of 2.40 meters. Its overall length varies between 8.30 to 9.00 meters, depending on the packer configuration.

The Tiger 3 MT weighs approximately 4,215 kg and requires a power input ranging from 110 to 220 kW (150 to 300 hp). It offers various packer options, including a tyre packer with a diameter of 78 cm or 100 cm, and an optional double RollPack packer with a diameter of 62 cm. The frame height stands at 850 mm, and the implement is compatible with lower linkages of categories III to IV.

These specifications make the HORSCH Tiger 3 MT a robust and efficient tool for modern agricultural practices, ensuring thorough mixing of organic material and effective soil consolidation.

Tests were conducted on a field with documented GPS coordinates, uniform soil conditions (texture, moisture, and compaction), and adequate area for consistent data collection. Fuel consumption was measured using a flowmeter or weighing system, while energy output and power delivery were assessed using a dynamometer and torque sensors. GPS systems tracked tractor movement and operational parameters like overlap and efficiency, while environmental sensors recorded soil resistance and ambient conditions. Baseline measurements under no-load conditions were taken before performing standardized tasks such as plowing or planting, with consistent engine speed, throttle settings, and working depth. Data such as fuel consumption, engine load, speed, and working depth were logged in real time. Energy efficiency was calculated as the ratio of useful work done (e.g., tilled area) to energy input, with specific fuel consumption (SFC) expressed as fuel consumed per kilowatt-hour of engine output. Field efficiency was determined as the ratio of effective working time to total time, and work rate was measured in hectares per hour.

RESULTS AND DISCUSSIONS

The comparison between GPS-guided and non-GPS operations on a 10-hectare field using the Horsch Tiger 3 MT reveals significant differences in time efficiency, fuel consumption, operational accuracy, and cost implications.

The results demonstrate that using GPS guidance significantly reduces the time required to complete soil preparation tasks. With GPS, the operation took 5.2 hours, compared to 6.8 hours without GPS. This translates to a 23.5% reduction in time, allowing the operator to cover more ground in a shorter period (*table 1*). The time savings are attributed to the optimized route planning provided by GPS, which minimizes redundant passes and ensures thorough coverage. By eliminating unnecessary overlaps, GPS reduces inefficiencies inherent in manual operations.

Table 1

Results regarding the performance comparison of GPS and Non-GPS operations on Fendt vario 930 with Horsch Tiger 3 MT

Metric	With GPS	Without GPS	Improvement with GPS (%)
Time Taken (hours)	5.2	6.8	23.5
Fuel Consumption (liters/ha)	14.5	18.3	20.8
Overlap (%)	0	8	100

Fuel efficiency is another critical metric where GPS proves advantageous. The operation with GPS consumed 14.5 liters per hectare, while the non-GPS operation used 18.3 liters per hectare, representing a 20.8% reduction in fuel consumption. This improvement can be directly linked to the elimination of overlaps and the precise alignment of field passes, ensuring that no area is covered more than necessary. Reduced fuel consumption not only lowers operational costs but also contributes to environmental sustainability by reducing carbon emissions.

The operational accuracy of the equipment was significantly enhanced by GPS. With GPS guidance, the overlap percentage was effectively reduced to 0%, meaning no area of the field was

unnecessarily covered more than once (*figure 2a, figure 2b*). In contrast, the non-GPS operation resulted in an 8% overlap, reflecting the limitations of manual navigation.

Overlap leads to wasted time, fuel, and wear on equipment, all of which are mitigated by GPS technology.

a. b.

Figure 2 **Furrow arrangement in shuttle pattern**
a. on tractor display;
b. on the field.

The reduction in fuel consumption directly impacts operational costs. These savings accumulate over multiple fields, making GPS a cost-effective solution for large-scale farming operations. Additionally, the time saved translates into opportunities for increased productivity, allowing farmers to prepare more land within the same timeframe.

Economic implications of these findings are significant. Reduced fuel consumption translates into direct cost savings. Additionally, the time saved allows for more fields to be prepared in the same timeframe, increasing overall productivity. Beyond economic benefits, GPS improves operational accuracy by ensuring no untreated areas or excessive overlap, thereby enhancing the effectiveness of soil preparation.

CONCLUSIONS

The findings of this study reveal clear advantages of integrating GPS technology with the Horsch Tiger 3 MT for soil preparation. Time savings of 23.5% highlight the productivity boost offered by GPS, while the 20.8% reduction in fuel consumption underscores its economic and environmental benefits. Enhanced operational accuracy further supports the case for GPS adoption, as it ensures optimal resource utilization. Although GPS technology requires an initial investment, the long-term savings in fuel and time, coupled with improved efficiency, justify its implementation. This study underscores the importance of adopting precision agriculture practices to enhance farm profitability and sustainability.

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OPTIMIZATION OF THE TENDERIZATION PROCESS AND NUTRITIONAL QUALITY OF PHEASANT MEAT

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Abstract

This study aims to explore and enhance the quality attributes of pheasant meat (*Phasianus colchicus*). The animals were not used exclusively for research purposes; rather, the game reserve manager authorized the collection of samples for scientific analysis, as outlined in the annual wildlife management plan. The research protocol adheres to bioethical guidelines, including principles of Replacement, Reduction, and Refinement to minimize animal use and harm. Feed supplementation was provided during the winter months, averaging 85.5 kg/animal/year, consisting of cereals, seeds, fruits, and root vegetables such as beets, turnips, and potatoes. Two distinct anatomical regions, the breast (*Musculus pectoralis*) and thighs (*Musculus femoralis*), were subjected to different tenderization techniques, specifically tumbling and tenderizing treatments. The study focused on chemical composition, texture, and pH balance, providing key insights into optimizing both the tenderness and nutritional value of pheasant meat based on the applied methods. The raw material was obtained from a hunting reserve by Romania's National Hunting and Wildlife Protection Legislation (Law No. 407/2006). Meat processing involved anatomical sectioning, deboning, and trimming in a microproduction unit, followed by storage in controlled refrigeration at 2-4°C to ensure optimal analysis conditions. Pheasant meat is recognized as a valuable source of high-quality protein essential for tissue growth and repair. The literature confirms a significant content of vitamins and minerals, including vitamin B12, iron, and zinc, which support optimal human health. The results indicated that while both tenderization techniques are effective, tumbling produced a marginal but notable improvement in meat tenderness. Although modest, this improvement can have a meaningful impact on both consumers and the food industry, highlighting the importance of selecting the optimal processing method to achieve the desired quality of the final product. Our research offers valuable insights for the food industry, suggesting promising directions for developing new pheasant meat products and promoting a healthy, balanced diet. The use of diverse evaluation methods provided a comprehensive understanding of pheasant meat quality and tenderness, reinforcing confidence in the study's findings.

Keywords: nutritional quality, pheasant meat, tenderization techniques, meat tenderness

To enhance the nutritional quality of pheasant meat through optimal tenderization, several key conditions and methods have been identified. These include postmortem handling, enzymatic treatments, and innovative processing techniques. Maintaining low temperatures (around 10 °C) during storage for approximately 9 days has been shown to improve meat tenderness and sensory acceptance compared to higher temperatures (Barnes *et al*, 1973).

The postmortem biology of muscle tissue indicates that low pH and high ionic strength can facilitate myofibrillar protein degradation, important for tenderization (Huff-Lonergan & Lonergan, 1999). The application of papaya latex proteases, particularly chymopapain, effectively degrades muscle proteins and connective tissue, enhancing tenderness (Kang & Warner, 1974). This method can be applied pre- or postmortem for optimal results. Utilizing electrical stimulation during processing can significantly improve tenderness by promoting muscle relaxation and protein breakdown (Burnett, 1997). This technique, applied for 8 to 13 seconds, enhances the overall quality of the meat.

While these methods show promise, it is essential to consider that excessive tenderization may lead to a loss of desirable texture and flavor, indicating a need for balance in processing techniques.

MATERIAL AND METHOD

For this study, the first stage consisted in the collection of biological material, represented by three pheasant carcasses, purchased from a hunting ground located in Tulcea County. The carcasses were transported under refrigerated conditions (4°C). The areas affected by the shot

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wound were removed to avoid negative influences on the quality of the samples. Subsequently, the carcasses were sectioned into the main anatomical regions: breast, legs, wings and back. To detach each region, the natural joints of the pheasants were followed. Complete deboning of the thighs was accomplished by sectioning at the joints and removing the bones. Each region was cleaned of connective tissue, bone, fat and tendons. From these anatomical regions, only the breast (*Musculus pectoralis*) and thighs (*Musculus femoralis*) were selected for analysis, as they provide a sufficient amount of material and a superior quality for the proposed tests. The total quantity obtained was 600 g of the pulp and 800 g of the breast, each divided into two equal portions for further processing.

Nitrate salt, known for its properties to improve moisture retention and tenderization of the meat, was used for part of the samples (16 g breast (*Musculus pectoralis*) and 12 g thighs (*Musculus femoralis*). The sodium nitrite included in the salt helped to prevent fat oxidation and extend the shelf life. The salted samples were placed for 30 minutes in a continuously running vacuum tumbler at 10 rpm to facilitate uniform marinading. For the remaining samples, a manual tenderizing machine was used, applying a series of 4 strokes on each piece of meat to break the muscle fibres and increase tenderness.

After processing, the samples were categorized according to anatomical region and type of processing: tender breast, tumbler breast, tender flesh and tumbler flesh. Each sample was packed in vacuum-sealed bags, labeled and stored at 2°C to 4°C until analysis.

The texture of the meat was assessed using a texturometer equipped with a Series 5 dynamometer with a maximum force of 1000 N and a resolution of 0.01 N. The samples were subjected to the Warner-Bratzler test using a V-type knife probe and the knife travel speed was set at 200 mm/min. Parameters evaluated included: hardness, elasticity, adhesion, chewability and resilience. The fat (%), water (%), protein (%), collagen (%) and salt (%) content was also analyzed using the Omega Bruins Food-Check near-infrared spectrophotometer (NIR) (Bruins Instruments GmbH, Puchheim, Germany). NIR refers to a region of the electromagnetic spectrum adjacent to the infrared range, characterized by wavelengths between approximately 700 and 2500 nanometres. In this range, visible light consists mainly of red, orange and yellow hues. These wavelengths allow the absorption and emission of radiation by various substances and facilitate interactions with various materials and biological systems. The pH of the samples was measured with a Testo 206-pH1 digital pH meter equipped with an integrated temperature probe. The pH electrode was calibrated before each measurement and was washed with distilled water to ensure accuracy. pH values were automatically recorded and measurements were repeated for accuracy. All experiments were conducted in five replicates, and the results are presented as mean ± standard deviation. Statistical analysis was performed using one-way analysis of variance (ANOVA) with IBM SPSS Statistics version 21. A p-value of less than 0.05 was considered to indicate statistically significant differences.

RESULTS AND DISCUSSION

In *table 1,* the physicochemical results from the Musculus pectoralis of pheasants (*Phasianus colchicus*) were compared between two treatments: tumblerization (TU) and tenderization (TE). Table 1 presents the average values and standard errors (SE) for moisture, protein, collagen, fat, salt, and pH, highlighting significant differences between the treatments. The *p*-value ($p < 0.001$) indicates a statistically significant decrease in moisture content in the TE group compared to TU. The TE treatment significantly increased protein content ($p < 0.001$), suggesting that tenderization had a positive effect on the protein concentration. Although the collagen content is lower in the TE group, the difference is highly significant ($p < 0.001$), which could imply that tenderization slightly breaks down collagen compared to tumbling. A small but statistically significant increase in fat content ($p < 0.001$) was observed with the tenderization process, possibly due to fat retention.

Table 1

The physicochemical results obtained from the *Musculus pectoralis* samples subjected to the tenderization treatment and the tumblerization treatment

Musculus pectoralis						
E.G.	**Physicochemical parameters (%)**					
	Moisture	**Protein**	**Collagen**	**Fat**	**Salt**	**Ph**
TU	73.94±1.023	20.78±1.052	19.90±0.392	1.88±0.014	2.34±0.067	5.86±0.043
TE	72.93±1.025	22.25±1.732	19.71±0.533	2.09±0.200	1.38±0.074	5.54±0.123
p-value	***p* < 0.001 *****	***p* < 0.001 *****	***p* < 0.001 *****	***p* < 0.001 *****	***p* < 0.001 *****	***p* < 0.001 *****

Values are presented as means ± standard error (SE) with five replicate determinations; ANOVA and t-test were used to compare differences; ns = $p > 0.05$ (not significant); *** = $p < 0.001$ (highly significant). E.G.- experimental groups; TU- tumbling treatments; TE- tenderizing treatments.

The salt content is significantly higher in the TU group ($p < 0.001$), which may relate to differences in processing techniques or seasoning absorption. A significant reduction in pH ($p < 0.001$) is noted for the TE group, which could reflect differences in muscle breakdown or post-treatment biochemical reactions.

Although the collagen content is lower in the TE group, the difference is highly significant ($p < 0.001$), which could imply that tenderization slightly breaks down collagen compared to tumbling. A small but statistically significant increase in fat content ($p < 0.001$) was observed with the tenderization process, possibly due to fat retention. The salt content is significantly higher in the TU group ($p < 0.001$), which may relate to differences in processing techniques or seasoning absorption. A significant reduction in pH ($p < 0.001$) is noted for the TE group, which could reflect differences in muscle breakdown or post-treatment biochemical reactions.

The *table 2* presents the physicochemical results for the *Musculus femoralis* of pheasants (*Phasianus colchicus*) subjected to two different treatments: tumbling (TU) and tenderizing (TE). The data shows the average values ± standard error (SE) for moisture, protein, collagen, fat, salt, and pH, along with their respective significance levels. The tenderized group (TE) showed significantly higher moisture content than the tumbling group ($p < 0.001$), which may suggest better water retention after the tenderization process. The protein content is significantly higher in the TE group ($p < 0.001$), which implies that tenderization positively effects the protein concentration in the Musculus femoralis. Although the collagen content is slightly lower in the TE group, this difference is statistically significant ($p < 0.001$), suggesting that tenderization breaks down collagen more effectively than tumbling.

Table 2

The physicochemical results obtained from the *Musculus pectoralis* samples subjected to the tenderization treatment and the tumblerization treatment

Musculus femoralis						
E.G.	**Physicochemical parameters (%)**					
	Moisture	**Protein**	**Collagen**	**Fat**	**Salt**	**pH**
TU	72.21±0.396	20.49±0.857	19.56±0.064	5.63±0.041	2.51±0.001	5.72±0.027
TE	73.14±0.331	21.16±0.181	19.48±0.063	5.51±0.718	2.76±0.008	6.02±0.271
p-value	**p < 0.001 *****	**p < 0.001 *****	**p < 0.001 *****	**p < 0.001 *****	**p < 0.001 *****	**p < 0.001 *****

Values are presented as means ± standard error (SE) with five replicate determinations; ANOVA and t-test were used to compare differences; ns = $p > 0.05$ (not significant); *** = $p < 0.001$ (highly significant). E.G.- experimental groups; TU- tumbling treatments; TE- tenderizing treatments.

A slight reduction in fat content was observed in the TE group, but the difference remains statistically significant ($p < 0.001$). The variation in fat content could be related to differences in fat distribution or loss during tenderization. The tenderized group (TE) had significantly higher salt content than the TU group ($p < 0.001$), indicating greater salt absorption or retention during the tenderizing process.

A significant increase in pH was noted in the TE group ($p < 0.001$). A higher pH in the tenderized samples may be due to biochemical changes during the tenderization process that affect the acid-base balance in the muscle.

The increase in protein content through tenderization is a significant advantage for meat quality, according to *figure 1*. Higher protein levels are often associated with better nutritional value, making the tenderized *Musculus femoralis* more attractive to consumers who prioritise high-protein diets (Bhat Z.F. *et al*, 2018). Additionally, the improved water and protein retention contribute to a juicier texture and potentially better flavour, enhancing the overall eating experience.

This outcome also underscores the importance of selecting the right mechanical or enzymatic tenderization techniques to enhance both the sensory and nutritional properties of game meat, such as that of the pheasant (Viganò R. *et al*, 2019; Ciobanu M.M. *et al*, 2023).

During the tenderization process, mechanical action may disrupt the fat globules embedded within the muscle tissue. This disruption can lead to the release of some fat, resulting in a lower fat percentage in the tenderized meat (*figure 2*). The tenderness achieved through this process may enhance the perception of flavor without the need for a higher fat content (Ouali A., 1990).

The study is focused on improving the quality attributes of pheasant meat (*Phasianus colchicus*), analyzing how different mechanical treatments (tumbling vs. tenderizing) affect key physicochemical properties. The significant differences across all parameters suggest that tenderization enhances certain properties like

protein content and fat, while reducing moisture and salt. Lower pH and collagen values observed in the TE group suggest potential tenderizing effects, which are commonly associated with the softening of muscle tissue.

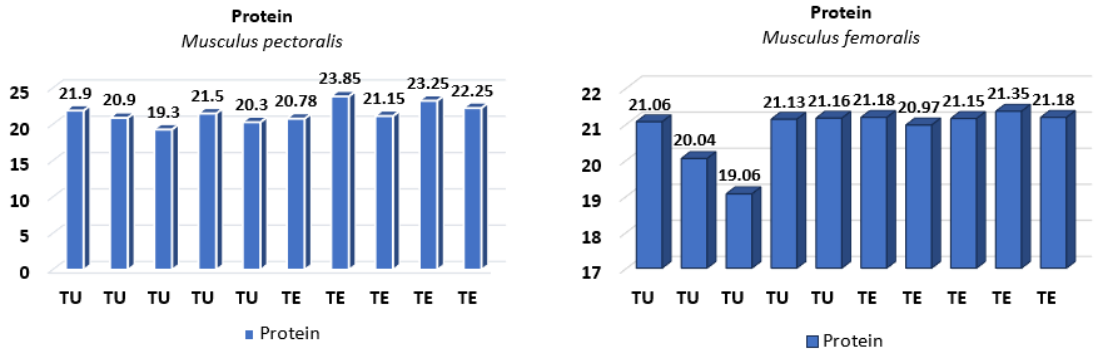

Figure 1 **Protein levels in the two anatomical areas studied (*Musculus pectoralis* and *Musculus femoralis*) subjected to TU (tumbling) and TE (tenderizing) treatment**

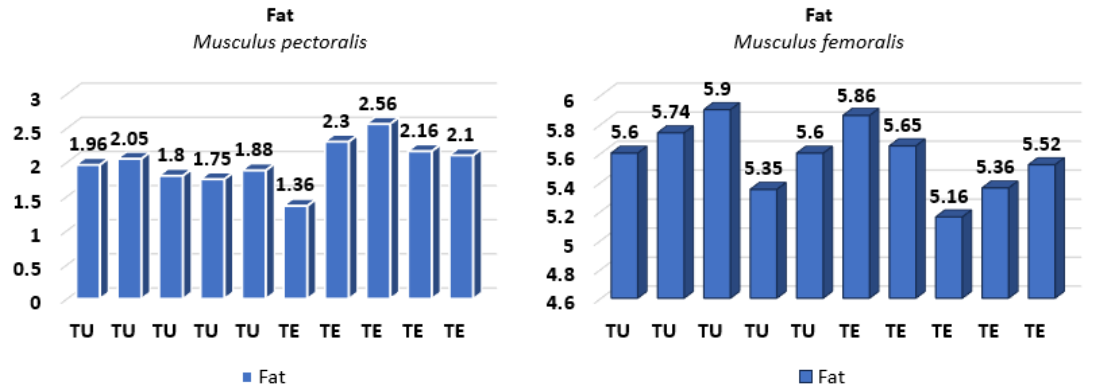

Figure 2 **Fat level in the two anatomical areas studied (*Musculus pectoralis* and *Musculus femoralis*) subjected to TU (tumbling) and TE (tenderizing) treatment**

These alterations may reflect changes in the structural integrity of the muscle fibers, leading to enhanced tenderness. A decrease in pH could result from biochemical processes such as the breakdown of muscle proteins, particularly myofibrillar proteins like actin and myosin, which are sensitive to acidic conditions. This breakdown leads to the release of intracellular ions, contributing to a lower pH environment. At the same time, reduced collagen values may indicate a reduction in the structural integrity of the connective tissue, which plays a crucial role in maintaining muscle firmness. As collagen is partially degraded by enzymatic or acid-induced processes, the muscle fibers become less encumbered by the surrounding tissue, thereby enhancing tenderness and improving the overall textural properties of the meat (Lonergan S.M., Huff-Lonergan E., 2006).

The study is focused on improving the quality attributes of pheasant meat (*Phasianus colchicus*), analyzing how different mechanical treatments (tumbling vs. tenderizing) affect key physicochemical properties. The significant differences across all parameters suggest that tenderization enhances certain properties like protein content and fat, while reducing moisture and salt. Lower pH and collagen values in the TE group may be indicative of tenderizing effects, which typically aim to soften muscle tissue.

The *table 3* presents the cutting forces (in Newtons) for two anatomical areas of the pheasant (*Phasianus colchicus*): *Musculus pectoralis* and *Musculus femoralis*, under two different treatment conditions: Tumbling treatments (TU) and Tenderizing treatments (TE).

For *Musculus pectoralis*, $p > 0.05$ (ns) indicates no significant difference between the two treatments for this anatomical area. Both tumbling and tenderizing treatments resulted in similar cutting forces, indicating that neither method significantly enhanced the tenderness of the pectoral muscle. This could imply that *Musculus pectoralis* naturally possesses sufficient tenderness or that the treatments applied did not affect its cutting force. *Musculus femoralis* $p < 0.001$ (***), indicating a highly significant increase in cutting force with tenderizing treatment compared to tumbling treatment. The tenderizing treatment resulted in a significantly higher cutting force than the tumbling treatment. This suggests that tenderizing methods are

effective in enhancing the tenderness of the femoral muscle, which could lead to improved palatability and consumer acceptance of pheasant meat.

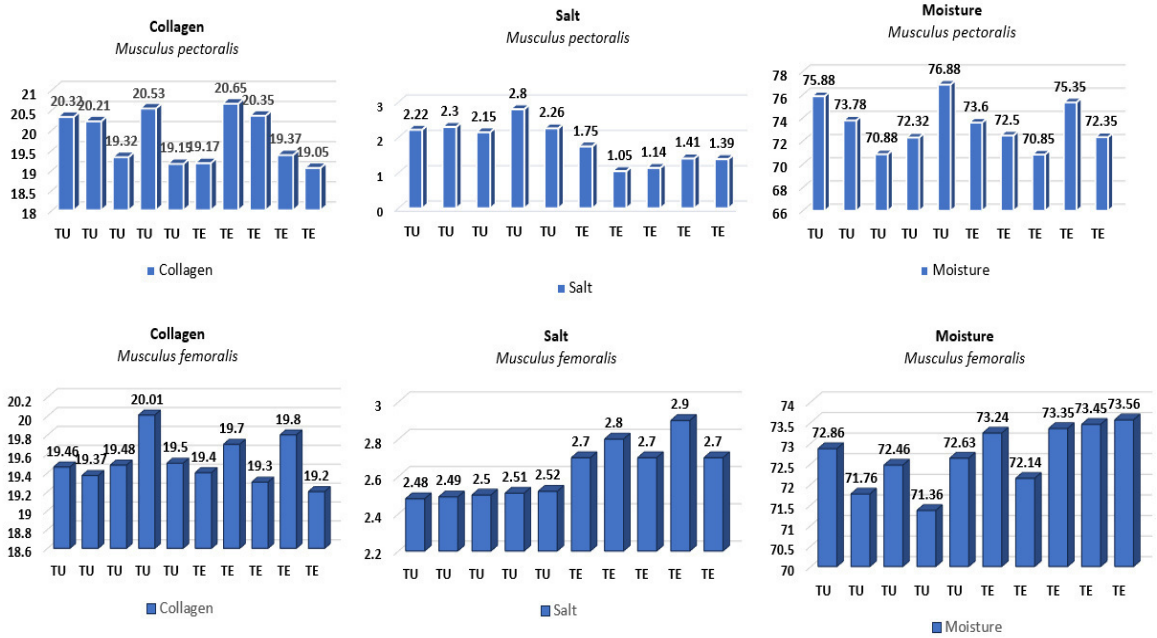

Figure 3 **Collagen, salt and moisture level in the two anatomical areas studied (*Musculus pectoralis* and *Musculus femoralis*) subjected to TU (tumbling) and TE (tenderizing) treatment**

Table 3

Cutting forces (in Newtons) for two anatomical areas of the pheasant (*Phasianus colchicus*): *Musculus pectoralis* and *Musculus femoralis*

Cutiing forces (N)		
E.G.	**Anatomical Area**	
	Musculus pectoralis	*Musculus femoralis*
TU	23.26±0.492	42.17±0.544
TE	23.7±0.152	52.35±0.225
p-value	***p* > 0.05^{ns}**	***p* < 0.001*****

Values are presented as means ± standard error (SE) with five replicate determinations; ANOVA and t-test were used to compare differences; ns = $p > 0.05$ (not significant); *** = $p < 0.001$ (highly significant). E.G.- experimental groups; TU- tumbling treatments; TE- tenderizing treatments.

CONCLUSIONS

The increase in protein content through tenderization represents a significant advantage for the quality of pheasant meat (*Phasianus colchicus*). Higher protein levels not only enhance the nutritional value of the meat but also make the tenderized *Musculus femoralis* more appealing to consumers, particularly those who prioritize high-protein diets. Furthermore, the improved water and protein retention resulting from tenderization contributes to a juicier texture and potentially better flavor, which enhances the overall eating experience. These factors are important for consumer satisfaction and can influence purchasing decisions in the market.

This study underscores the importance of selecting appropriate mechanical or enzymatic tenderization techniques to enhance both the sensory and nutritional properties of game meat. By optimizing these methods, producers can significantly improve the quality attributes of pheasant meat, catering to consumer preferences for healthier, high-quality meat products.

Ultimately, the insights gained from this research can guide industry practices and contribute to the successful marketing of pheasant as a premium protein source. This study focuses on enhancing the quality attributes of pheasant meat (*Phasianus colchicus*) by analyzing the effects of different mechanical treatments—tumbling versus tenderizing—on key physicochemical properties. The significant differences observed across various parameters indicate that tenderizing treatments (TE) effectively improve certain qualities of the meat, such as protein content and fat levels, while simultaneously reducing moisture and salt content. For *Musculus pectoralis*, no significant difference was observed between the two treatments ($p > 0.05$), suggesting that both tumbling and tenderizing had similar effects on cutting force, without significantly improving the tenderness of this muscle. In contrast, for *Musculus femoralis*,

the tenderizing treatment significantly increased the cutting force ($p < 0.001$), indicating the effectiveness of this treatment in enhancing the tenderness of the femoral muscle, contributing to better acceptability of pheasant meat.

The findings provide insights into optimizing the tenderness and quality of pheasant meat, suggesting that specific treatments, particularly tenderizing methods, are more effective for certain anatomical areas. This information could guide poultry producers and processors in developing better meat quality enhancement strategies, potentially influencing market competitiveness and consumer satisfaction.

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THE USE OF GRAPE POMACE FOR DEVELOPING AN INNOVATIVE YOGHURT WITH ENHANCED ANTIOXIDANT PROPERTIES

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Abstract

The present paper explores the use of grape pomace, a by-product of the wine industry, as a functional ingredient for enriching yoghurt with the aim of increasing its nutritional value and antioxidant capacity. Through modern ultrasound-assisted extraction techniques, bioactive compounds were recovered from the grape pomace, resulting in a high content of polyphenols, flavonoids, and anthocyanins. The study evaluated the impact of adding grape pomace powder in 1% and 2% proportions on the chemical, phytochemical, and sensory properties of the yoghurt. The chemical results showed an increase in fibre, protein, and dry matter content, while the phytochemical analysis revealed a significant rise in total anthocyanins, flavonoids, and polyphenols, along with greater antioxidant activity in the enriched yoghurts compared to the control yoghurt. Additionally, the sensory analysis demonstrated high acceptability for the yoghurt with 3% grape pomace powder, achieving a total score of 19.6, classifying it as "very good," while the 6% variant received a lower score. These findings highlight the potential of using grape pomace to create innovative dairy products with improved nutritional and functional benefits, thus contributing to the sustainable valorisation of an agro-industrial by-product.

Key words: yoghurt, by-product, grape pomace, quality.

Grape pomace, a by-product of wine and juice production, contains skins, seeds, and stems rich in bioactive compounds, particularly polyphenols like anthocyanins and flavonols with strong antioxidant and health-promoting properties (Averilla A. *et al*, 2019; Beres C. *et al,* 2017). Its nutritional potential has sparked interest in its application in functional foods, such as yogurt (Almanza-Oliveros A. *et al,* 2024). Yogurt, a probiotic-rich dairy product, is widely recognised for promoting gastrointestinal health, enhancing nutrient absorption, and supporting immune function (Gavril R.N. *et al,* 2024; Tikhomirova N.A. *et al*., 2020). The incorporation of grape pomace into yogurt may not only enhance its antioxidant capacity but also provide additional dietary fiber and nutrients, making it a promising avenue for innovation in dairy products (Constantin O. *et al*, 2024).

Recent studies show that incorporating horticultural by-products into yogurt can enhance its quality and consumer appeal (Belardi I. *et al*, 2024). Adding grape pomace aligns with food innovation trends, addressing sustainability and health demands (Marchiani R. *et al*, 2016). Combining grape pomace with probiotics offers potential for a novel yogurt with improved health benefits and reduced grape processing waste (Castangia I. *et al*, 2023).

The purpose of this work is to explore the integration of grape pomace into yogurt formulations, addressing the dual objectives of promoting health benefits and enhancing sustainability. This aligns with contemporary trends in food innovation, which emphasize the development of products that support consumer well-being and reduce environmental impact. By combining the nutritional properties of grape pomace with the probiotic benefits of yogurt, this study aims to create a novel yogurt product that delivers enhanced health benefits while simultaneously addressing the challenge of food waste generated during grape processing.

MATERIAL AND METHOD

The unfermented GP of the Feteasca Neagra variety came from a winery (Iaşi University of Life Sciences). 50 litres of cow's milk were given by the Rediu Iași Research Station of the University of Life Sciences. The skins were separated mechanically and then dried in an oven at 40±2°C for 48 hours, until they had a moisture

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content of 9.87%. With a food grinder, the GP were ground down to 0.5 mm. For 15 minutes at 121 °C, a steriliser was used to clean GP before it was used to make yoghurt.

The following chemicals were bought from Sigma Aldrich: DPPH (2,2-diphenyl1-picrylhydrazyl), gallic acid, sodium acetate, potassium chloride solution, ethanol, sodium carbonate, methanol, sodium carbonate, Folin-Ciocâlteu reagent, sodium hydroxide, and aluminium chloride.

The bioactives were taken out of GP powder using the ultrasound-assisted extraction method. So, 1 gramme of GP was mixed with 10 millilitres of an 80% ethanol solution that had been acidified with citric acid (7:1, v/v). The mixture was then subjected to ultrasound for 25 minutes at 35°C and 37 kHz. The supernatant that was left over was gathered and spun at 6500 rpm for 10 minutes at 4°C. After that, the GP extract was used to study phytochemicals (including anthocyanins, flavonoids, and polyphenols) and antioxidant action. The amount of total monomeric anthocyanin was found using a modified version of the pH difference method used by Lipșa et al. (2024). We checked the absorption of diluted extracts using different buffer solutions with pH levels of 1.0 and 4.5 at 520 nm and 700 nm. The results were shown as mg cyanidin-3-glucoside (C3G)/g of dry weight (dw).

The method outlined by Dewanto et al. (2002) was used to find out how many total flavonoids were in GP extract. Soon, 2 mL of pure water were mixed with 0.25 mL of the GP extract and 0.075 mL of 5% sodium nitrite.

After 5 min., 0.15 mL of 10% aluminium chloride is added and the mixture is left to work for another 6 minutes. Finally, 0.5 mL of 1M sodium hydroxide is added. A wavelength of 510 nm was used to measure the absorption of the mixture that was made. The total amount of flavonoids is given in mg catechin equivalents/g sample (mg CE/g d.w.). To find out how much total polyphenolic content there was, the Folin-Ciocâlteu spectrophotometric method described by Dewanto *et al.* (2002) was used.

200 µL of the GP extract, 1 mL of the Folin-Ciocâlteu reagent, and 15.8 mL of pure water were put into a test tube. They were left alone for 10 minutes, then 3 mL of 20% sodium carbonate was added. They were then left alone in the dark at room temperature for an hour. 765 nm was used to measure the absorption. The findings were given in mg of gallic acid equivalents per gramme of sample (mg GAE/g d.w.).

To find out how much antioxidant activity there is by blocking the DPPH radical, the steps outlined by Castro-Vargas et al. (2010) were followed. In a 100 mL volumetric 560 flask, 3.8 mg of DPPH was mixed with methanol to make a stock solution. After that, 100 µL of the sample to be tested (GP extract) and 3.9 mL of DPPH (A sample) were put into a test tube. 100 µL of methanol and 3.9 mL of DPPH (A control) were used for the control sample. It was read at a wavelength of 515 nm after being left alone for 90 minutes in the dark. The values were shown as µmol of Trolox equivalents (TE)/g dry weight. We looked at how the antioxidant capacity changed by finding the inhibition (I%) for each sample. To do this, we used the formula I% = (A controlA sample)/A control x 100.

Getting unpasteurised milk, tasting it, and analysing it. 200 litres of milk were taken from the farm's storage tank and put in clean containers. It was kept at 4°C for twenty-five hours.

Once the milk was completely mixed, it was added to the lab tests for analysis. According to Ratu et al. (2024), the AOAC methods were used to find out the physicochemical parameters of milk samples. These parameters included the pH, solid non-fat content, protein content, and fat content (moisture content).

Making yoghurt that has been improved with GP.

The pasteurised milk was heated to 42°C, at which point the selected lactic cultures YF-L812, a commercial product from Chr. HANSEN, Denmark – a mix of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp*. bulgaricus* (2:1) – were added. After the addition of the selected lactic cultures (with the milk temperature maintained at 42°C), the three batches were prepared as follows: Lc – the control batch (without added powder), LY-3 – the batch with 3% GP added, and LY-6 – the batch with 6% GP added. Once the batches were prepared, the milk was portioned into plastic cups, heat-sealed, and placed into a thermostat *(figure 1*). According to the Association of Official Analytical Chemists (AOAC) (Usturoi *et al*, 2017; Tseng & Zhao, 2013), the pH, fat, ash, moisture content, and total protein of the samples were measured.

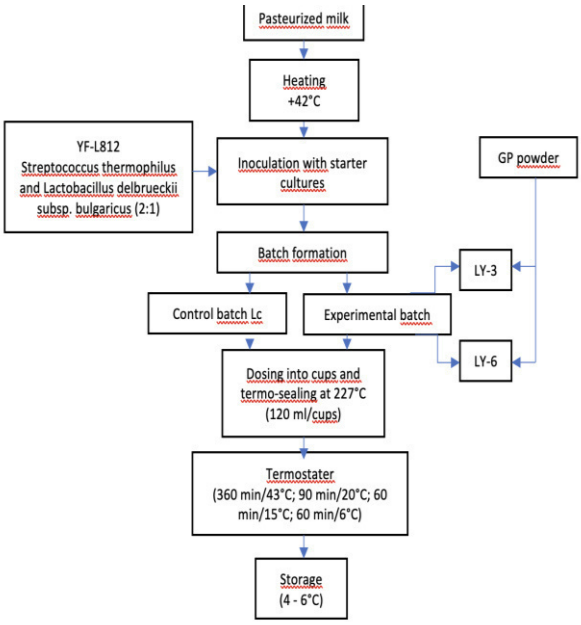

Figure 1 **Flow diagram illustrating the processing step of yoghurt**

Sensory Analysis

The sensory evaluation of the yoghurt samples was carried out by a panel comprising 10 individuals. A 9-point hedonic scale was employed to assess the sensory attributes, with 1 representing the least pleasant/weakest and 9 representing the most pleasant/strongest. The attributes evaluated included appearance, colour, aroma, texture, taste, odour, aftertaste, and overall acceptability. The panel members were non-smokers, aged between 24 and 40 years, all with academic backgrounds in the food industry. The yoghurt samples were presented in a randomised order. Prior to the evaluation, participants were informed about the study's purpose and the measures taken to ensure the confidentiality of their personal data.

Statistical Analysis

The statistical analysis was performed using the data analysis tools available in Microsoft Excel and the statistical software Minitab 19. Standard deviations were determined based on results obtained from triplicate experiments.

RESULTS AND DISCUSSIONS

The polyphenolic, flavonoid, and anthocyanin contents in the ethanolic extract of GP powder were determined using spectrophotometric methods (*table 1*).

Table 1

Phytochemical characterizations and colorimetric parameters of the GP powder

Parameters	GP powder
Total anthocyanin content (mg C3G/g d.w.)	1.60±0.23
Total flavonoid content (mg CE/g d.w.)	8.90±0.69
Total polyphenol content (mg GAE/g d.w.)	21.06±0.69
Antioxidant activity (DPPH, µmol TE/g d.w.)	25.01±0.09
Inhibition %	89.03±0.33

The total polyphenol content measured 21.06±0.69 mg GAE/g d.w., while the total flavonoid content was 8.90±0.69 mg CE/g d.w.. The anthocyanin content reached 1.60±0.23 mg C3G/g d.w., accompanied by significant antioxidant activity of 25.01±0.09 µmol TE/g d.w., with a high inhibition rate of 89.03±0.33%.

Comparative studies have reported variations due to differences in extraction methods and raw material. For instance, Serea et al. (2021) observed higher anthocyanin values (4.29±0.04 mg C3G/g) but lower antioxidant activity (14.07±1.03 mM Trolox/g) in red grape peel extracts, while Rockenbach *et al.* (2011) reported anthocyanin ranges of 1.84-11.22 mg C3G/g d.w. in pomace extracts. Variability in phytochemical content can be attributed to the plant source, extraction techniques, and solvent composition.

The principal chemical indices were evaluated to determine the quality parameters of raw cow's milk. *Table 2* summarises the chemical composition of the analysed samples. The water content averaged 87.13±0.08%, while total solids constituted 12.87±0.12%. Notably, the fat content was measured at 3.93±0.11%, contributing to a solid non-fat content of 8.94±0.16%. The mean protein level was 3.39±0.05%, and the average pH value was 6.61±0.04.

Table 2

Chemical composition of raw milk

Parameters	Mean
Water (%)	87.13±0.08
Fat (%)	3.93±0.11
Protein (%)	3.39±0.05
Total Solids (%)	12.87±0.12
Solid non fat (%)	8.94±0.16
pH	6,61±0.04

These results highlight that milk's solid components—primarily fat and protein—are essential for its economic and nutritional significance. Overall, the findings confirm that the assessed parameters align with established quality criteria for raw milk.

The phytochemical composition and DPPH free radical scavenging activity of control and supplemented yoghurt samples are summarised in Table 3. The results indicate a dose-dependent increase in bioactive compounds and antioxidant capacity with the addition of grape pomace (GP) powder. The control yoghurt (LC) showed no detectable anthocyanin content, while LY-3 and LY-6 exhibited significantly higher values (15.33±0.07 mg C3G/100 g d.w. and 43.27±0.06 mg C3G/100 g d.w., respectively). A similar trend was observed for flavonoid content, increasing from 1.28±0.02 mg CE/g d.w. (LC) to 4.72±0.03 mg CE/g d.w. (LY-3) and 10.69±0.11 mg CE/g d.w. (LY-6).

Table 3

The content of phytochemical compounds and the antioxidant activity of added-value yogurt samples

Parameters	Batch		
	LC	LY-3	LY-6
Total anthocyanin content (mg C3G /100 g d.w.)	0.0	15.33±0.07^{b}	43.27±0.06^{a}
Total flavonoid content (mg CE/g d.w.)	1.28±0.02^{c}	4.72±0.03^{b}	10.69±0.11^{a}
Total polyphenol content (mg GAE/g d.w.)	2.58±0.01^{c}	7.47±0.04^{b}	16.64±0.09^{a}
Antioxidant activity (µmol TE/g d.w.)	13.45±0.06^{c}	36.53±0.03^{b}	61.59±0.14^{a}

The presence of distinct letters within rows denotes statistically significant variations between the samples ($p < 0.05$).

The total polyphenol content also showed marked improvements, rising from 2.58±0.01 mg GAE/g d.w. (LC) to 7.47±0.04 mg GAE/g d.w. (LY-3) and 16.64±0.09 mg GAE/g d.w. (LY-6). Antioxidant activity, as measured by DPPH scavenging capacity, increased significantly from 13.45±0.06 µmol TE/g d.w. (LC) to 36.53±0.03 µmol TE/g d.w. (LY-3) and 61.59±0.14 µmol TE/g d.w. (LY-6). These findings confirm that the incorporation of GP powder into yoghurt formulations enhances anthocyanins, flavonoids, polyphenols, and antioxidant activity in a dose-dependent manner. The elevated values demonstrate the nutritional and functional benefits of GP supplementation compared to the control sample. This trend aligns with Marchiani *et a*l. (2016), where grape pomace addition significantly improved the polyphenolic content (+55%) and antioxidant capacity (+80%) in yoghurt formulations. The chemical composition of control and value-added yoghurts (LY-3 and LY-6) is presented in *table 4*. The results reveal significant differences in moisture, total solids, protein, and ash content between the control yoghurt (LC) and the supplemented variants.

Table 4

Chemical composition of added-value yogurts samples

Parameters	Batch		
	LC	LY-3	LY-6
Moisture (%)	86.51±0.12^{a}	81.22±0.09^{b}	78.09±0.11^{c}
Total solid (%)	13.49±0.12^{c}	18.78±0.09^{b}	21.91±0.11^{a}
Fat (%)	3.75±0.02^{a}	4.11±0.07^{a}	4.21±0.09^{a}
Protein (%)	3.69±0.11^{a}	4.19±0.14^{ab}	4.43±0.12^{a}
Ash (%)	0.71±0.02^{b}	1.07±0.06^{a}	1.25±0.07^{a}
pH	4.63±0.11^{a}	4.59±0.11^{b}	4.55±0.07^{b}

The presence of distinct letters within rows denotes statistically significant variations between the samples ($p < 0.05$).

The moisture content decreased progressively with the inclusion of grape pomace (GP) powder, from 86.51±0.12% in the control sample (LC) to 81.22±0.09% in LY-3 and 78.09±0.11% in LY-6. This reduction is accompanied by a corresponding increase in total solids content, which rose from 13.49±0.12% in LC to 18.78±0.09% in LY-3 and 21.91±0.11% in LY-6, indicating the concentration effect of GP powder addition. The protein content exhibited a significant increase with higher concentrations of GP powder ($p < 0.05$). Specifically, the control yoghurt (LC) contained 3.69±0.11%, whereas LY-3 and LY-6 showed elevated values of 4.19±0.14% and 4.43±0.12%, respectively. This rise in protein content highlights the nutritional enhancement achieved through GP supplementation.

In contrast, the fat content remained relatively stable across all samples, with values of 3.75±0.02% in LC, 4.11±0.07% in LY-3, and 4.21±0.09% in LY-6. This suggests that the addition of GP powder has minimal impact on the fat composition of yoghurt. The ash content increased progressively with the inclusion of GP powder, reflecting the mineral contribution of the added grape pomace. The control yoghurt exhibited an ash content of 0.71±0.02%, which increased to 1.07±0.06% in LY-3 and 1.25±0.07% in LY-6. This trend aligns with the dose-dependent nature of GP powder addition, enhancing the mineral composition of the final product. The pH values showed a slight but consistent decline with increasing GP powder concentrations, from 4.63±0.11 in the control to 4.59±0.11 in LY-3 and 4.55±0.07 in LY-6. This reduction may be attributed to the acidic nature of the grape pomace components, which can influence the overall acidity of the yoghurt. In conclusion, the incorporation of GP powder into yoghurt formulations significantly improves the protein, total solids, and ash content while slightly reducing the pH. The results confirm the nutritional and functional benefits of GP supplementation, supporting its potential application in yoghurt products. These findings align with previous studies, such as Marchiani et al. (2016), which reported similar trends when grape skin flour was added to yoghurt formulations, resulting in reduced pH and increased mineral content. The sensory evaluation of the analysed yoghurt samples was conducted using a 9-point hedonic scale, assessing attributes such as appearance, colour, aroma, texture, taste, odour, aftertaste, and overall acceptability. The results of the sensory analysis are summarised in Table 5.

As the concentration of grape pomace (GP) powder increased in the yoghurt formulations, a noticeable enhancement in the sensory attributes was observed. Specifically, the red colour intensity became more pronounced in the yoghurts containing GP powder, attributed to the pigments present in the grape pomace, especially anthocyanins. The control yoghurt (LC) exhibited lower scores across all sensory parameters compared to the supplemented variants, LY-3 (3% GP powder) and LY-6 (6% GP powder).

Table 5

Sensory evaluation values of control and added-value yogurts (LY-3, LY-6)

Parameters	Batch		
	LC	LY-3	LY-6
Appeance	7.70±0.12^{c}	8.11±0.07^{b}	8.45±0.09^{a}
Colour	8.07±0.05^{c}	8.17±0.04^{b}	8.55±0.06^{a}
Aroma	8.04^{b}±0.11^{c}	8.18^{ab}±0.04^{b}	8.55±0.08^{a}
Texture	8.04^{b}±0.09^{a}	8.22^{ab}±0.06^{b}	8.38^{a}±0.11^{a}
Taste	8.07^{c}±0.03^{c}	8.25^{b}±0.07^{b}	8.59±0.05^{a}
Odour	8.09^{c}±0.02^{a}	8.40^{b}±0.05^{b}	8.75±0.07^{a}
Aftertaste	8.16^{c}±0.05^{c}	8.45^{b}±0.08^{b}	8.71^{a}±0.04^{a}
Overall acceptability	8.30^{c}±0.08^{a}	8.65^{b}±0.07^{b}	8.83^{a}±0.05^{a}

The presence of distinct letters within rows denotes statistically significant variations between the samples ($p < 0.05$).

For appearance, the panel rated LY-6 the highest (8.45±0.09), reflecting its visually appealing red hue, followed by LY-3 (8.11±0.07) and LC (7.70±0.12). Similar trends were observed for colour, where LY-6 (8.55±0.06) stood out due to the enriched pigmentation, and for texture, which also improved progressively with the addition of GP powder. In terms of aroma and odour, LY-6 was again rated the highest (8.55±0.08 for aroma and 8.75±0.07 for odour), with the panellists appreciating the balanced and agreeable characteristics imparted by the GP powder. The incorporation of GP powder not only enhanced the taste but also the aftertaste, with LY-6 receiving top scores (8.59±0.05 for taste and 8.71±0.04 for aftertaste). The overall acceptability of the yoghurt samples reflected a clear preference for the GP-supplemented variants. LY-6 achieved the highest overall score (8.83±0.05), highlighting its superior sensory attributes, while LY-3 (8.65±0.07) also demonstrated significant improvements compared to the control (8.30±0.08). These findings are consistent with the study by Freitas-Sá et al. (2018), who reported enhanced sensory scores for yoghurts supplemented with jabuticaba peel powder. Their results indicated that the addition of natural colourants and bioactive components could significantly improve sensory appeal and consumer acceptance.

CONCLUSIONS

The comprehensive characterisation of grape by-product extracts confirmed that GP extract contains a notably high anthocyanin content and exhibits strong antioxidant activity. These findings highlight the potential of GP powder as a rich source of bioactive compounds with antioxidant properties. Accordingly, we advocate for its incorporation as a natural ingredient in fortified yoghurt formulations.

Yoghurts supplemented with GP powder demonstrated elevated levels of total phenolic content and enhanced antioxidant potential compared to the plain yoghurt. Sensory evaluations revealed that the panellists appreciated the enriched colour and overall sensory characteristics of the GP-supplemented samples, deeming them acceptable and appealing.

This research underscores promising opportunities for the dairy industry to cater to the growing consumer demand for functional foods by developing innovative, nutritious, and flavourful yoghurt products. Furthermore, the findings validate the quality and bioactive potential of natural powders derived from the skin and seeds of grape berries, specifically from the Feteasc Neagră variety. These ingredients hold substantial promise for application in the food industry, enabling the creation of functional products while simultaneously supporting circular economy principles by valorising agricultural by-products.

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SIMULATION AND IMPORTANCE OF A TRACEABILITY SYSTEM IN DAIRY MICROPRODUCTION FOR ENSURING FOOD SAFETY AND QUALITY

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Abstract

Traceability, which provides the ability to track each step of the production chain from raw materials to the finished product, is crucial for guaranteeing the quality and safety of food. In this study, we examine the importance of implementing an effective traceability system in the production of milk and by-products from the Milk Microproduction Workshop of Iasi University of Life Sciences. A system like this makes it possible to quickly identify the causes of non-compliance, reducing the risks involved in removing items from the market and safeguarding consumers' health. In addition, the article offers a realistic simulation of a traceability exercise that involves monitoring raw milk batches, processing them, and identifying each final product, including cheeses and yogurts. The results of the exercise show that a well-designed traceability system increases consumer confidence in the products obtained within the workshop, while guaranteeing compliance with existing laws. The results emphasize how this system must be continuously modified to satisfy market demands and enhance the efficiency of the production and food safety procedures.

Key words: traceability, food safety, food quality, HACCP.

Introduction. The dairy industry was created to keep an eye on and confirm the quality and safety of dairy products from the farm to the customer. By making it easier to track products in the supply chain, these systems encourage accountability and openness among all parties involved, including manufacturers, processors, and retailers (Anastasiadis F. *et al,* 2021).

Implementing traceability methods is essential because they enhance food safety by facilitating quick reactions to contamination and boost consumer confidence by guaranteeing the quality and authenticity of products.

Because it can mimic real-world situations, simulation is important in traceability systems because it helps stakeholders see the supply chain and spot any weaknesses that can jeopardize food safety (Velește I.D. *et al,* 2023).

In order to ensure adherence to safety procedures like Hazard Analysis and Critical Control Points (HACCP), the simulations enable producers to assess different risk management techniques that can be used in the dairy industry. The dairy business may enhance its operational procedures and produce safer and better-quality products by utilizing simulation technologies efficiently (Morrissey M., 2017).

However, there are significant obstacles to the implementation of traceability systems, particularly for small dairy producers. The deployment of these systems may be hampered by the high price of technological expenditures and the requirement for uniform information transmission. Furthermore, a lot of manufacturers continue to use paper records, which reduces the efficiency and quality of data. In order to guarantee product quality and advance food safety procedures in the microdairy industry, these obstacles must be removed (Charlebois S, Sanaz H., 2015).

The necessity for affordable, user-friendly traceability solutions designed for small-scale businesses is emphasized in future research and development areas. The dairy industry may enhance its traceability procedures and eventually satisfy the rising customer demand for safe, premium dairy products by enhancing training programs and creating cooperative projects among stakeholders (Elghannam A. *et al,* 2019).

With particular relevance to a dairy microproduction workshop, the aim of this article is to assess the significance of putting in place an efficient traceability system in the dairy industry. The purpose of the article is to show how

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traceability supports food safety, efficient risk management, and adherence to national and international laws. This study attempts to determine crucial points in the production chain where monitoring techniques can be used to guarantee the quality and safety of dairy products from the point of origin to the end user by simulating a traceability effort (Razak G. M. *et al,* 2021*;* Veleșcu I.D. *et al*, 2022).

MATERIAL AND METHOD

This subchapter provides a detailed framework on the methodology used in the implementation of traceability and the simulation of a traceability exercise in a milk and milk products microproduction. For this study, a Milk and Dairy Products Microproduction Workshop of the Faculty of Agriculture, within the "Ion Ionescu de la Brad" University of Life Sciences from Iasi, with an average processing capacity of approximately 500 liters of milk per day. The main dairy products made in the workshop include pasteurized milk, yogurt, fresh and matured cheeses.

The materials and equipment used in the traceability process and simulation of the traceability exercise included:

- *Batch database* - for recording all relevant batch information: collection date, processing date, supplier details, and the identifier of each processed batch.
- *Batch identification labels* - used to label each dairy product based on the internal coding system.
- *Traceability management software* - for real-time data management, monitoring and verification of the production and distribution process.
- *Parameters monitoring system* - for controlling the processing and storage conditions of milk and dairy products during transport and storage.
- *Employee and supplier questionnaires* - to collect data on food safety practices and traceability.

RESULTS AND DISCUSSIONS

The use and earlier implementation of HACCP concepts (Hazard Analysis and Critical Control Points) in the micro-production workshop was crucial to guaranteeing efficient traceability and a strong food safety system. Any traceability system is built on the foundation of HACCP principles, which guarantee the identification, monitoring, and control of risks at every stage of the production process.

The following are the primary phases of HACCP implementation:

Hazard analysis is the process of identifying and evaluating the biological, chemical, and physical dangers that could arise at various points during the production of milk and dairy products, such as the presence of residual chemicals or bacterial contamination (*table 1*).

Table 1

Hazard identification

Crt. no	Stage	Hazard	Specification
1	Reception Raw Milk	B	- Presence of pathogens such *as Listeria monocytogenes*, *Salmonella*, *E. coli*, *Staphylococcus aureus*, and *Campylobacter* in raw milk. - Cross-contamination from infected animals or poor hygiene during milking. - Bacterial spore formers (e.g., *Bacillus cereus* or *Clostridium*) that can survive pasteurization.
		C	- Residues of antibiotics, hormones, or veterinary drugs in the milk. - Presence of pesticides or herbicides from feed. - Mycotoxins (like aflatoxins) from contaminated animal feed.
		P	- Presence of foreign materials like dirt, hair, or metal particles in milk. - Contaminants from milking equipment, such as plastic or rubber fragments.
2	Milk Pasteurization	B	- Inadequate heat treatment could allow survival of harmful pathogens. - Recontamination after pasteurization due to improper handling or equipment.
		C	- Degradation of milk quality due to improper temperature control. - Cleaning agent residues if the pasteurizer isn't cleaned thoroughly.
		P	- Potential fragments from faulty equipment.
3	Curdling Process	B	- Growth of spoilage microorganisms if temperature control is inadequate. - Pathogens surviving if unclean rennet or starter cultures are used.
		C	- Improper dosage of rennet or incorrect pH adjustment can lead to defective curds. - Contaminants in rennet or starter cultures.
		P	- Introduction of foreign objects during mixing or curd cutting.
4	Cutting, Draining, and II Heating the Curds	B	- Bacterial growth due to improper temperature control or cross-contamination.
		C	- Contamination from cleaning chemicals if equipment is not rinsed properly.
		P	- Metal fragments from cutting knives or equipment used during the process.
5	Moulding and Pressing the Cheese	B	- Potential for contamination from air, surfaces, or hands during handling. - Growth of mold or spoilage organisms if hygienic practices are poor.
		C	- Residues from processing aids or cleaning products.
		P	- Pieces of cloth, plastic, or metal from equipment used in moulding or pressing.
6	Salting	B	- Pathogen contamination due to improperly stored or contaminated salt. - Microbial growth if salting is not done at the correct concentration or time.

		C	- Excessive salt content can affect safety and product quality. - Potential for iodine or anti-caking agents in salt to cause contamination.
		P	- Foreign particles in salt, like dirt or plastic fragments.
7	Maturation	B	- Growth of harmful bacteria or spoilage microorganisms during ripening due to inadequate temperature or humidity control. - Cross-contamination from the environment, other cheeses, or surfaces.
		C	- Accumulation of undesirable substances (like biogenic amines) if ripening conditions are not monitored.
		P	Foreign objects introduced during storage or handling.
8	Packaging and Labeling	B	- Recontamination of cheese by workers or equipment during packaging.
		C	- Use of non-food-grade packaging materials, leading to chemical migration. - Incorrect labeling regarding allergens (e.g., milk), which can lead to food safety risks for consumers.
		P	- Fragments of packaging material (like plastic or metal) getting into the product.
9	Storage and Distribution	B	- Growth of pathogens if cold chain is broken during storage or transport.
		C	- Absorption of external odors or chemicals during storage, affecting safety and quality.
		P	- Contamination from damaged containers or exposure to foreign objects.

Finding the crucial stages in the production cycle where hazards can be reduced or eliminated is known as *identifying critical control points*, or CCPs. Critical aspects in the dairy business usually include equipment sanitation, storage temperature regulation, and pasteurization procedures (*table 2*).

Identifying the measurable parameters (such as temperature and time) that determine the safety limits in order to establish the critical limits for each CCP. For instance, the crucial limit for pasteurization is the lowest temperature at which harmful microbes are removed from milk.

CCP monitoring: putting in place regular or ongoing monitoring techniques to make sure every CCP stays within crucial bounds. To avoid biological hazards, pasteurization requires constant temperature and time monitoring (*figure 1*).

Table 2

Hazard analysis and assessment

Crt. no.	Operation	Hazards	Hazard			What measure(s) can be applied to prevent or eliminate the hazard or reduce in to an acceptable level?
			S	P	HR	
1	Reception Raw Milk	B	3	1	3	Use only milk from certified and regularly inspected farms. Implement testing for pathogens and microbial counts (e.g., *Listeria, E. coli*) upon receipt. Keep strict cold chain control (below 4°C) from farm to processing facility.
		C	2	1	2	Conduct routine screening for antibiotic, hormone, and pesticide residues. Ensure milk suppliers provide certificates of analysis (COA) for each batch.
		P	2	1	2	Use filtration systems at milk reception to remove physical contaminants. Inspect the transportation and milking equipment for wear and tear.
2	Milk Pasteurization	B	**3**	**2**	**6**	Monitor and control time and temperature during pasteurization (CCP). Verify the equipment's calibration regularly. Test post-pasteurization milk for microbial activity.
		C	2	1	2	Implement proper cleaning procedures for pasteurization equipment. Use food-grade cleaning agents and verify rinse cycles to avoid residues.
		P	2	1	2	Regularly inspect equipment for wear, including gaskets, seals, and pipes. Filter milk post-pasteurization to remove potential small particles.
3	Curdling Process	B	2	1	2	Ensure starter cultures and rennet are sourced from approved suppliers and are of food-grade quality. Maintain strict hygiene standards during the handling and preparation of milk.
		C	2	1	2	Monitor the addition of rennet and cultures to ensure accurate dosing. Store rennet and cultures under recommended conditions to prevent contamination.
		P	2	1	2	Conduct regular checks on knives and cutting equipment for potential contaminants.
4	Cutting, Draining, and Cooking the Curds	B	2	1	2	Control temperature during curd processing. Ensure curds are handled with clean, sanitized equipment.
		C	2	1	2	Ensure proper rinsing of equipment to avoid chemical residue contamination. Use validated cleaning procedures for all surfaces and utensils.
		P	2	1	2	Regularly inspect cutting tools and equipment to detect wear or damage.
5	Moulding and Pressing the Cheese	B	2	1	2	Practice good hygiene and wear protective gloves while handling curds. Sanitize pressing and moulding equipment between batches.
		C	2	1	2	Avoid using non-food-grade materials for moulding and ensure equipment is thoroughly rinsed after sanitation.
		P	2	1	2	Inspect pressing machines for loose parts and wear before use.
6	Salting	B	2	1	2	Use only high-quality, food-grade salt and store it in sanitary conditions. Monitor salt concentration and salting time to ensure proper food safety.
		C	2	1	2	Ensure the salt does not contain contaminants such as iodine or anti-caking agents that may affect cheese quality.

		P	2	1	2	Screen salt for foreign particles or use pre-filtered salt.
7	Maturation	B	3	2	6	Control temperature, humidity, and air quality in ripening chambers (CCP). Regularly test for microbial contamination and monitor for spoilage organisms.
		C	3	1	3	Prevent accumulation of undesirable compounds by controlling environmental conditions. Regularly check for off-flavors caused by volatile compounds in ripening rooms.
		P	2	1	2	Keep the maturation environment clean and free from debris.
8	Packaging and Labeling	B	2	1	2	Ensure proper hygiene during packaging. Use sanitized equipment and materials to prevent recontamination.
		C	2	1	2	Ensure packaging materials are food-grade and free from harmful chemicals. Perform allergen checks and validate accurate labeling to avoid consumer risks.
		P	2	1	2	Inspect packaging materials for integrity and foreign objects before use.
9	Storage and Distribution	B	2	1	2	Maintain cold chain during storage and distribution. Regularly monitor storage temperatures and ensure proper handling.
		C	2	1	2	Store cheese away from chemicals or products that could cause contamination. Use proper storage conditions to avoid the absorption of external odors or chemicals.
		P	2	1	2	Use durable, undamaged containers and packaging to prevent contamination during transport.

Corrective actions: setting up the required procedures in the event that monitoring shows a departure from crucial limits. Recalling the impacted batch or making process adjustments are two examples of these measures.

Verification of the HACCP system involves conducting *internal audits and checks* to make sure the system is operating as intended and effectively managing hazards.

Maintaining precise records of risk assessments, CCP monitoring, remedial measures, and recurring checks to support product traceability and compliance inspections is known as documentation and record keeping.

To guarantee an all-encompassing approach to risk management, potential production hazards were categorized according to their risk levels. The three main types of risks—Critical, Significant, and Minor—each call for a different degree of oversight and management. Critical Risks (High) require constant monitoring and strict controls at Critical Control Points (CCPs), such as in maturation and pasteurization procedures (*figures 1, 2*). Significant Risks (Medium) necessitate frequent monitoring and efficient preventive actions, which apply to processes including packaging, salting, and curdling. Good Manufacturing Practices (GMP) and routine inspections are used to handle minor risks (low), which are frequently associated with physical hazards from equipment.

CCP	Hazards		Critical Limits	Monitoring	Corrective Actions	Records	Verification
Milk Pasteurization	B	Pathogens (*Listeria, E. coli, Salmonella*)	Temp: ≥ 65°C; Time: ≥ 30 min	**What:** Temperature & time. **How:** Continuous automatic monitoring. **Who:** Operator. **Frequency:** Continuous, with batch checks.	Re-pasteurize or discard if limits are not met	Temperature & time logs, corrective actions	Calibration logs, microbiological tests
	C	Cleaning agent residues					
	P	Foreign particles from equipment					

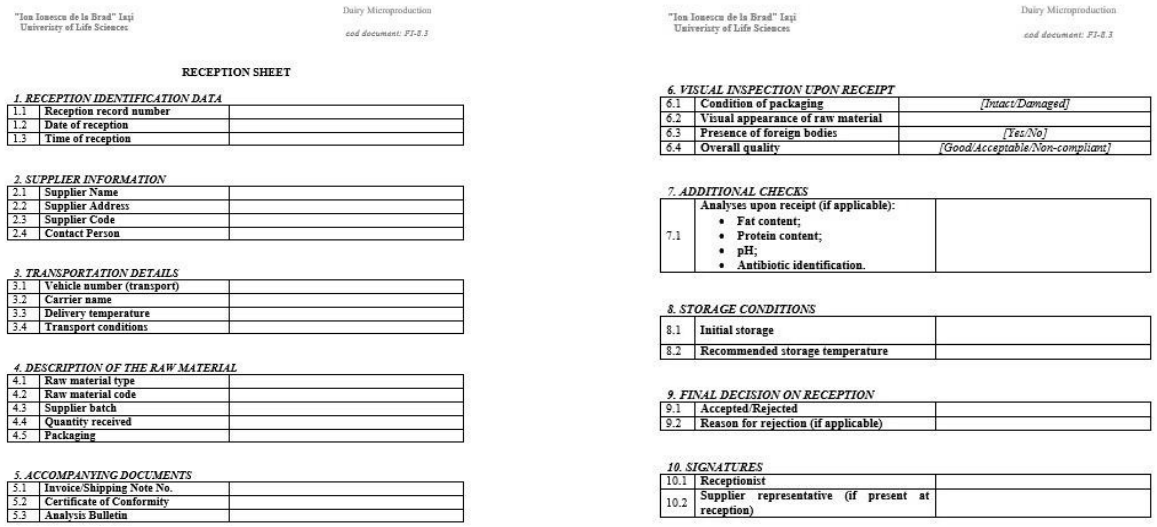
Figure 1 **HACCP Plan for Milk Pasteurization (CCP1)**

CCP	Hazard		Critical Limits	Monitoring	Corrective Actions	Records	Verification
Maturation	B	Pathogens, spoilage organisms	**Temp:** 12-14°C. **Humidity:** 75-85%.	**What:** Temperature & humidity. **How:** Continuous data logging. **Who:** Quality control staff. **Frequency:** Daily review of logs.	**If limits are not met:** Adjust ripening conditions. Evaluate and discard affected cheese if necessary.	Temperature & humidity logs, corrective action reports.	Microbiological tests (monthly), sensory evaluations, log reviews (daily).
	C	Biogenic amines					
	P	Foreign materials					

Figure 2 **HACCP Plan for Cheese maturation (CCP2)**

Standardized processes have been created and put into place to follow the entire manufacturing chain, from the acquisition of raw materials to the finished product, in order to guarantee a high degree of traceability. The methodology used the following assumptions:

Milk batch registration: Every batch of raw milk that was gathered was entered into the database along with comprehensive details on the supplier, the collection date, and any quality checks that were performed (*figure 3, 4*).



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cod document: FI-8.3

RECEPTION SHEET

1. RECEPTION IDENTIFICATION DATA

1.1	**Reception record number**	
1.2	**Date of reception**	
1.3	**Time of reception**	

2. SUPPLIER INFORMATION

2.1	**Supplier Name**	
2.2	**Supplier Address**	
2.3	**Supplier Code**	
2.4	**Contact Person**	

3. TRANSPORTATION DETAILS

3.1	**Vehicle number (transport)**	
3.2	**Carrier name**	
3.3	**Delivery temperature**	
3.4	**Transport conditions**	

4. DESCRIPTION OF THE RAW MATERIAL

4.1	**Raw material type**	
4.2	**Raw material code**	
4.3	**Supplier batch**	
4.4	**Quantity received**	
4.5	**Packaging**	

5. ACCOMPANYING DOCUMENTS

5.1	**Invoice/Shipping Note No.**	
5.2	**Certificate of Conformity**	
5.3	**Analysis Bulletin**	

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6. VISUAL INSPECTION UPON RECEIPT

6.1	**Condition of packaging**	*[Intact/Damaged]*
6.2	**Visual appearance of raw material**	
6.3	**Presence of foreign bodies**	*[Yes/No]*
6.4	**Overall quality**	*[Good/Acceptable/Non-compliant]*

7. ADDITIONAL CHECKS

7.1	**Analyses upon receipt (if applicable):** • **Fat content;** • **Protein content;** • **pH;** • **Antibiotic identification.**	

8. STORAGE CONDITIONS

8.1	**Initial storage**	
8.2	**Recommended storage temperature**	

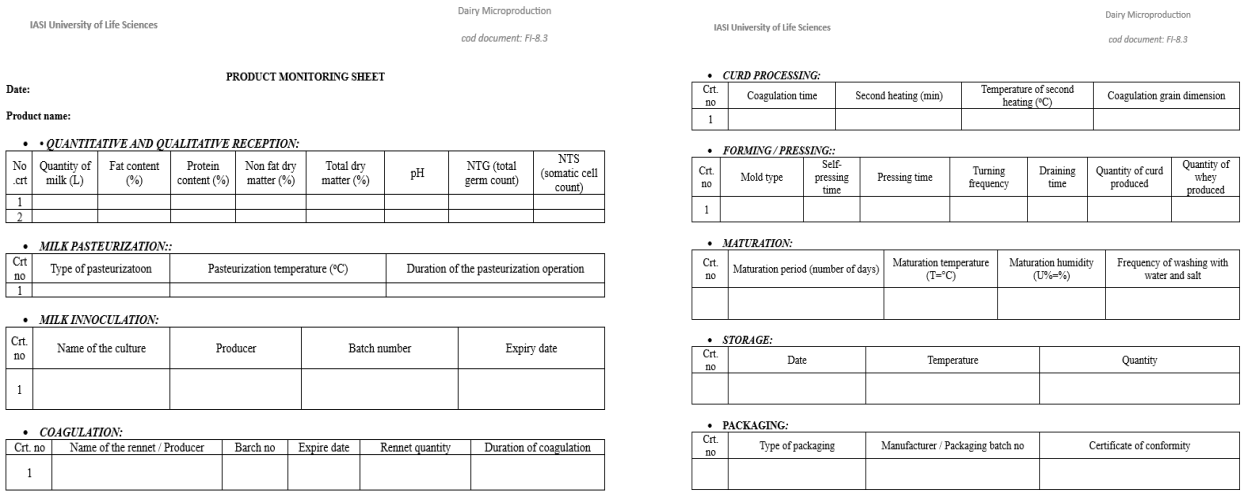
9. FINAL DECISION ON RECEPTION

9.1	**Accepted/Rejected**	
9.2	**Reason for rejection (if applicable)**	

10. SIGNATURES

10.1	**Receptionist**	
10.2	**Supplier representative (if present at reception)**	

Figure 3 **Reception documents**



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PRODUCT MONITORING SHEET

Date:

Product name:

• *• QUANTITATIVE AND QUALITATIVE RECEPTION:*

No .crt	Quantity of milk (L)	Fat content (%)	Protein content (%)	Non fat dry matter (%)	Total dry matter (%)	pH	NTG (total germ count)	NTS (somatic cell count)
1								
2								

• *MILK PASTEURIZATION::*

Crt no	Type of pasteurizatoon	Pasteurization temperature (°C)	Duration of the pasteurization operation
1			

• *MILK INNOCULATION:*

Crt. no	Name of the culture	Producer	Batch number	Expiry date
1				

• *COAGULATION:*

Crt. no	Name of the rennet / Producer	Barch no	Expire date	Rennet quantity	Duration of coagulation
1					

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• *CURD PROCESSING:*

Crt. no	Coagulation time	Second heating (min)	Temperature of second heating (°C)	Coagulation grain dimension
1				

• *FORMING / PRESSING::*

Crt. no	Mold type	Self-pressing time	Pressing time	Turning frequency	Draining time	Quantity of curd produced	Quantity of whey produced
1							

• *MATURATION:*

Crt. no	Maturation period (number of days)	Maturation temperature (T=°C)	Maturation humidity (U%=%)	Frequency of washing with water and salt

• *STORAGE:*

Crt. no	Date	Temperature	Quantity

• PACKAGING:

Crt. no	Type of packaging	Manufacturer / Packaging batch no	Certificate of conformity

Figure 4 **Production documents**

Final product labeling: Every final product received a distinct label with a batch code that contained details on the equipment utilized, the responsible operator, and the date and time of processing.

Monitoring during distribution: In order to verify ideal storage conditions, temperature data was frequently reviewed and products were monitored along the entire distribution chain.

To assess the system's effectiveness and the precision of the data gathered during the production and distribution process, a traceability exercise simulation was conducted. The following was the format of the exercise:

- *Milk batch selection*: To replicate the traceability procedure, a batch of raw milk was chosen.
- *Identification of a final product*: From the chosen batch of milk, a certain final product was picked.
- *Trail tracing*: To identify each step of the process, the operators involved, and the equipment used, every record in the database—from the raw material collection to the packing stage—was combed through.
- *Results reporting*: To evaluate the level of precision and speed of the traceability process, gathered data was compiled into a report.
- *Data analysis*: The data was analyzed using descriptive and internal process compliance evaluation techniques. Performance metrics for the number of critical spots found during the traceability exercise and batch identification time were computed. The outcomes were contrasted

with the benchmarks set by the current European rules and industry best practices for dairy products.

The following analysis techniques were used to assess how well the traceability system was working and whether internal procedures adhered to food safety regulations:

- The data was analyzed using *descriptive and internal process* compliance evaluation techniques. Performance metrics for the number of critical spots found during the traceability exercise and batch identification time were computed.
- Data was compared to the guidelines and best practices set forth by European laws and regulations pertaining to the dairy sector as part of the compliance evaluation.

Performance metrics: Two primary metrics were computed:

- *Identification of Batches Time*: Indicates the amount of time needed to monitor and identify a particular batch from raw materials to the final product.
- *The quantity of critical points (CCP)* that are accurately tracked: demonstrates both the efficacy of the food safety system in place and adherence to the HACCP plan.

Good practices from other dairy processing facilities were examined in order to evaluate the traceability system's performance level and match internal procedures with global norms. Benchmarking involved comparing identification and monitoring times with information released by other dairy sector micro-productions and businesses. Assessment of traceability protocols: Labeling, monitoring, and recording protocols were examined using industry examples in order to pinpoint areas that could have improvement.

CONCLUSIONS

Adherence to HACCP principles was necessary for the establishment of a trustworthy traceability system in order to guarantee efficient production flow monitoring. Traceability, which provides all pertinent information about each batch of milk and final product, was added as an extra food safety measure following the implementation of HACCP principles.

To sum up, in order to guarantee product safety, improve quality control, and enable prompt reaction to possible contamination incidents, an efficient traceability system is crucial in the dairy industry. By tracking every component and stage of manufacturing, traceability enables manufacturers to maintain an uninterrupted information flow from raw materials to the finished product. This visibility promotes regulatory compliance, keeps pollutants from spreading, and increases consumer confidence in dairy products.

One useful method to evaluate and enhance the traceability system's efficacy is to carry out a traceability simulation exercise. Dairy farmers can test the effectiveness, timeliness, and precision of their response systems by modeling a fictitious contamination event. By identifying possible gaps in the supply chain's data collection and transmission, this exercise makes it possible to put corrective measures in place before a real disaster happens. In the end, a proactive food safety management strategy for the dairy industry inside the Iasi Faculty of Agriculture's Dairy Production Workshop is based on strong traceability and recurring simulation exercises.

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APPLE POMACE POWDER AS A NATURAL FOOD INGREDIENT FOR THE DEVELOPMENT OF YOGURT

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Abstract

Apple pomace, the by-product of apple juice and cider production, is a promising source of phytochemicals and contains substantial quantities of dietary fibers, vitamins, and minerals. Incorporating apple pomace powder (APP) as a natural ingredient in yogurt presents a novel strategy to enhance the nutritional profile of a dairy product. The study examines the effects of APP addition on the physicochemical, bioactivity, sensory, and textural properties of APP-enriched yogurt—the evaluation involved including APP at different concentrations (1% and 2% w/w). The results showed that yogurts enriched with APP had enhanced antioxidant activity due to their increased polyphenol content. The investigation of the texture showed that yogurts with APP had a thicker and creamier consistency.
The sensory evaluation revealed that consumers found smaller concentrations (up to 1%) acceptable, whereas greater concentrations impacted their taste and texture preferences. The APP demonstrates potential as a natural ingredient in yogurt, providing nutritional advantages and improving functional characteristics while maintaining consumer acceptability at suitable levels.

Key words: apple pomace, natural ingredient, bioactive compounds, yogurt enhancement, consumer acceptance

Agro-industrial waste has a high amount of dietary fiber, phytochemicals, and other important elements. A significant portion of this waste is sometimes incinerated or disposed of improperly; yet, it contains numerous valuable and advantageous nutrients (Esparza I. *et al,* 2020).

Apple (*Malus domestica*) is one of the most extensively cultivated crops worldwide, with a recorded production of over 89 million tonnes in 2016 (FAO, 2018). One approximate estimate suggests that 35% of the overall apple production is allocated for cider, juices, and extracts (Malec J. *et al,* 2014). Apple pomace (AP), a cheap residual product of apple juice processing, contains an abundant concentration of pectin, antioxidants, and flavor components. Apple pomace is a promising source of phytochemicals and contains substantial amounts of carbs, dietary fibers, vitamins, and minerals (Bhushan S. *et al,* 2008). Naturally occurring antioxidants include catechins, procyanidins, caffeic acid, polyphenols, phloretin glycosides, quercetin glycosides, and chlorogenic acid (Golebiewska E. *et al,* 2022).

Approximately 25-30% of all apple products, such as juice, wine, jams, and dried goods, are derived from the skin, flesh, seeds, and stems. According to estimates, apple juice processing yields a product with a low concentration of polyphenolic chemicals and just 3-10% of the antioxidant activity found in the original fruit. The majority of polyphenol chemicals are retained in apple pomace, which is a diverse combination of peel, stem, core, seed, and soft tissue (Adil I.H. *et al,* 2007).

The composition of AP includes sugars that are not soluble, such as cellulose (127.9 g/kg dried weight), hemicellulose (7.2–43.6 g/kg dried weight), and lignin (15.3–23.5 g/kg dried weight). Additionally, AP contains simple sugars like glucose, fructose, and galactose (Cruz M.G. *et al,* 2018). Several investigations have shown that the use of AP can help prevent, reduce, and eliminate various diseases by positively affecting antioxidant status, metabolic dysfunction, gastrointestinal health, and weight loss (Skinner R.C. *et al,* 2018).

It has various potential uses, including the recovery of pectin, the preparation of jam and jelly, the manufacturing of enzymes, the production of animal feed, the production of organic acids, the production of ethanol, as a source of aroma compounds, and as a source of natural antioxidants (Szabó-Nótin B. *et al,* 2014).

Prior research has demonstrated that AP powder displayed favorable characteristics in terms of water retention capacity, solubility, swelling, and its ability to increase the viscosity of milk

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(Wang K. *et al,* 2019). Thus, AP has the ability to stabilize acidic dairy products.

Yogurt is a top-rated dairy product widely consumed worldwide. Consumers have chosen this product because of its positive effects on the intestinal environment and the body's immune system. Yogurt possesses distinctive flavor, texture, and favorable sensory attributes. Yogurt also has positive effects on our intestinal microflora (Issar K. *et al,* 2017). However, the indicated health-promoting qualities motivate food entrepreneurs to prioritize apple pomace phytochemicals in food products such as food supplements, nutraceuticals, and diets enhanced with phenolic compounds. (Ganesh K.S. *et al,* 2021). Hence, the use of sustainable agricultural practices provides the potential to mitigate environmental damage and enhance the convergence into a circular economy.

The objective of this study was to examine the possibility of apple pomace powder (APP) as a natural component in yogurt. The physicochemical, phytochemical, and color aspects of the yogurt, along with its textural and sensory evaluations, were assessed to demonstrate the enhanced value of the product itself.

MATERIAL AND METHOD

The University of Life Sciences' Rediu Iași Research Station provided 200 L of cow's milk. In order to obtain the APP, the fruits were washed and squeezed using a fruit juices. Following this process, the apple core was then dried at a controlled temperature of +42ºC in the oven. The resulting by-product was ground into a fine, ready-to-use powder using a grinder (Blender Nutribullet Original).

The following chemicals were obtained from Sigma Aldrich Steinheim (Darmstadt, Germany): Hexane, acetone, ethanol, methanol, Folin-Ciocalteu reagent, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 6-hydroxy2,5,7,8 tetramethylchromane-2-carboxylic acid (Trolox), sodium hydroxide, sodium nitrite, Gallic acid, aluminum chloride solution, and sodium carbonate. All the other substances utilized in the studies were of analytical quality.

Extraction of biological active compounds from APP. The ultrasound-assisted extraction technique, as outlined by Gavril (Ratu) R.N. *et al* (2024), was employed to extract the bioactive constituents from APP with slight adjustments. 1.0 g of APP was combined with 10 mL of a solvent combination consisting of 3 parts n-hexane to 1-part acetone, or 70% ethanol (used for extracting polyphenols and flavonoids). The mixture was then subjected to ultrasonic treatment using an Elmasonic S 180 H ultrasound bath from Elma, Germany. The treatment lasted for 35 minutes at a temperature of 30°C and a frequency of 37 kHz. The obtained extract was thereafter retrieved and subjected to centrifugation at a speed of 6500 rpm and a temperature of 10°C for 10 minutes. Subsequently, the APP supernatant was analyzed for the overall content of carotenoids, flavonoids, and polyphenols.

The determination of carotenoids, phenolic compounds and antioxidant activity of APP extract.

Total carotenoid content. The carotenoid concentration was quantified using the spectrophotometric techniques described by Mihalcea L. *et al* (2018). The absorbance at 450 nm for the total carotenoid concentration of the extract was measured using a UV–VIS spectrophotometer, namely the Analytik Jena - Specord 210 Plus model from Germany. The results were expressed in milligrams per 100 grams of dry weight (d.w.).

Total flavonoid content. The Horincar G. *et al.* (2019) method was employed to quantify the total flavonoid concentration of the APP extract, with certain adjustments. The absorbance of the resultant mixture was promptly measured at a wavelength of 510 nm. The total flavonoid content was calculated in milligrams of catechin equivalents (EC) per gram, using the equation derived from the standard catechin calibration curve ($y = 2.8919x + 0.006$ with $R^2 = 0.9968$).

Total polyphenolic content. The Folin-Ciocâlteu colorimetric method was employed to quantify the total polyphenol concentration. According to Horincar G. *et al* (2019), absorbance measurement was taken at a specific wavelength of 765 nm. The polyphenolic component content was quantified as milligrams of Gallic acid equivalents (GAE) per gram of dry weight (dw), using an equation derived from the standard Gallic acid calibration curve ($y = 1.6991x - 0.0256$ with $R^2 = 0.9837$).

Antioxidant activity (DPPH). The antioxidant activity was measured using the DPPH technique, and the results were reported as µmol of Trolox equivalents per gram of dry weight (µmol TE/g d.w.) (Castro-Vargas H.I. *et al,* 2010). The calibration curve employed Trolox as the standard, with a linear equation of $y = 0.45x + 0.0075$ and a coefficient of determination (R^2) of 0.993. The samples were produced by combining 0.10 mL of each extract with 3.90 mL of a 0.1 M DPPH solution. The solutions were thereafter incubated at ambient temperature in the absence of light for 30 minutes before measuring the absorbance (Af) at a wavelength of 515 nm. For the blank (A0), the 3.9 mL solution of DPPH along with 0.10 mL of pure methanol was prepared. Additionally, the percentage of inhibition was computed. The inhibition percentage can be calculated using the formula: (A0 - Af) / A0 x 100.

Yogurt manufacturing. The yogurt manufacturing process using APP starts with the initial stage of receiving the raw materials and ingredients, which include cow's milk, lactic cultures, and auxiliary materials. Once the milk has

been filtered, it undergoes a low-pasteurization procedure at a temperature of 65 °C for 20 minutes. The milk was subjected to a process of concentration at a temperature of 90–91 °C for 14 seconds. Afterward, the milk was chilled while the temperature was observed and kept at 43 °C. Following the prior dosing and preparation, the subsequent step in the technological process involved the inoculation of milk with lactic starter cultures. The concentration of lactic starter cultures per batch was also measured (mg/batch). Subsequently, the technical technique advanced by incorporating the bioactive component and closely monitoring its concentration at levels of 1% YAPP1 and 2% YAPP2 per batch. The yogurt was dispensed into PET glasses with a volume of 250 mL, and then sealed by thermo-welding at a temperature of 227 °C. The thermostating technique entails the controlled maintenance of yogurt-filled glasses at certain temperatures for a specific duration. During this step, the time and temperature of the thermostat were observed and recorded in the following manner: 360 minutes at 43 °C; 90 minutes at 20 °C; 60 minutes at 15 °C; and 360 minutes at 6 °C. Subsequently, the yogurt was stored at a temperature range of 2–4 °C for further analyses.

The samples were analyzed for moisture content, total protein, fat, ash, and pH following the methods specified by the Association of Official Analytical Chemists (AOAC, 2010).

Texture analysis. The texture of the yogurt samples was analyzed by Texture Profile Analysis method (TPA), applied with a Brookfield CT3 Texture Analyzer. The testing parameters were as follows: the diameter of the cylinder probe was 35 mm, the test speed was 1.0 mm/s, the penetration distance was 25 mm, and the surface trigger force was 10 g. The Exponent software estimated the following parameters: Cohesiveness, Elasticity, Firmness, Gumminess, Chewiness, Resilience. Five measurements were conducted for each sample, and the texture parameters were computed using TexturePro CT v1.5 software developed by Brookfield Engineering Labs. Inc.

Color analysis. The measurement of color was conducted using a colorimeter (Konica Minolta Chroma Meter CR-410, Osaka, Japan). Three yogurt samples were used to fill the cuvette. The CIELab parameters L∗, a∗, and b* were provided, together with the hue angle Hue angle = 180 + arctan(b*/a*) for quadrant II (-a*, +b*)), ΔE= total color difference ($\sqrt{L*^2 + a*^2 + b*^2}$) and Chroma ($\sqrt{(a^*)^2 + (b^*)^2}$). The value of L* (lightness) ranges from 0 (representing black) to 100 (representing white). The coordinate a* represents the color spectrum from red (positive) to green (negative), while the coordinate b* represents the color spectrum from yellow (positive) to blue (negative) (McGuire R.G., 1992).

Sensorial analysis. The sensory evaluation of yogurt, both with and without APP, was conducted by a group of 20 panelists who were not trained in sensory evaluation. These panelists were habitual consumers of yogurt (consuming it more than once a month) and were between the ages of 18 and 41. The group consisted of 9 males and 11 females, who were recruited randomly. The participants were notified about the study's primary goal and the essential protocols for managing personal data. Panelists were instructed to assess the enriched yogurts on a 9-point hedonic scale, rating several aspects such as appearance, color, odor, flavor, consistency, taste, aftertaste, and overall acceptability. The scale ranged from 1 (very dislike) to 9 (highly like). The sensory evaluation area was kept in an appropriately air-conditioned environment, with the temperature in the booths controlled at around 25 ºC. The samples were exhibited in a randomized sequence. Panelists were instructed to cleanse their mouths meticulously with water following each sample assessment.

Statistical Analysis. The experiments were replicated three times unless otherwise specified. The data are presented as the average value ±the standard deviation. The statistical study was conducted using Minitab 17 software. The statistical significance was established with a p-value of less than 0.05. The data were examined using a one-way analysis of variance (ANOVA) followed by a Tukey test.

RESULTS AND DISCUSSIONS

Fruit juice processing firms produce a significant quantity of industrial waste, such as apple pomace. The phytochemical composition and antioxidant capacity of the apple pomace extract were assessed and the findings are presented in *table 1*.

Table 1 shows that APP extract had a high carotenoid content of 15.25±0.22 mg/100g d.w. DPPH radical scavaging activity was 18.78±0.09 µmol TE/g d.w. Our results were lower compared to another study, that reported a total polyphenol content of 52.36 ± 1.22 mg GAE/g and a total flavonoid content of 8.40 ± 0.13 mg CE mg/g (Ahmed M.A. *et al.* 2022) after the conventional extraction of APP bioactives with ethyl acetate and stirred at 20°C for 3 hours.

Table 1

Phytochemical content of the APP extract

Parameters	*Sample APP*
Total carotenoids (mg/100g d.w.)	15.25±0.22
Total flavonoids (mg CE/g d.w.)	2.71±0.04
Total polyphenols (mg GAE/g d.w.)	8.40±0.26
DPPH (µmol TE/g d.w.)	18.78±0.09
Inhibition (DPPH) %	83.34 ±0.28

The phytochemical composition of the apple pomace extract varies because of differences in the phytochemical variability of raw materials, raw material fractions, extraction procedures, and environment. The extracts from the apple pomace appear to be remarkable due to their bioactive potential and antioxidant activity.

The samples' phytochemical composition and antioxidant activity are displayed in *table 2*. The food products obtained were examined for their overall phytochemical composition.

Table 2

Phytochemical profile of the control and APP-supplemented yogurts

Parameters	*Type of* Yogurt		
	YC	**YAPP1**	**YAPP2**
Total carotenoids (mg/100g d.w.)	-	17.32±0.28^{b}	29.19±0.50^{a}
Total flavonoids (mg CE/g d.w.)	1.18±0.12^{c}	3.88±0.10^{b}	8.23±0.08^{a}
Total polyphenols (mg GAE/g d.w.)	1.73±0.14^{c}	5.10±0.22^{b}	10.17±0.27^{a}
DPPH (µmol TE/g d.w.)	16.89±0.25^{c}	35.24±0.27^{b}	47.02±0.32^{a}
Inhibition (%)	27.20±0.29^{c}	41.12±0.17^{b}	52.03±0.19^{a}

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

The inclusion of APP in the yogurt products resulted in a dose-dependent increase in phytochemicals (carotenoids, flavonoids, polyphenols) and the ability to scavenge free radicals, as compared to the control group ($p < 0.05$). The addition of increasing concentrations of RFP, ranging from 1 to 2%, resulted in a proportional rise in the levels of carotenoids, flavonoids, and polyphenols in the supplemented yogurts, demonstrating a dose-dependent effect. The scavenging of free radicals by antioxidant activity is directly correlated with the presence of phenolic and flavonoid components in specific food systems. A notable increase in antioxidant activity was seen when the quantities of APP steadily increased. The obtained yogurts highlighted the satisfactory content in phytochemicals. These findings are consistent with those of Ahmed M.A. *et al.* (2022), who found that yogurt containing apple pomace (1 to 2%) increased polyphenols (3.67 to 3.99 mg GAE/g), flavonoids (1.24 to 1.35 CE mg/g), and antioxidant activity (61.80 to 63.85%).

Table 3

Chemical composition of the control and APP-supplemented yogurts

Parameters	*Type of Yogurt*		
	YC	**YAPP1**	**YAPP2**
Water (%)	85.30±0.05^{a}	83.71±0.02^{b}	83.11±0.03^{b}
Dry mattter (%)	14.70±0.07^{b}	16.29±0.03^{a}	16.89±0.02^{a}
Fat (%)	4.43±0.04^{a}	4.66±0.03^{a}	5.07±0.03^{b}
Carbohydrate (%)	5.22±0.06^{a}	3.29±0.06^{b}	1.99±0.05^{c}
Protein (%)	4.53±0.04^{b}	4.92±0.04^{b}	5.12±0.03^{a}
Crude fiber (%)	0.00±0.00^{c}	3.40±0.03^{b}	4.01±0.03^{a}
Ash (%)	0.75±0.02^{c}	0.97±0.03^{b}	1.12±0.04^{a}
pH	4.40 ± 0.11^{b}	4.60 ± 0.11^{a}	4.64 ± 0.11^{a}
Energy value (Kcal/100 g)	77.98±0.16^{a}	73.20±0.12^{b}	72.69±0.07^{b}

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

Table 4

Texture of the control and APP-supplemented yogurt samples

Component	*Type of Yogurt*		
	YC	**YAPP1**	**YAPP2**
Cohesiveness	0.36 ± 0.01^{b}	0.37 ± 0.01^{ab}	0.40 ± 0.01^{a}
Elasticity	5.20± 0.01^{a}	4.31± 0.01^{b}	2.98 ± 0.02^{c}
Firmness, N	5.45 ± 0.02^{c}	6.40 ± 0.02^{b}	7.10 ± 0.01^{a}
Gumminess,	2.00 ± 0.01^{b}	2.60 ± 0.01^{a}	2.64 ± 0.02^{a}
Chewiness, N	14.15± 0.03^{c}	16.11± 0.02^{b}	17.56± 0.03^{a}
Resilience	2.91± 0.01^{c}	3.54± 0.03^{b}	3.89± 0.02^{a}

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

Kennas A. *et al* (2020) documented the beneficial effects of including extra fruit by-products into yogurt polyphenols. They discovered a significant correlation between the levels of yogurt polyphenols and the quantities of added pomegranate peel. Chemical composition of supplemented yogurt. The results of physicochemical composition of yogurt supplemented with APP are summarized in *table 3*.

The addition of APP to yogurt resulted in a substantial enhancement of its chemical composition in comparison to the control. The addition of 1%, and 2%, of APP increased the dry matter, fat, total protein, ash content, and crude fiber of enriched yogurts compared with the control. These results may be due to apple pomace having a high amount of total solids, and proteins. The moisture and carbohydrate levels of all developed yogurts showed a considerable decrease compared to the control yogurt.

The pH of yogurt tends to rise, indicating a decrease in its acidity, which could be attributed to the dilution component. After introducing APP in ascending order, there was a considerable increase in the levels of total solids, as well as fat and ash. There were similar increases in total soluble solids levels when APP was added to the development of fiber-enriched yogurt, as reported in the study of Nagaoka S. (2019).

The textural characteristics of yogurt are essential in evaluating its quality, directly influencing the sensory perception and acceptability of the product by consumers. The evaluation of yogurt samples texture includes essential criteria such as hardness, cohesiveness, elasticity, gumminess chewiness and resilience, which are significantly influenced by the addition of apple powder. The results of these parameters are presented in *table 4*. The APP- supplemented yogurts exhibited lower elasticity, and higher firmness, cohesiveness, gumminess, chewiness, and resilience compared with the control sample.

Yogurt firmness, defined as the force required to cause a certain deformation, is a critical parameter in texture evaluation. Research have shown that yogurt firmness increases with increasing apple powder concentration (Wang X. *et al,* 2019). Thus, firmness was 5.45 N for YC, 6.40 N for yogurt with 1% apple powder (YAPP1) and 7.10 N for yogurt with 2% apple powder (YAPP2). This increase in firmness can be attributed to the interactions between the powder and the protein matrix, which modify the gel network formed during fermentation (Wang X. *et al,* 2019).

The energy required for food breakdown during mastication is referred to as chewiness. It was found to be 16.11± 0.02 N for YAPP1 and 17.56± 0.03 for YAPP2, indicating an increase. Yogurt cohesiveness, another crucial factor, indicates the internal strength of the product structure. The addition of apple powder caused a significant increase in cohesion compared to the control yogurt. Yogurt samples with the addition of 1% and 2% apple powder showed higher cohesion, due to the additional structure provided by the powder, suggesting that apple powder can strengthen the protein network and improve the textural stability of the yogurt.

Table 5

Color evaluation of the control and APP-supplemented yogurt samples

Parameters	*Type of Yogurt*		
	YC	**YAPP1**	**YAPP2**
L*	91.44±0.03^{a}	82.76±0.04^{b}	79.24±0.07^{c}
a*	-8.99±0.02^{a}	1.89±0.01^{b}	2.89±0.07^{c}
b*	11.16±0.01^{c}	16.57±0.02^{b}	19.33±0.10^{a}
Chroma	14.33±0.01^{c}	16.68±0.03^{b}	19.54±0.06^{a}
Hue angle	179.11±0.02^{a}	1.45±0.01^{b}	1.43±0.07^{b}
ΔE	92.53±0.01^{a}	84.41±0.02^{b}	81.58±0.10^{c}

The letters used for every sort of yogurt reflect a comparison based on color characteristics. The distinct characters in each row represent means that show significantly different results ($p < 0.05$).

The investigation of the texture showed that yogurts with APP had a thicker and creamier consistency. This can be ascribed to the high fiber content, which also had a favorable effect on the ability of the yogurt to retain water. Based on the texture analysis, the inclusion of RFP enhanced the textural characteristics of the yogurt in direct proportion to the concentration.

Color evaluation of the control and APP-supplemented yogurt samples. The study revealed significant variations in L*, a* and b* values, depending on the concentration of added apple powder (*table 5*).

The control sample, without the addition of apple powder, showed a lighter color, highlighted by a higher L* value compared to yogurts containing apple powder. This observation suggests that the addition of apple powder lowers the brightness, resulting in a darker color. This change is attributed to the presence of colored compounds in apple powder, which absorb light and reduce the L* value. The a* and b* values increased with the increase in the percentage of apple powder added to the yogurt. Increasing a* values indicate an intensification of red hues, while increasing b* values reflect an accentuation of yellow hues. These changes suggest that the apple powder adds greater color complexity to the yogurt, perceptibly influencing the visual appearance of the product. The highest b* value was obtained for the YAPP2 sample, indicating an intense yellow hue. According to the data presented in *table 5*, yogurts enriched with apple powder (YAPP1 and YAPP2) are characterized by an increased intensity of yellow color, directly proportional to the concentration of added apple powder. This observation is consistent with the presence of phenolic and carotenoid compounds in apple powder, which contribute to the intensification of yellow shades. The hue of yellow was the most descriptive in describing the color of the sample, according to Chroma, a measure of color intensity and saturation, which showed the same trend as the parameter b*. ΔE is the attribute of total color change and ranged from 81.58 to 92.53. The results of the CIELAB colorimetric analysis demonstrate that the addition of apple powder significantly influences the color parameters of the yogurt. The decrease in the L* value and the increase in the a* and b* values reflect a noticeable change in visual appearance, giving the supplemented yogurt a darker and more complex color. These color changes not only improve the visual appeal of the product, but can also be correlated with increased content of bioactive compounds, bringing additional benefits to the final product.

Using a 9-point hedonic scale, the produced yogurts were subjected to a sensory examination, assessing sensory qualities such as appearance, color, odor, flavor, consistency, taste, aftertaste, and overall acceptability. The average results of the sensory evaluation are shown in *table 6*. The results showed that yogurt with 1% and 2% (*w/w*) APP had good overall consumer acceptability for the majority of the attributes assessed.

Table 6

Sensory evaluation scores of control and APP-supplemented yogurts

Sensory attributes	***Type of Yogurt samples***		
	YC	**YAPP1**	**YAPP2**
Color	8.01 ± 0.09^{c}	8.21 ± 0.21^{b}	8.33 ± 0.29^{a}
External appearance	7.27 ± 0.11^{b}	8.07 ± 0.13^{a}	8.22 ± 0.19^{a}
Odor	7.20 ± 0.08^{b}	8.00 ± 0.17^{a}	8.20 ± 0.21^{a}
Flavor	7.32 ± 0.10^{c}	8.12 ± 0.20^{b}	8.30 ± 0.31^{a}
Consistency	8.00 ± 0.22^{c}	8.14 ± 0.33^{b}	8.28 ± 0.41^{a}
Taste	8.07 ± 0.13^{c}	8.20 ± 0.22^{b}	8.32 ± 0.34^{a}
Aftertaste	8.03 ± 0.11^{c}	8.11 ± 0.17^{b}	8.25 ± 0.22^{a}
Overall acceptability	8.11 ± 0.08^{c}	8.31 ± 0.16^{b}	8.42 ± 0.19^{a}

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

All tested products received positive evaluations from the panelists. Overall acceptability hedonic scores increased as APP concentration increased. The YAPP2 yogurt with 2% APP scored highest overall for acceptance attributes in terms of sensory evaluation. This implies that incorporating APP into yogurts can improve their sensory attributes.

Figure 1 **Yogurt samples with different percentages of APP: YC (control), 1% (YAPP1), and 2% (YAPP2)**

The sensory evaluation scores exhibited a significant ($p<0.05$) disparity between the supplemented and control yogurt following the addition of varied quantities of APP. The inclusion of APP up to 2% in yogurt resulted in a high like score of "8" for appearance, odor, flavor, consistency, taste, aftertaste, and overall acceptability, as evaluated by the panelists. This was in comparison to the control yogurts (*figure 1*). The YAPP2 yogurt, which contain 2% APP, received the highest ratings across all 8 characteristics.

CONCLUSIONS

The efficacy of apple pomace as a natural and attractive ingredient in yogurt manufacturing has been proven. Apple pomace not only provides food but also serves as a valuable source of natural flavors and coloration. The yogurt samples that were treated showed a greater quantity of total phenolic contents and antioxidant potential compared to the control yogurt. When apple powder is added to yogurt, it improves some nutritional properties compared to the control sample. It offers the dairy industry new prospects to satisfy the increasing consumers desire for nutritious meals by creating inventive, healthy, and attractive yogurt products.

According to the sensory evaluations, the APP-supplemented yogurts are likely to be acceptable for consumers because they have generally satisfactory characteristics. Hence, apple pomace, a fruit by-product, can be integrated as a natural ingredient and texturizer during yogurt fermentation. This approach enhances the health benefits of yogurt and also encourages sustainable practices by utilizing agricultural by-products. Future research should focus on optimizing the concentration of APP and exploring the long-term health consequences of regular use of yogurt enriched with APP.

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OPTIMISING THE NUTRITIONAL PROFILE OF BUTTER THROUGH ENRICHMENT WITH CACTUS POWDER: AN INNOVATIVE SOLUTION FOR THE FOOD INDUSTRY

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Abstract

In the context of growing concerns around health and nutrition, this research focuses on enhancing the nutritional profile of butter by incorporating cactus powder, an ingredient known for its high fibre and antioxidant content. The study compares the chemical, nutritional, and phytochemical composition of plain butter with butter enriched with cactus powder, assessing the impact of this addition on various physical and chemical properties. The results show that the enriched butter exhibits higher protein content (1.48%) and non-fat solids (4.34%), while the fat and moisture values remain similar to those of plain butter. Phytochemically, the addition of cactus powder led to a significant increase in carotenoids (81.43 µg/g d.m.), flavonoids (1.16 mg EC/g d.m.), and polyphenols (1.91 mg GAE/g d.m.), thus improving the antioxidant potential of the final product, with a free radical inhibition capacity of 60.11%. These findings suggest that cactus powder-enriched butter could contribute to the diversification of healthy food products available on the market, offering a food item with enhanced nutritional value and functional benefits.

Key words: cactus powder, antioxidant potential, nutritional value, enriched butter, food enhancement

Butter, an essential dairy product, obtained through physical processes from milk, cream, yogurt or secondary products such as whey, is one of the most valuable components of milk, both economically and nutritionally. Being a high-fat product, butter plays a significant role in nutrition due to its unique fatty acid composition and the low melting point of milk fat, facilitating easier digestion and providing a high physiological value (Usturoi M.G., 2022).

According to the Turkish Codex Alimentarius standards (Communication No. 2005/19), butter must contain between 80% and 90% milk fat, up to 2% skimmed milk powder and a maximum water content of 16% of its total weight. This composition makes butter easy to digest and a valuable source of energy for the body. As the world's population grows, the demands on food production, including butter, are becoming more stringent, requiring efficiency and quality in the production process.

According to the World Health Organization (WHO), food fortification is an effective and rapid approach to increase the dietary intake of nutrients in large populations without requiring major changes in dietary behavior (WHO, 2006).

In recent years, interest in healthy foods has increased markedly. Consumers prefer low cholesterol, low-fat, low-calorie and high-fiber foods. There are many studies about the effects of fiber in humans (Alsubhi M. *et al,* 2023) the trend is to search for new, natural sources of dietary fiber for the development of food ingredients. *Opuntia ficus indica* is known for its high content in polyphenols exhibiting antioxidant and anti-inflammatory properties (Kuti J.O., 2004). Therefore, functional ingredients rich in antioxidants, dietary fibers, minerals, and vitamins, low in calories and fat, and free of synthetic additives used in the formulation of conventional foods can enhance their nutraceutical potential. In this context, the composition of *Opuntia ficus indica* cladodes makes it a potential ingredient to produce functional foods that promote health (Aparicio-Ortuño R. *et al*, 2024).

Cactus cladode (*Opuntia ficus-indica*) powder appears to bea promising source to obtain this kind of ingredient. This powder could be considered a natural food supplement to be used in solid or liquid foods (Sáenz C. *et al,* 2010). Powdered cactus is highly valued due to its abundance of antioxidants, high dietary fiber content, and essential minerals and vitamins

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including C and magnesium. It is also free of sugar, low in calories, and high in fiber. These characteristics add to its potential health benefits, which include improved digestion and blood sugar regulation. Because cactus powder works well in both savory and sweet recipes, it's a popular choice for anybody searching for an inventive and healthful ingredient (Monteiro S.S. *et al*, 2023). The study seeks to maximize the nutritional benefits of cactus powder, which is well-known for having a high antioxidant and fiber content. The purpose of this study is to create a butter that has been enhanced with cactus powder to increase its nutritional content and examine the effects of this addition on the phytochemical profile. In addition, we aim to develop a novel product that blends the health advantages of cactus powder with a well-known and digestible meal. By offering new nutrient-rich food options, this study hopes to support a healthier and more sustainable diet and benefit the food sector. This study also assessed the impact of cactus powder on the physicochemical, phytochemicals, texture, and sensory characteristics of butters enriched with cactus powder.

MATERIAL AND METHOD

Regarding the methodology part applied to the research, qualitative analyzes were carried out in the first phase on the raw material, namely the cream. After the cream was processed in order to obtain butter, the technological stages were described and in the last part, the finished products were analyzed from a chemical, phytochemical, physical and sensory point of view.

Determination of total dry matter. The process of oven drying butter at 102°C until a consistent mass is achieved serves as the basis for calculating the total dry material. The process for dealing with an ampoule entails weighing five grams of butter. The butter is combined with sand, stirred, and weighed again. To dry, the ampoules are put in the oven. The sheets are taken out and allowed to cool in a desiccator until the butter has fully dried, at which point they are weighed (Bondoc I., 2014).

Determination of the fat content of sour cream by the butyric acid method. The protein components in the cream are broken down by the sulfuric acid, and the fat is then separated by heating and centrifuging the mixture while it passes through the butyrometer rod and isoamyl alcohol acts upon it.The butyrometer is filled with 10 mL of H2 SO_4 (d=1.820), the cream is well homogenized, and 5 mL is taken with a pipette and put on top of the H_2SO_4. After wiping the butyrometer's neck and adding 1 mL of isoamyl alcohol, seal the butyrometer with a rubber stopper. Mix the ingredients together until the casein clot vanishes. The butyrometer is placed inside the centrifuge and left there for five minutes after mineralization.The butyrometer is set up in a 65–70°C sea bath following centrifugation. The fat reading is done on the butyrometer rod at the top, being expressed in percentages (Bondoc I., 2014).

Determination of titratable acidity. It relies on the neutralization of acids with sodium hydroxide in the presence of phenolphthalein, which is utilized as a color indicator. Therefore, 5 mL of the previously homogenized cream should be placed into the Berzelius glass with the aid of a pipette. After washing the used pipette, put 20–25 milliliters of lukewarm distilled water into the glass. When a pink hue lasts for 30 seconds, add two to three drops of 1% phenolphthalein and titrate with 0.1 n NaOH (Bondoc I., 2013).

The manufacture of butter with cactus powder addition. The first step in making butter is the reception of milk, followed by filtering to remove impurities. To separate cream, 50 L of milk were heated to 45-50°C and gradually introduced into a centrifugal separator with a 12 L capacity. The cream was separated in batches. The cream was then physically ripened at 4-6°C for 6 hours. Three batches were prepared: a control batch of plain cream and an experimental batch with 1% cactus powder *(figure 1)*. After forming the batches, the cream was whipped in a mixer *(figure 2)*, and the resulting whey was removed by draining and washing the butter in cold water with ice cubes (Rațu R.N., Usturoi M.G., 2019).

The butter is washed until all the buttermilk is removed and it hardens. Once fully washed, the butter is molded *(figure 3)* and placed on waxed paper for shaping and packaging. After packaging, it is stored at 0-4°C.

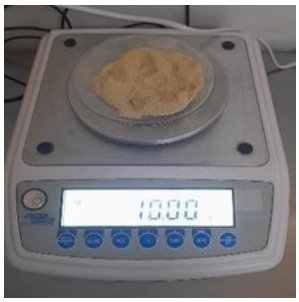

Figure 1 **Weighing the cactus powder**

Figure 2 **Adding the cactus powder to the cream**

Figure 3 **Modeling the butter**

Sensory analysis. From a sensory perspective, the quality parameters were established using the point approach *(table 1*). The point method was used for the sensory examination, the product being analyzed by five tasters who followed the appearance, color, appearance in section, consistency, smell, and taste.

Table 1

Sensory characteristics

Total average score	Qualifying	Product characterization
18.1-20	Very good	The product has positive, specific, well-defined sensory characteristics. It does not have any noticeable defects.
15.1-18	Good	The product has specific positive features that are quite defined, but also very small, insignificant defects.
12.1-15	Satisfactory	The product has poorly outlined specific characteristics, but also small defects due to which it is at the level minimum allowed by the product standard.
7.1-12	Unsatisfactory	The product has defects due to which it is below the minimum quality in the product standard.
4.1-7	Bad	The product has major defects, due to which it is unsuitable for consumption.
0-4	Very bad	Altered product, unsuitable for consumption

In the part of qualitative analyses, sensory, physico-chemical, phytochemical analyzes were carried out in order to establish the qualitative parameters of the samples obtained with the addition of cactus powder as well as of the control sample, according to the AOAC methods.

Phytochemical analysis of butter

Extraction methodology. The study offers a successful procedure for physiologically active compounds extraction that makes use of a 3:1 solvent mixture of n-hexane and acetone. To maximize chemical release, two grams of powder were combined with solvents and sonicated for 40 minutes at 40°C. To separate the liquid from the solid phase, the mixture was centrifuged at 5500 x g for 10 minutes at 4°C. After going through four rounds of repeated extraction, the supernatant was concentrated at 40°C using a rotary evaporator. The quick and pure extraction of physiologically active substances using this approach has shown to be successful; it can be used in food technology, biochemistry, and medicines.

Methodology for determining the total content of flavonoids using spectrophotometry. This section describes the flavonoid quantification procedure according to the method of Dewanto et al. (2002). In this regard, 0.250 mL of the diluted extract (1:10) was mixed with 1.25 mL of distilled water and 0.075 mL of 5% sodium nitrite solution. After five minutes, 0.15 mL of 10% aluminum chloride was added, allowing the mixture to react for 6 minutes. The reaction was neutralized with 0.5 mL of sodium hydroxide 1 M, and the optical absorbance was measured at 510 nm using a spectrophotometer. Total flavonoid concentration was determined using a catechin standard curve, with results expressed as mg EC/g dm.

Evaluation of the content of total phenolic compounds by Folin-Ciocâlteu method. The Folin-Ciocâlteu method for calculating total phenolic compounds in extracts is explained in this section. After adding 1 mL of Folin-Ciocâlteu reagent and 15.8 mL of distilled water to 200 µL of extract, the total volume was 17 mL. Ten minutes later, three milliliters of 20% sodium carbonate were added, and the mixture was left to incubate for sixty minutes at 25°C in the dark. A UV-VIS spectrophotometer was used to detect absorbance at 765 nm. The results allowed for a standardized comparison of the phenolic content between samples because they were represented in milligrams of gallic acid equivalents (GAE) per gram of dry matter (dm).

The methodology for determining the antioxidant activity using DPPH. The DPPH technique was employed in the study to assess antioxidant capability. To obtain a 100 mL stock solution, 25 mg of DPPH was dissolved in methanol. This solution was then further diluted 1:10 to obtain the working solution. Concurrently, a TROLOX stock solution (25 mg in 50 mL 10% ethanol) was made, with concentrations for the standard curve ranging from 1.25 to 25 µM. Included in the reaction volumes were:100 µL of plant extract coupled with 3.9 mL of DPPH solution. Control: 3.9 mL of DPPH solution mixed with 100 µL of 10% methanol. After 90 minutes in the dark, the absorbance at 515 nm was measured, demonstrating the degree of antioxidant activity and the solutions' capacity to lower the DPPH radical.

Texture analysis. was determined using a MARK-10 texturometer (USA) equipped with a series 5 dynamometer, having a maximum capacity of 250 N (25 kgf) and a resolution and accuracy of 0.01 N *(figure 4)*.

Figure 4 **Request to cut a sample of butter**

RESULTS AND DISCUSSIONS

In order to guarantee a high quality finished product, the cream used to make the butter must be of a certain quality *(table 2)*. The average water content of cream was measured at 56.16±0.05%, while the average dry matter value was 43.84±0.01%. These figures show that the composition of the cream is ideal because they are balanced. To guarantee the fluidity of the cream and to facilitate the process of fat separation during butter formation, an adequate water content is necessary.

From *table 2* it can be seen that the average protein value was 2.37±0.01%, which means that it can improve the quality of the cream and at the same time it can help in the process of beating and separation of fats. Fat content averaged 31.95±0.05%, with a range of variation between 32.06% and 31.80%. This fact can help the finished product have a rich texture and remarkable stability, making it perfect for making butter. Regarding acidity, it has an average value of 17.04±0.31.

Table 2

Chemical analysis results for cream

Specify	N	$X \pm s_X$	V%	Min	Max
Water %	5	56,16±0,05	0,31	31,80	32,06
Dry matter %		43,84±0,01	0,07	43,80	43,88
Fat %e		31,95±0,05	0,31	31,80	32,06
Protein %		2,37±0,01	0,81	2,35	2,40
Acidity (°)		17,04±0,31	4,12	16,20	18,10

The outcomes for simple butter are shown in the *table 3*. The acquired data indicates that the average water content value was 13.64±0.014% and the average total dry matter value was 86.36±0.014%. The average value obtained for the protein content was 1.34±0.005%, and the average fat content was 82.50±0.006%, with 82.48% and 82.52% as the limits of variance.

Table 3

Chemical results of plain butter

Specify	Values of Reference	N	$\bar{X} \pm s_X$	V%	Min	Max
Water +Non-fat dry matter	17	5	17,5±0,006	0,08	17,48	17,52
Water (%)	16		13,64±0,014	0,22	13,60	13,67
Dry mattter (%)	84		86,36±0,014	0,04	86,33	86,40
Non-fat dry matter	1		3,86±0,014	0,79	3,83	3,90
Protein (%)	0,7		1,34±0,005	0,85	1,32	1,35
Fat (%)	83		82,50±0,006	0,02	82,48	82,52

Table 4 shows the results obtained for the chemical composition of the butter with the addition of cactus powder, highlighting the following values: the combined content of water and non-fat dry substance has an average value of 17.71 ± 0.03%, with an average water content of and a total dry matter of 86.63 ± 0.01%.

These data reflect the impact of the addition of cactus powder on the chemical composition of the butter, showing minor changes compared to plain butter. Therefore, in terms of water and dry matter content, the reference value for butter is 17%, the average values we obtained being 17.5±0.006% for plain butter and 17.71±0.03% for butter with cactus powder.

Table 4

Chemical results of butter with cactus powder

Specify	Values of Reference	N	$\bar{X} \pm s_X$	V%	Min	Max
Water + non-fat dry matter	17	5	17,71±0,03	0,44	17,59	17,80
Water (%)	16		13,37±0,01	0,18	13,35	13,40
Dry matter (%)	84		86,63±0,01	0,03	86,60	86,65
Non-fat dry matter	1		4,34±0,03	1,63	4,24	4,41
Protein (%)	0,7		1,48±0,005	0,77	1,47	1,50
Fat (%)	83		82,29±0,035	0,10	82,20	82,41

It is noted that the butter with the addition of cactus powder has an average value of non-fat dry substance of 4.34%, significantly higher compared to plain butter (3.86%) as well as to the reference value of 1%, indicating a improving the nutritional content by adding cactus powder. The fact that

butter with cactus powder has a significantly higher protein content of 1.48% compared to plain butter (1.32%), as well as the reference value of 0.7% indicating an improvement in protein content by adding cactus powder.

The phytochemical profile of plain butter compared to that enriched with cactus powder reveals significant improvements in the bioactive composition and antioxidant potential of the final product. *Table* 5 shows that plain butter lacks carotenoids compared to butter with cactus powder, which has an average value of 81.43 ±1.50 µg/g d.u. These natural pigments, because of their antioxidant qualities, play important roles in immunological and eye health. The product's anti-inflammatory and antioxidant properties are enhanced when the flavonoid concentration rises from 0.49±0.02 mg ec/g s.u. in plain butter to 1.16 ±0.02 mg ec/g s.u. in the one with cactus powder. Because they neutralize free radicals, total polyphenols, with an average value of 1.91 ±0.03 mg EAG/g s.u. in the enriched butter and 0.81±0.04 mg EAG/g s.u. in plain butter, imply a greater potential for cell protection and cardioprotection. Using the ABTS method to assess antioxidant activity, the results indicate a free radical inhibition capacity of 36.81±0.49% in plain butter and 60.11±0.45% in butter with cactus powder. This translates to 687.55± 10.87 µM Trolox/g s.u. and 1186.04±9.84 µM Trolox/g s.u., depending on the type of butter.

These findings suggest that adding cactus powder to butter enhances its nutritional profile and gives it better functionality, promoting it as a novel product with more health benefits.

Table 5

Phytochemical results of butter

Butter samples	Total carotenoids, µg/g dm.	Total flavonoids, mg EC/g dm.	Total polyphenols, mg EAG/ dm.	Antioxidant activity (ABTS),	
				µM Trolox/g dm.	Inhibition, %
Butter	-	0,49±0,02	0,81±0,04	687,55±10,87	36,81±0,49
Butter with cactus powder	81,43 ±1,50	1,16 ±0,02	1,91 ±0,03	1186,04±9,84	60,11±0,45

In terms of average cutting forces, recorded from texturometer tests *(figures 5, 6)*, we can see that for plain butter the cutting force is 2.85N and for butter with 1% cactus powder it is 3.05N. Since the tested butter samples were of the same size and the tests were performed at the same temperature 10.75°C, the difference in cutting force obtained is due to the addition of cactus powder, and this difference is very small at 0.2N.

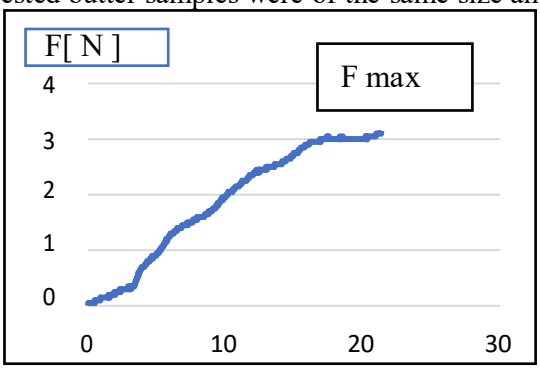

Figure 5 **Maximum cutting force recorded with a plain butter texturometer**

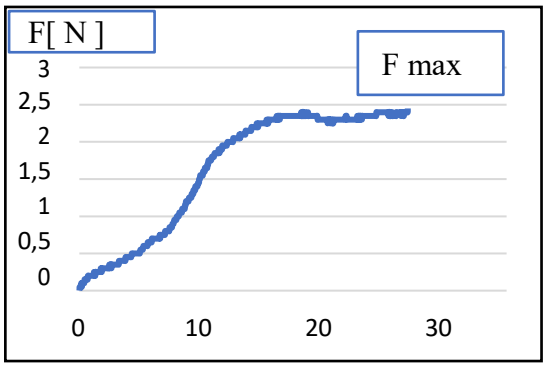

Figure 6 **Maximum cutting force recorded with a texturometer of butter with cactus powder**

The quality of the cream used in butter production is crucial to ensure a high-quality final product. In the interpretation of the results obtained from the sensory analysis of the plain butter and the one enriched with cactus powder, we observe significant differences. *Figure 7* shows us that plain butter has more balanced scores in all categories, but without extreme values. In contrast, in *Figure 8* we can see that the butter with cactus powder obtained higher ratings in terms of smell and taste, which suggests an improvement of these attributes due to the cactus powder. Plain butter scored 17.8 points, reflecting high quality and appreciation for its traditional characteristics. On the other hand, the cactus powder enriched butter scored higher at 18.6 points, reflecting a slightly higher appreciation due to the innovation brought by the addition of cactus powder.

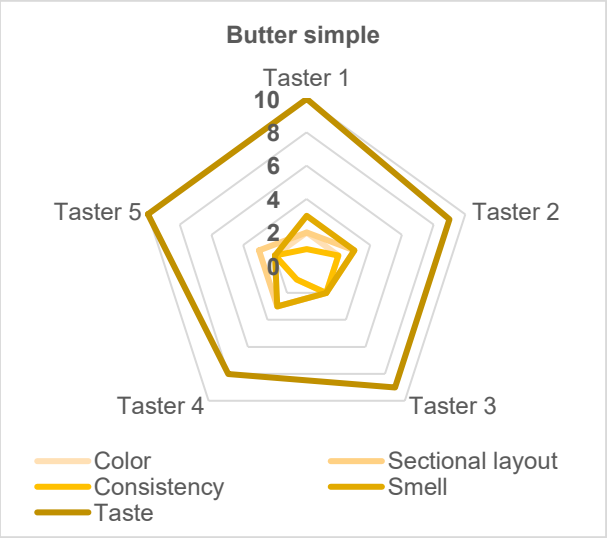

Figure 7 **Sensory evaluation of simple butter**

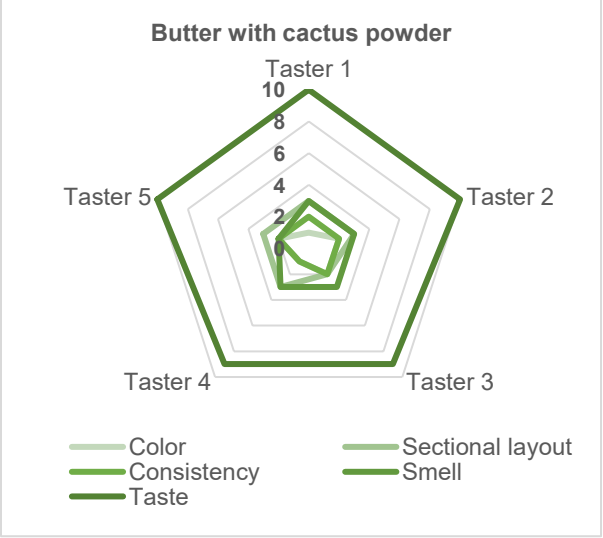

Figure 8 **Sensory evaluation of butter with cactus powder**

CONCLUSIONS

In the modern era, consumers are increasingly interested in food products that offer not only the pleasure of taste, but also health benefits. The sensory acceptability of any food product is a crucial component. The new variety may have been preferred by customers because of its improved taste, texture, and aroma compared to the butter made with cactus powder.

The innovation of adding cactus powder to butter is an important step towards the development of functional food products. This product not only offers a superior taste experience, but also brings significant health benefits due to its high content of antioxidants and nutrients.

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QUALITY ASSESSMENT OF SOME ASSORTMENTS OF CHICKEN BREAST PASTRAMI

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Abstract

The purpose of this paper was the comparative assessment of the quality of some assortments of chicken breast pastrami sold in Romania. Two batches from five manufacturer of chicken breast pastrami were taken in the study: Marcel, Aldis, Caroli, Jumbo, Prodprosper, coded from A to E. Sensory (five-point scale method) and physico-chemical properties were analyzed. Were determined the pH of the products, the content of water, lipids, proteins, collagen and salt (with the Food-Check infrared spectrophotometer). The results showed significant differences between products in terms of fat content (between 0.9% and 5.5%), the variability was lower for proteins (between 21.1% and 21.9%) and water content (between 72.9% and 76,1%). The salt content had the highest value of 4.03%, exceeding the maximum standard limit, only in the case of C product. The pH value varied between 5.49 for E product, and 6.28 for B product. The results of the sensory analysis revealed a minimum score for product E (12.58 points/ "satisfactory product" according to quality standards), compared to product D which obtained the best score among all the analyzed assortments (18.06 points/ "very good product ").

Key words: *quality, chicken meat, pastrami, sensory*

Meat and meat products, are of important in terms of adequate and balanced nutrition and known as a good source of protein, B vitamins and iron. Pastrami is a meat product obtained by subjecting all the muscles extracted from certain parts of animal carcasses to various processes and made ready for consumption by cutting them into thin slices. Salt brought together with pastrami in the curing step dissolves functional myofibrillar proteins, increasing the water-holding capacity and binding properties of proteins as well as its concentration-dependent bacteriostatic effect, which plays a critical role in establishing microbial stability in pastrami (Gurun G., *et al,* 2021).

Chicken breast meat is recognized as a healthy food source with an excellent nutrient composition (Jung D.Y., *et al,* 2022; Da Silva *et al,* 2017). It is high in protein content and low in cholesterol and fat content, as well as low in calories (Kim H.J., *et al*, 2020). Therefore, in terms of nutrition, it is more attractive to the modern health-conscious consumer (Petracci M., *et al*, 2014). With the increasing trend in wellness-oriented consumerism, the consumption of chicken breast meat has increased along with the consumers' interest in improving meat quality such as texture, flavor, juiciness, appearance, health, organic, and safety (Henchion M., *et al,* 2014). The consumer's request for animal welfare during the meat production process has raised the question as to whether animal-friendly rearing has an impact on the meat quality (Enfalt *et al,* 1997; Lin et al., 2014; da Silva *et al,* 2017). A method of valorization with added value to poultry meat is represented by the processing of chicken breast through heat treatment and smoking.

The purpose of this paper was the comparative assessment of the quality of some assortments of chicken breast pastrami sold in Romania.

MATERIAL AND METHOD

Two batches from five manufacturer of chicken breast pastrami were taken in the study: Marcel, Aldis, Caroli, Jumbo, Prodprosper, coded from A to E. Sensory (five-point scale method) and physico-chemical properties were analyzed. Were determined the pH of the products, the content of water, lipids, proteins, collagen and salt (with the Food-Check infrared spectrophotometer). The data obtained were statistically processed, applying the *t-test* and *ANOVA* multiple comparison/Graph Prism 10.3.1.

The evaluation of the sensory quality was carried out in the Sensory Analysis Laboratory of USV Iasi by the participation of a group of 41 students in food engineering, each receiving an individual sheet (*table 1* and *table 2)* according to the professional standard for meat industry (SP 3196-83).

Prior to analysis, the samples were brought to a temperature of 18-21°C, according to the provisions of the professional/product standards.

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The evaluation of each sensory characteristic was performed by comparing with scoring scales of 0-5 points, by obtaining the total average score for all the characteristics examined by the group of tasters and by comparing it with a scale from 0 to 20 points for weighted average score obtained after tasting (*table 2*).

Table 1

The sensory characteristics of meat products

Score	Positive and negative characteristics
5	Very good = specific positive characteristic, very well defined. It does not present any kind of lacks or perceptible defects.
4	Good = specific positive characteristic, quite defined, but also very small, insignificant shortcomings or defects.
3	Satisfactory = specific positive characteristic, poorly outlined and small deficiencies or defects; the quality is at the minimum level allowed by the standard.
2	Unsatisfactory = lacks or defects in the appropriation, does not meet the minimum condition in the standard, but can be used under certain conditions.
1	Bad = lacks or defects in the property such that it can no longer be used for consumption except after appropriate processing (if possible).
0	Altered = specific obvious defects of the altered product – it cannot be used as food.

Table 2

The quality class of meat product

Total average score	Quality
18.01 ÷20	Very good
15.01÷18	Good
11.01÷15	Satisfactorily/acceptably
7.01÷11.0	Unsatisfactory
0÷7	Altered

The analysis of shape- appearance and color is performed in natural light. The appearance and color were examined on the outside of the products, then on the inside.

The smell analysis was performed by simple inspiration.

The tasting of the samples was done carefully, without haste, with relaxation breaks of about 2 minutes between the portions of the sample; 5-10 g of product were taken for tasting.

Before and after tasting each sample, the tasters rinsed the oral cavity with drinking water to eliminate the remaining taste.

RESULTS AND DISCUSSIONS

From the analysis of ingredients (*table* 3), it is observed that three out of five producers (A, B and D), added monosodium glutamate (a controversial flavor enhancer that should not be present in high-quality meat products), thus emphasizing the distrust of educated consumers in this regard in the loyalty of industrial production practices, specific to ready-to-eat meat preparations. The same three manufacturers added carbohydrates in the form of maltodextrins, dextrose and in addition glucose (D product), which deceives the consumers, also enhancing the flavors. Producer B had also added flavors, without the legal obligation to present them on the label.

Table 3

The ingredients of the products analyzed

Ingredients	A	B	C	D	E
Chicken breast	85%	91%	?	?	90%
Water	?	?	?	?	?
Salt	Salt	Salt	Salt	Salt	Salt
Stabilizers	sodium diphosphate, sodium triphosphate	sodium polyphosphates	diphosphates, triphosphates, polyphosphates	triphosphates, polyphosphates	polyphosphates
Thickening agents	carrageenan	carrageenan	xanthan gum	carrageenan	-
Sugars	maltodextrins, dextrose	dextrose, maltodextrin	-	dextrose, glucose, maltodextrin	-
Flavor enhancers	sodium monoglutamate	sodium monoglutamate	-	sodium monoglutamate	-
Antioxidants	sodium ascorbate	ascorbic acid	sodium erythorbate	sodium erythorbate	sodium erythorbate
Preservatives	sodium nitrite	-	sodium nitrite	sodium nitrite+sulfites	sodium nitrite
Dyes	carmine	carmine	-	carmine	paprika emulsion
Other ingredients	paprika extract	soy protein, potato extract, spices and spice extracts, flavors?	starch, spices	spice extract, vegetable soy protein	polyphosphates

Following the sensory evaluation of the five products studied (*figure* 1), it was observed that product D had the highest score, being the most appreciated by the tasters (by average 4.6 points for smell, 4.5 points for taste and global assessment, and 4.4 points for color and appearance). Close values were obtained by the products A, B and C. The smallest average score was obtained by the product E (3.6 points for appearance, 3.3 points for color, 3.2 for global assessment and 3.1 for taste and smell.

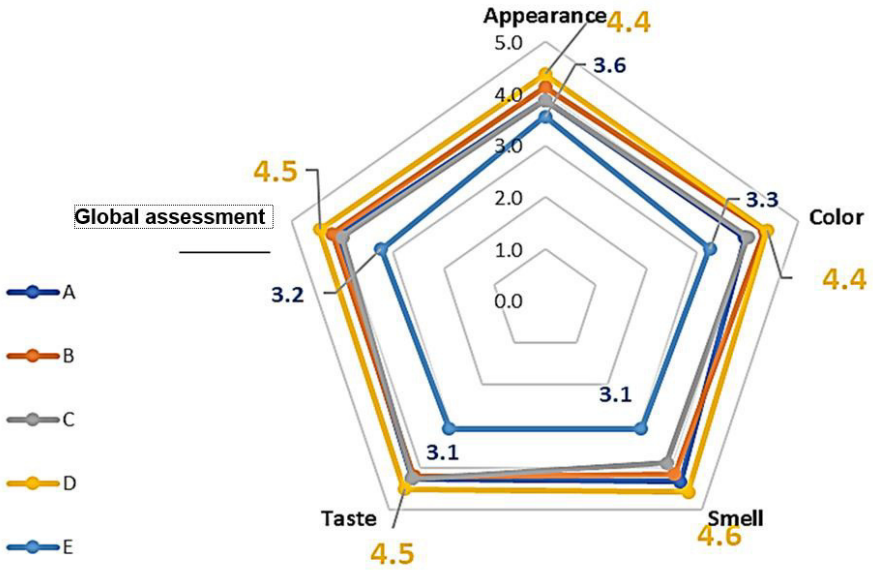


Figure 1 **The average score for the product studied**

Total weighted score for the product studied (*figure* 2) classified the products into three quality classes, based on the values obtained. Thus, three products A, B and C were classified into the quality class "good products", one product (product E) was into "satisfactory /acceptably" quality class and only one product (product D) was classified into the quality class "very good" product, at the lower limit (with 18.06 weighted score), otherwise showing the lack of high quality of this product's analyzed.

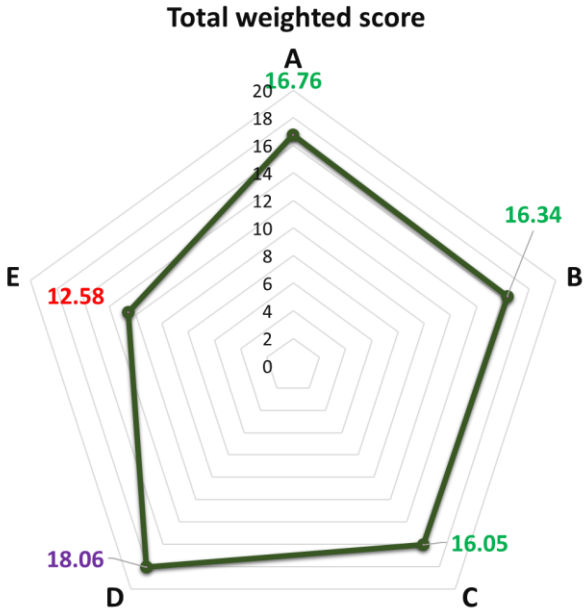
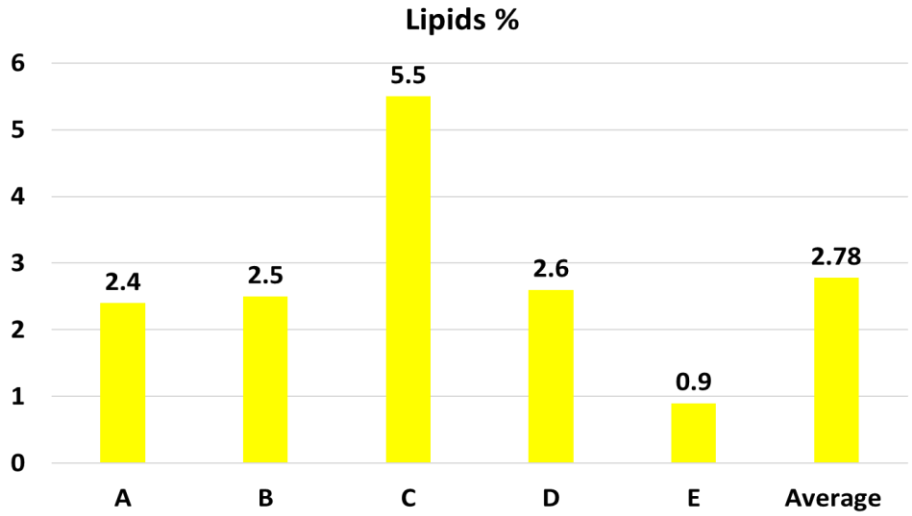


Figure 2 **Total weighted score for the product studied**

The content of lipids in the five products analyzed show very significant differences between E product and the other four products (*figure* 3).

The highest amount of lipids was observed in C product, 5.5%, surprisingly high compared to the other products analyzed, being the only product that had added starch in its composition, (this fact being found in the list of ingredients); a possible explanation would be that starch binds the fats in the products, thus there is no lipids loss through the applied heat treatment compared to A, B, D and E products.

The lowest lipid content was found in product E (0.9%), being the only product, of those analyzed, that did not have a thickening agent added to the ingredients.



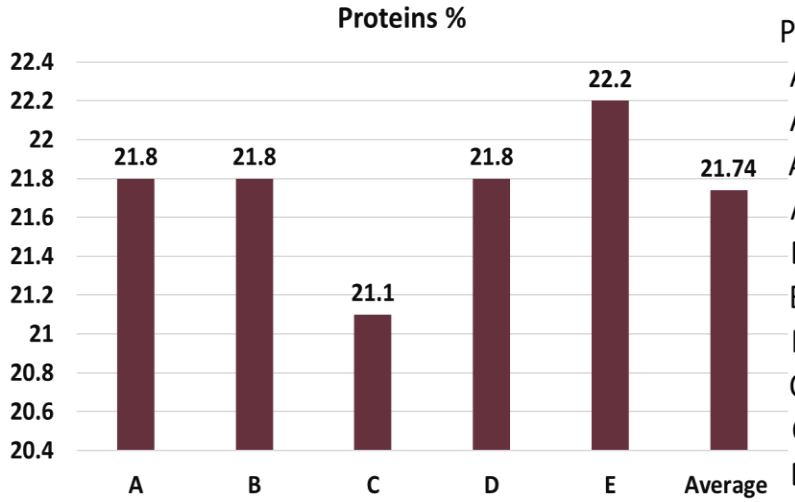
Lipids %	Signif.
A vs B	ns
A vs C	**
A vs D	ns
A vs E	***
B vs C	**
B vs D	ns
B vs E	***
C vs D	**
C vs E	***
D vs E	***

Figure 3 **The lipids content of the product studied**

The highest content of proteins (*figure* 4) was found in product E (22.2%) and the lowest in the product C (21.1%), being inversely proportional to the amount of lipids determined.

Statistically, the differences were predominantly insignificant between the products analyzed, and distinctly significant between products A vs B, A vs C, and A vs E.

On average

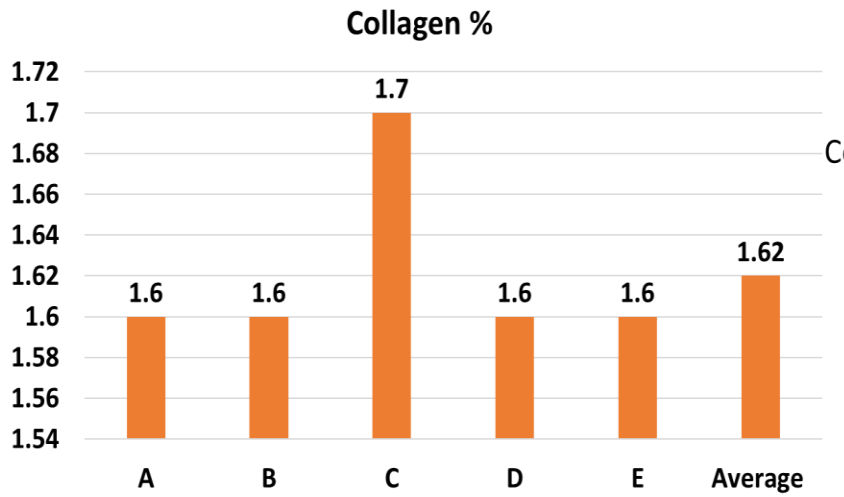


Proteins	t	p	Signif.
A vs. B	4.97	<0.001	**
A vs. C	4.20	0.00	**
A vs. D	1.29	0.23	ns
A vs. E	4.97	<0.001	**
B vs. C	0.29	0.78	ns
B vs. D	0.60	0.56	ns
B vs. E	0.00	1.00	ns
C vs. D	1.54	0.16	ns
C vs. E	0.00	1.00	ns
D vs. E	0.00	1.00	ns

Figure 4 **The proteins content of the product studied**

The collagen content of the studied products (*figure* 5) was higher in product C compared to the rest of the products, being the same (1.6% average values) with an average of 1.62% for all five products. The statistically differences for collagen were predominantly insignificant between the products analyzed, and distinctly significant between products A vs C, and C vs E.

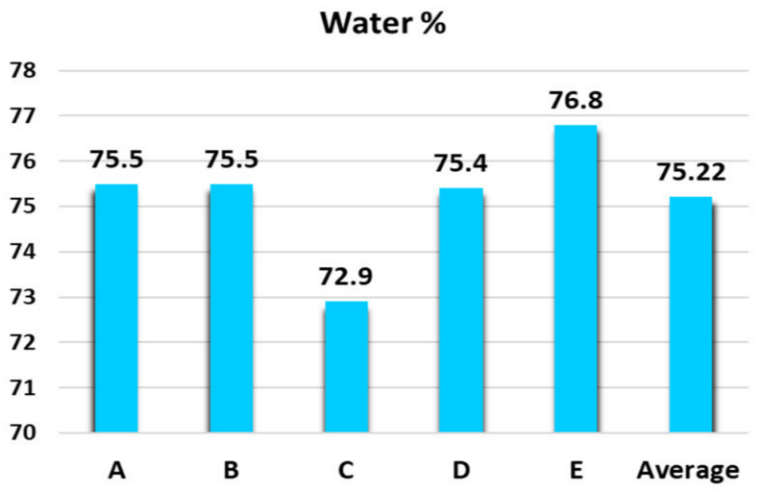
The water content (*figure* 6) was the highest for E product (76.8 %) and smallest for C product (72.9%) being inversely proportional to the lipid content (*figure* 3) and in close correlation with the protein content (*figure* 4) of the analyzed products.



Collagen %	t	p	Signif.
A vs B	0.52	0.617	ns
A vs C	2.552	0.034	**
A vs D	0.053	0.959	ns
A vs E	1.683	0.133	ns
C vs E	3.177	0.013	**

Figure 5 **The collagen content of the product studied**

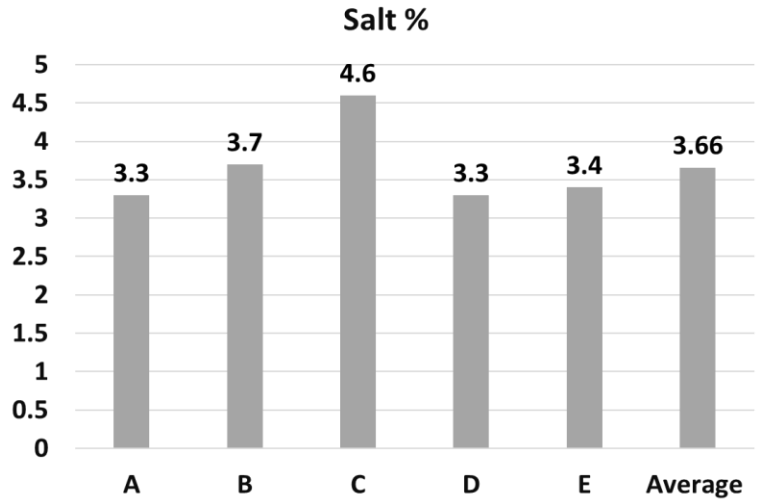
The statistically differences for water content were predominantly insignificant between the products analyzed, and significant between products A vs C, B vs C and C vs E.



Water %	t	p	Signif.
A vs B	0.168	0.872	ns
A vs C	9.980	0	*
A vs D	0.292	0.781	ns
A vs E	2.005	0.078	ns
B vs C	9.972	0	*
B vs D	0.16	0.876	ns
B vs E	2.959	0.018	*

Figure 6 **The water content of the product studied**

The salt content (*figure* 7) was highest for C product 4.6%, exceeding the maximum standard limit, followed by B product with 3.7 %. Products A, D and E had similar mean value for salt content (3.3 to 3.4), with an average value of 3.66%.



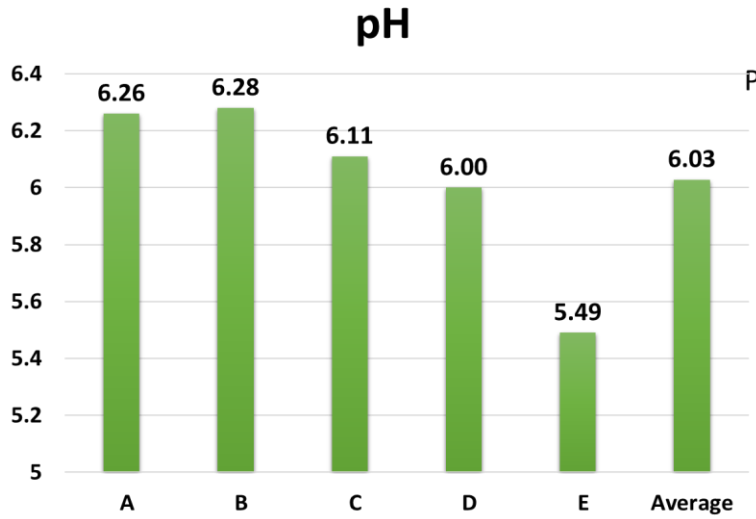
Salt	t	p	Signif.
A vs. B	2.67	0.03	**
A vs. C	2.00	0.08	*
A vs. D	0.33	0.75	ns
A vs. E	0.00	1.00	ns
B vs. C	1.00	0.35	ns
B vs. D	0.25	0.81	ns
B vs. E	0.00	1.00	ns
C vs. D	1.50	0.16	ns
C vs. E	1.00	0.35	ns
D vs. E	0.00	1.00	ns

Figure 7 **The salt content of the product studied**

The statistically differences were predominantly insignificant, with the exception of A vs B products where distinctly significant differences were highlighted, and A vs C products, where significant differences were found.

The pH values (*figure* 8) of the products analyzed was smallest for E product (5.49) and highest for B and A products (6.26 for A product and 6.28 for B product).

The mean values were 6.03 for all products studied. The pH value indicates a good state of freshness of the analyzed products.



Products	t	p	Signif.
A vs. B	0.37	0.717	ns
A vs. C	2.256	0.052	*
A vs. D	2.905	0.015	**
A vs. E	5.295	<0.001	**
B vs. C	1.649	0.144	ns
B vs. D	2.297	0.048	**
B vs. E	4.811	<0.001	**
C vs. D	0.735	0.486	ns
C vs. E	3.979	0.002	**
D vs. E	1.827	0.093	ns

Figure 8 **The pH value of the product studied**

The statistically differences were distinct significant for A vs D and E products, for B vs D and E product and C vs E products. Significant differences were found for A vs C products and insignificant differences for A vs B, B vs C, C vs D, and D vs E.

CONCLUSIONS

The results showed significant differences between products in terms of fat content (between 0.9% and 5.5%), the variability was lower for proteins (between 21.1% and 21.9%) and water content (between 72.9% and 76.1%).

The salt content had the highest value of 4.03%, exceeding the maximum standard limit, only in the case of C product.

The pH value varied between 5.49 for E product, and 6.28 for B product.

The results of the sensory analysis revealed a minimum score for product E (12.58 points/ "satisfactory product" according to quality standards), compared to product D which obtained the best score among all the analyzed assortments (18.06 points/ " very good product ").

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INNOVATIVE BIOSENSOR TECHNOLOGY FOR REAL-TIME DETECTION OF PATHOGENIC BACTERIA IN FOOD SUPPLY CHAINS

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Abstract

Microbiological foodborne diseases pose significant difficulties to public health and the food sector, involving prompt and precise detection techniques to avoid foodborne diseases and guarantee food safety. Traditional individual biosensing methods often have constraints regarding their sensitivity, specificity, and response time. Implementing biosensors has been recognized as an innovative method for quickly identifying foodborne diseases in food products. A biosensor is a system that combines a biological detection material with chemical or physical transducers to convert chemical, biological, or biochemical information into detectable electrically transmitted impulses. This review presents an examination of the benefits, difficulties, and future possibilities of multimodal biosensing for foodborne diseases, highlighting its revolutionary capacity for ensuring food safety and improving public health. Finally, the primary objective of this study is to make a valuable contribution to the advancement of novel approaches in addressing foodborne diseases and guaranteeing the authenticity of the food supply chain.

Key words: foodborne diseases, biosensors, food safety, food supply.

Understanding the problem

Foodborne diseases have increased in frequency and now they pose a significant hazard to worldwide public health, impacting around 600 million individuals annually. Foodborne pathogens induce thousands of diseases, being considered important risks to human health and economy due to their detrimental health impacts (Faour-Klingbeil D. *et al,* 2020; Moi I.M. *et al,* 2022). The World Health Organization (WHO) reports that about 30% of foodborne fatalities occur in children under five years old. Foodborne bacteria, the etiological agents of foodborne diseases, can induce symptoms ranging from mild to severe, including diarrhea, or debilitating illnesses like meningitis (Scallan Walter E.J. *et al,* 2020; Elbehiry, A. *et al,* 2023).

Food poisoning may lead to malnutrition, serious gastrointestinal disorders, and potentially cancer. To successfully manage the challenge of toxicity in food products, it is essential to create rapid and precise instruments for detecting harmful substances in food. Sun drying and heating were likely the initial procedures employed, followed by polymerase chain reactions and instrumental analysis, which are two of the most prevalent traditional techniques for detecting food toxins (Tarannum N. *et al,* 2024). These procedures are laborious, costly, and time-consuming, rendering them impractical for business applications that require rapid and on-site screening of a significant number of samples (Wang L.Y.Z. *et al,* 2019).

The surveillance of bacterial contamination in the food chain encompasses several analytical techniques and the application of advanced automated tools designed for the detection of foodborne contaminants (Silvestri E.E. *et al,* 2017). Nonetheless, certain challenges and constraints exist in the application of these conventional methods. Furthermore, diagnostic instruments must evaluate feasibility and provide flexibility to detect specific pathogens responsible for the occurrence of foodborne diseases (Ali A.A. *et al,* 2020). In this context, nanotechnology, specifically nanosensors, can be employed in the food industry to detect toxicity in food during packing and storage. There is an increasing demand for nanotechnologies due to the development of remarkable potential and innovative applications across various sectors, including the food businesses (Tarannum N. *et al,* 2024).

Nanotechnology-based sensors and other technologies are employed to detect harmful microparticles, including microplastics and bacteria, found in various materials used by consumers. Nanomaterials are defined as substances possessing at least one dimension less than 100 nanometers. Owing to their very small dimensions, they display unique chemical and

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physical features. Nanoparticles can enhance the physical, mechanical, and biological attributes of food packaging by improving its quality, flexibility, grade, and sustainability (Ashfaq A.N. *et al,* 2022).

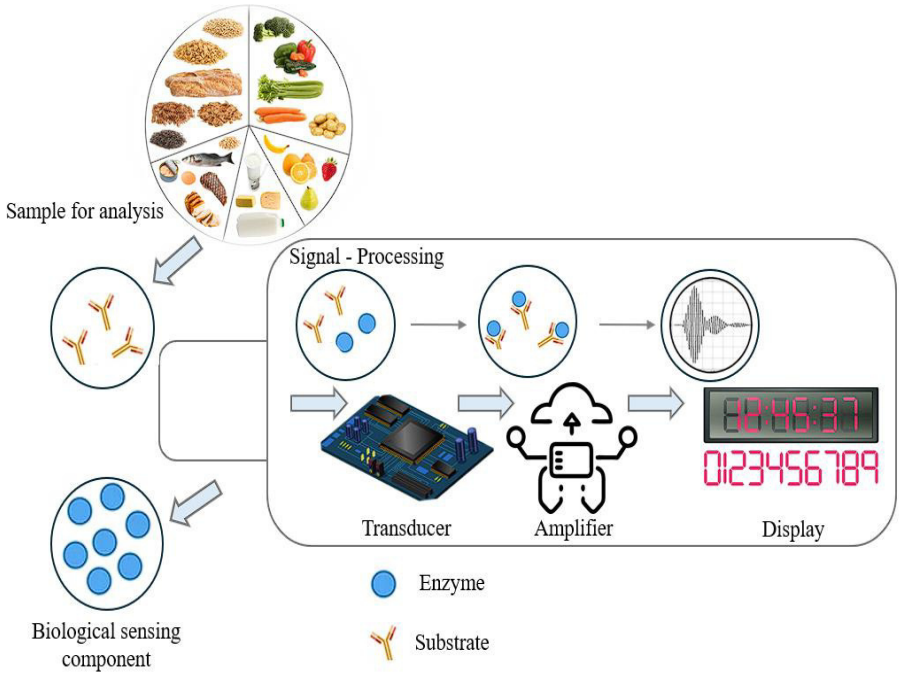

Figure 1 **- Diagram of biosensor operation, indicating recognition element – analyte contact and signal transduction (adapted from Nath S., 2024)**

Introduction to Biosensor Technology

A biosensor is an analytical instrument that quantitatively or semi-quantitatively measures, having a sensing element of biological origin that is either integrated with or closely associated with a physico-chemical transducer. A chemical sensor is an instrument that converts biochemical information, from the concentration of a particular element to comprehensive composition analysis, into an output which is analytically valuable *(figure 1)* (Thakur, M.S. *et al,* 2012). Chemical sensors typically have two fundamental components linked in the series: a chemical identification system (receptor) and a physicochemical transducer. Biosensors are chemical sensors that employ a biological process for recognition, interacting with a photoelectric device. A device that employs specialized biochemical processes facilitated by isolated enzymes, immune systems, tissues, organelles, or entire cells to identify chemical molecules, typically through electrical, thermal, or luminescent signals (Nic M. *et al,* 2006).

The sensor layer, integrated with appropriate transducers such as carbon nanotubes, graphene, or nanoparticles, produces quantifiable signals from these biorecognition processes. Diverse signal detecting methodologies, including as impedimetric, amperometric, and voltametric procedures, enable biosensors to provide responses that are proportionate to the number of specific analytes. This approach is applicable for the pre-treatment procedures and identification of microorganisms in different food products (Zhang L. *et al,* 2024).

Biosensors are instruments that identify diseases through the utilization of biological recognition features such as antigens, enzymes, or sequences of DNA. They can detect and quantify the presence of pathogenic germs in real time. Several types of biosensors exist, such as electrochemical and optical sensors (Castillo-Henríquez L. *et al,* 2020). Electrochemical sensors identify alterations in electrical signals in the presence of a pathogen, whereas optical biosensors utilize variations in light patterns, such as fluorescence, that indicate the contamination. The advantages of such devices are manifold - rapidity, sensibility, and accuracy (Naresh, V. *et al,* 2021).

Due to their minuscule scale, nanomaterials provide a significantly broader surface for reactions. This enhances the biosensor's sensitivity, enabling the detection of very small amounts of pollutants or pathogens. Nanomaterial biosensors are frequently coated with biological detection components such as antigens, enzymes, or DNA that exhibit high affinity for the biological target (bacteria, toxins,

etc.). After binding the target substance to the sensor, the characteristics of the nanomaterial (such as electrical conductivity, color, or fluorescence) undergo alteration. The biosensor's transducer identifies these alterations, converting the physical or chemical reaction into a signal that can be measured. This signal is subsequently analyzed and exhibited, enabling users to promptly ascertain contamination levels in real time (Malik S. *et al,* 2023; Fu Y. *et al,* 2024). *Identification of pathogens (e.g. E. coli or Salmonella spp.) in food products such as meat, dairy products, and vegetables:* a biosensor embedded with gold nanoparticles is engineered to selectively attach to the DNA of bacteria or protein molecules. When the pathogen is detected in a food sample, such as meat, the bacterial particles adhere to the surface of the sensor. This alters the characteristics of the nanoparticles, such as their electric or optic signals. Thus, these alterations are subsequently identified and analyzed, signifying the pathogen's presence in real-time (Xu L. *et al,* 2021). *Identification of pesticide residues on agricultural products, facilitating food safety and adherence to health standards*: nanosensors derived from graphene are capable of detecting pesticide residues. The sensor is equipped with enzymes that bind with pesticide compounds. The interaction between the pesticide and the surface of graphene alters the sensor's electrical conductivity. This alteration is subsequently assessed and quantified, yielding prompt feedback on the concentrations of pesticides detected. In a supply chain, business companies can employ these types of biosensors to rapidly assess batches of products before shipment to verify compliance with safety regulations (Srinivasan S. *et al*, 2024; Pan Y. *et al*, 2024).

Identification of toxins (e.g., aflatoxins) in cereals, nuts, or herbs and spices: nanomaterial biosensors are employed to identify minimal quantities of aflatoxins in the food chain. Quantum dots, which are semiconductor nanoparticles, are employed in fluorescence biosensors for the detection of harmful substances. These sensors are covered with antibodies that specifically attach to aflatoxins. Thus, aflatoxins from a food product adhere to the quantum dot surface, modifying the sensor's fluorescence characteristics. The alteration in fluorescence is recognized, yielding a rapid and precise assessment of the toxin level. Grain facilities for storage use these types of sensors to test corn or nuts for aflatoxin contamination prior to processing or exportation (Yan C. *et al,* 2020; Yadav N. *et al,* 2021).

Monitoring heavy metals, including residues of lead or mercury, in food and water to guarantee food safety by preventing hazardous concentrations of metals in products: silver nanoparticles are frequently utilized in biosensors for the detection of metals like lead or mercury. These nanoparticles exhibit high sensitivity to metal ions. The binding of lead or mercury ions to the silver nanoparticles in the sensor results in a quantifiable alteration in the optical or electrochemical properties, signifying the presence of heavy metals in the sample. A biosensor can be submerged in a sample of water or a beverage such as juice, to detect heavy metal contamination during the production or the packing process (Ivanišević I. *et al,* 2021; Anchidin - Norocel L. *et al,* 2024).

Assessing the freshness of food products to identify spoiling gases, including free ammonia or hydrogen sulfide, that are emitted during degradation: carbon nanotube-based sensors may be incorporated into innovative packaging. They identify gases generated by bacterial action during decomposition. The interaction of gases with carbon nanotubes alters the sensor's electrical characteristics, resulting in a visual signal, such as a color change, or the transmission of an electrical signal for monitoring purposes. Consequently, packed meat or fish may be embedded with these sensors to notify retailers or consumers of spoilage, therefore guaranteeing fresher food in the marketplace (Erna K.H. *et al,* 2021; Chiu I. *et al,* 2023).

AI-Enhanced Biosensors

A notable innovation is the incorporation of artificial intelligence (AI). AI-enhanced biosensors integrate the rapidity and sensitivity of conventional biosensors with the computational capabilities of artificial intelligence. These systems can evaluate extensive data sets in real time, offering precise predictive capabilities and reducing false positives/responses. AI-enhanced biosensors in the food industry combine sophisticated sensor technology and machine learning algorithms to deliver rapid and precise detection of food spoilage, contaminants, and the level of quality. By recreating human sensory systems like taste and olfaction and analyzing intricate data sets, these sensors guarantee food safety and quality control from production to consumption (Zhang L. *et al,* 2023; Chen Y. *et al*, 2024). AI-enhanced biosensors are ideal for application in milk processing facilities. Consequently, they can assess vapor and liquid samples to identify potential bacterial contamination or food degradation more rapidly than conventional methods. Consequently, AI contributes in discovering and recognizing spoiling patterns that may differ between samples, thereby mitigating food loss. The electronic nose and tongue are engineered to replicate human senses through

sensor networks that identify various scents, flavors, or chemical substances in food products. Moreover, the sensor data undergoes processing through sophisticated algorithms that differentiate between fresh and rotten samples by comparing them with established data patterns (Zhang L. *et al,* 2023). AI-enhanced electronic noses may be employed in the wine industry to oversee fermentation and detect potential spoilage at an early stage. An electronic tongue may identify off-flavors in beverages or assess the balance of certain compounds, such as sugar or acidity levels (Figure 2).

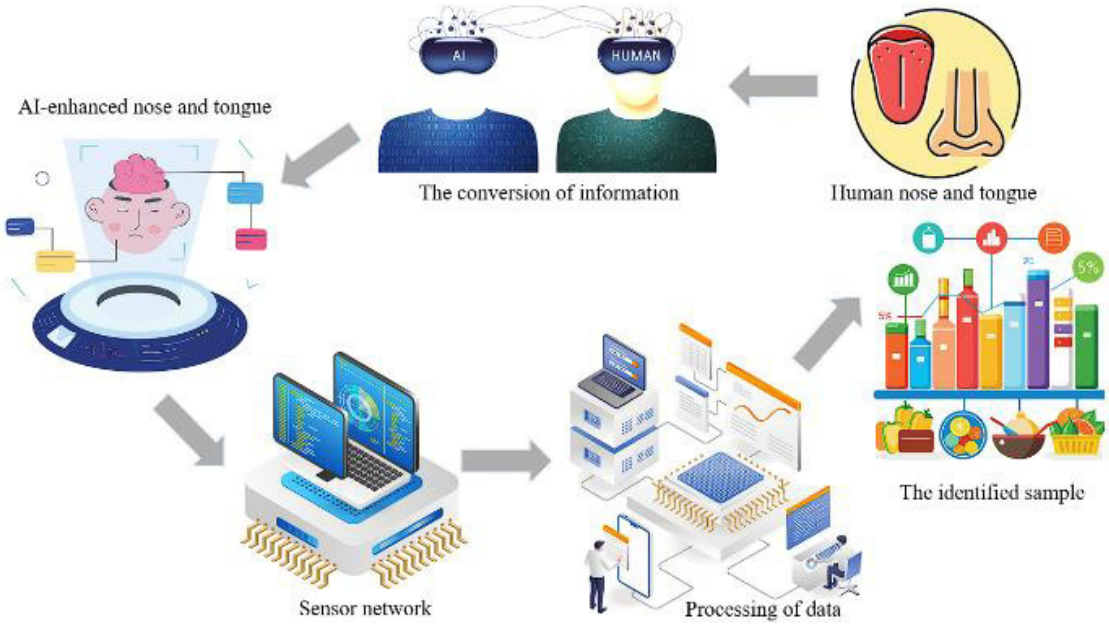

Figure 2 - **Food industry use of AI and biosensors. Comparison of gustatory and olfactory systems (adapted from Zhang et al, 2024)**

Artificial intelligence techniques, like Principal Component Analysis (PCA) and machine learning algorithms, can enhance the sensor's capacity to evaluate extensive data sets and recognize significant patterns within them. This facilitates a significantly faster and more precise classification of a food sample, ascertaining whether the food is spoiled or fresh (L.M. & De Saja, J.A., 2016; Munekata, P. E. *et al,* 2022).

In the food industry, AI-enhanced biosensors can be employed to identify pesticides in fruits and vegetables. They can assess product samples on-site to ascertain the presence of pesticide residues that may pose a risk to human health. AI algorithms possess the capacity to analyze complex data to distinguish between safe and hazardous chemical levels, hence ensuring adherence to food safety requirements (Zhao G. *et al,* 2015). Similarly to carbon nanotube-based sensors AI-enhanced electronic noses and tongues may identify spoilage gases, including ammonia and hydrogen sulfide, released by decomposing food. AI-enhanced sensors can be incorporated into packaging to notify retailers or consumers when food is decreasing in freshness. Another use may involve smart packaging with AI-enhanced biosensors. These can be included in intelligent packaging to assess the freshness of food. Packaged meat might incorporate sensors that identify spoiling gases and generate a visual signal, such as a color change on the packaging, to alert the consumer that the item is no longer safe for consumption (Singh R. *et al,* 2023).

Multimodal Biosensing

Multimodal biosensing integrates many technologies, including optical and electrochemical methods, within a single platform, beyond single-use biosensors. This combination facilitates a more comprehensive detection of contamination, as various signals can be simultaneously evaluated. Multimodal biosensors integrate various detection techniques (optical, electrochemical, or piezoelectric) to identify a diverse array of contaminants within a single sample. Consequently, by employing many detection techniques, multimodal biosensors may simultaneously identify several contaminants with enhanced precision (Ullah N. *et al,* 2023).

In seafood processing facilities, multimodal biosensors could simultaneously identify several risks, including heavy metals (mercury in fish), different pathogens (*Vibrio* in shellfish), and pesticide residues (in farmed shrimps). These sensors may conduct a comprehensive assessment of the interested food products by integrating label-free and label-based detection methods, alongside employing both electrical and optical signals. Multimodal biosensors use AI and machine learning

algorithms to analyze and interpret intricate data. Consequently, AI can rapidly recognize certain patterns within the data and acquire knowledge through machine learning, hence identifying novel contamination patterns (Zhang L. *et al,* 2023). An example of this is the intelligent food packaging system that may incorporate multimodal biosensors to detect contamination and spoiling in real time. AI algorithms can analyze data from various sensors, including those that identify gases emitted during spoilage, pesticide residues, and heavy metals, and alert consumers through a smartphone application if the product is deemed unsafe for human consumption. The use of AI for analyzing intricate sensor data enhances the system's adaptability in identifying new contaminants or changing concentrations of recognized chemicals (Sonwani E. *et al,* 2022; Popescu S.M. *et al,* 2024).

Despite the considerable advantages of biosensors, including rapidity, sensitivity, and real-time monitoring abilities numerous problems remain. Initially, calibration is required to ensure functionality with various intricate food matrices. Moreover, biosensors have not been extensively implemented in all sectors of the food industry, and standardization is essential to guarantee accuracy and reliability among various biosensor technologies (Kaushal J. B. *et al,* 2023).

CONCLUSION

Biosensors represent a novel solution for the real-time detection of pathogens within food supply chains. These technologies have the capacity to revolutionize contamination detection and prevention across the food supply chain, hence providing safer food products for consumers. The future step in this field is to promote research and the eventual implementation of these modern and accessible techniques within the food industry to maximize the advantages of this technology.

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RESEARCH ON THE TECHNOLOGY OF OBTAINING PRODUCTS WITH HETEROGENEOUS STRUCTURE: A COMPARATIVE STUDY.

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Abstract

Innovative approaches in food technology focus on optimizing and maintaining food quality to meet consumer preferences, needs, and requirements. At the same time, they aim to reduce the environmental impacts associated with transforming agro-resources into food products. This is achieved by implementing efficient processing systems that consume minimal amounts of energy and water and through co-product valorization. These principles are applicable throughout the food processing chain. The present study provides a comparative analysis of technologies for the production of a heterogeneous structure cooked smoked pork product. Two processing methods were applied: a classical method and a current method. In the analysis, technological losses, the gross chemical composition of the product as well as sensory aspects evaluated by a panel of experts were monitored. The analyzed data concluded that the protein value between the two samples does not present significant values (Italian salami - classic method has a protein content value of 20.4% and Italian salami - current method has a protein content value of 20.2%). Lower losses of raw material were found in the technological flow obtained by the current method, but at the same time, the batches obtained by the classic method obtained an average score of 6.1 points out of the 8 points achieved in the applied method.

Keywords: heterogeneous structure, classical method, current method

Food innovation is commonly perceived as the antagonist of food tradition, operating as a threat or an opportunity within societies. However, the interrelationship between the two terms is much more complex than is often assumed by the public and interpreted by contemporary food marketers. Tradition and innovation are mutually constitutive, tradition feeding into innovation and vice versa. (Geyzen A. *et al*, 2019).

The approach described by Prakash V. (2016) suggests that modern science and technology will aim to provide the authentic food that the consumer wants, but bears the responsibility of ensuring that the nutritional components of these foods are preserved and promoted as they reach the consumer. Today's businesses constantly have to adapt to new conditions, increase activity, rationalize production, and at the same time improve the quality of the products they produce. They are thus obliged to apply various industrial engineering methods and techniques to obtain optimal products, eliminating activities in the production flow that add unjustified value.

The amount of energy, human resources, and machinery, constitute the necessary basis for the realization of a technological production flow in the meat preparations segment. Appropriate efficiency has a positive impact on the entire processing industry, thus, the awareness of production flow efficiency leads to decisions that support the proper management of all factors involved in this segment.

Heterogeneous pork products are those products containing different ingredients that can be identified visually or by taste in the finished product. They are created by combining different types of meat, fats, seasonings, and other ingredients to achieve varied textures, flavors, and textures. Consumers are in constant search for foods that are low in fat and cholesterol, as well as with a healthy fatty acid profile (Ospina-E J.C, 2012). The meat industry has also started to adopt more sustainable practices and offer healthier options for consumers, such as products without preservatives or artificial additives. At the same time, consumer interest in traditional and local products has increased, leading producers to return to traditional recipes and less industrialized production processes.

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MATERIALS AND METHODS

The experimental batches were realized in the food technology department of IULS Iasi, meat and meat preparations workshop. The raw material for the realization of the batches came from the pig species *Sus scrofa domesticus*, from which the anatomical region selected was the ham, from which the connective tissue, non-conforming fat, and neuronal vessels were removed. During the production of the experimental batches *(figure 1)*, the raw material followed the cryogenic chain required by ISO standards for meat processing conditions and a post-processing maturation period of 12 hours at 2-4ºC in well-ventilated cold stores. Thus, for shredding the meat necessary for the first batch (Italian salami obtained by the classic method), two machines were used, first an industrial grinder for coarse grinding of the meat (Grinder WP-105), which was used a sieve with a 5 mm hole diameter through which the meat was ground in a ratio of 70% of the total quantity.

A cutter (Cutter Titane V45) was used to finely grind the meat at 1500 rpm for the remaining 30% of the ham to obtain a fine paste, which was necessary for binding the final composition. For the production of the second batch (salam Italiam obtained using the current method), the meat was not finely minced in the Titane cutter and the pork ham was only coarsely minced through a sieve with 5 mm holes. Both obtained stews were mixed with the spices, using a 180 BA double-arm malxor (La Felsinea).

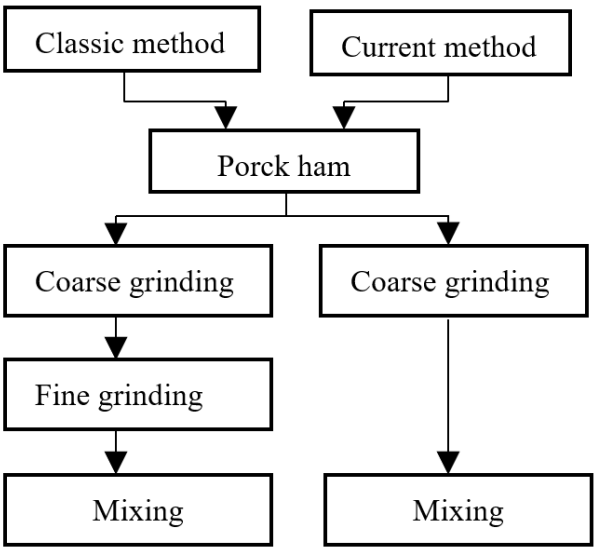

Figure 1 **Schematic of the technological flow of Italian salami production**

The composition was dosed into artificial membranes (inedible collagen membranes) and the product was subjected to heat treatment according to *table 1.*

Table 1

The stages of heat treatment

Stage	*Drying I*	*Smoking*	*Boiling*	*Drying II*
Temperature (℃)	48	56	74	68
Time (min.)	30	50	60	10

The determinations applied to the two samples consisted of a determination of the gross chemical composition using the Omega Bruins Food-Check Near Infrared (NIR) spectrophotometer, determining the percentages of protein, moisture, fat, collagen, and salt. To determine consumers' sensory preferences, a quick and descriptive CATA (check-all-that-apply) data collection method and a hedonic method (9-point scale) were applied to assess the degree of liking associated with the experimental batches in question. Losses were also calculated on the technological flow to determine the efficiency of eliminating the fine shredding step from the flow.

RESULTS AND DISCUSSIONS

The nutritional quality of a meat preparation is determined by its nutritional value, which depends to a greater extent on the way the raw material has been previously processed, by removing as efficiently as possible the connective, adipose, bone, and cartilage tissue. Detailed knowledge of the chemical composition of the meat makes it possible to optimize the technological production flow to produce preparations with high nutritional qualities. The composition of the raw material is known to change with the age of the animal. The protein, intra- and inter-muscular fat, and mineral content increase with age, but at the same time, the water content decreases. In order not to lose the juiciness of the product, the main raw material chosen was pork ham.

For the determination of the gross chemical composition indices, five sample repetitions were carried out, and the mean, standard deviation, minimum, and maximum of the sample were determined by the statistical descriptive method, as shown in *table 2.*

As for the gross chemical composition, 5 readings were taken for each batch obtained, and then the mean, minimum, and maximum were calculated for each index. From *table 2* it can be seen that the average protein percentage is 20.06% with a low fat percentage of 9.62%.

As regards the batch obtained by the classical method (*table 3)*, the average protein percentage is 20.05% and the average fat percentage is 7.6%, the latter being much lower

compared to the fat percentage found in the batch obtained by the current method (9.62%).

Table 2

Determination of the raw chemical composition of Italian salami obtained with the current method using the descriptive statistical method

Indice	*Fat %*	*Moisture %*	*Protein %*	*Collagen %*	*Salt %*
Number of samples	5	5	5	5	5
$\bar{X} \pm S_{\bar{x}}$	9.62±0.109545	69.068±0.08438	20.06±0.054772	18.26±0.054772	2.64±0.054772
Minimum	9.5	69	20	18.2	2.6
Maximum	9.7	69.2	20.1	18.3	2.7

Tabele 3

Determination of the raw chemical composition of Italian salami obtained with the classic method using the descriptive statistical method

Indice	*Fat %*	*Moisture %*	*Protein %*	*Collagen %*	*Salt %*
Number of samples	5	5	5	5	5
$\bar{X} \pm S_{\bar{x}}$	7.6±0.260768	70.62±0.614003	20.05±0.1	20.05±0.1	2.32±0.083666
Minimum	7.1	69.9	20.4	20.4	2.2
Maximum	7.7	71.1	20.6	20.6	2.4

As far as the losses in the technological flow are concerned in the case of the technology of obtaining the Italian salami sample, the losses are lower, since one technological stage (that of fine shredding of the meat) is excluded.

Bypassing this stage brings about changes in terms of loss of meat raw material (about 0.3% of a total of 100 kg), reduced electricity consumption, and shorter total technological flow time.

For a comparison between the two methods, the two-tailed t-test was also applied, thus obtaining p values > 0.05. For the determinations of sensory characteristics, a panel of 20 panelists was formed. The hedonic test followed the characteristics of color, smell, taste, flavor, aroma, texture, and general appreciation of the two batches of products taken for analysis *(table 4)*.

The influence of chemical composition on the sensory quality of meat mainly involves the lipid components as variations in these affect sensory attributes such as taste, flavour, juiciness and texture (Ciobanu M.M. *et. al*, 2023).

Table 4

Results on hedonic appreciation

Summary (LS means) - Sample coding:							
Category	ASPECT	COLOR	ODOR	TASTE	AROMA	FLAVOR	OVERALL APPRECIATION
519	7.571 a	7.714 a	7.667 a	7.000 a	7.238 a	8.095 a	7.619 a
437	7.333 a	7.619 a	7.857 a	6.905 a	7.476 a	7.857 a	7.429 a
Pr > F(Model)	0.517	0.787	0.565	0.770	0.499	0.540	0.551
Significant	No	No	No	No	No	No	No
Pr > F(Sample coding)	0.517	0.787	0.565	0.770	0.499	0.540	0.551
Significant	No	No	No	No	No	No	No

Means with the same letter in a column are not significantly different at level ($p < 0.05$).

After applying the ANOVA statistical test, it can be observed that there are no significant differences between the two batches. This means that the technological method applied differently to the two products did not significantly impact their general characteristics.

Also, to obtain information about possible changes between the two samples of samples taken in the analysis, the Check-All-That-Apply (CATA) sensory analysis method was applied, according to Ruiz-Capillas C. *et al* (2021), is a new sensory analysis method that has become widely used and has become popular for sensory analysis with consumers. The sensory cues tracked in this research were grouped into cues serving the general quality of the samples

(elasticity, saliva production, chewing perception, and breaking strength), as well as taste cues such as, acid, bitter, sweet, pepper, thyme, and tarragon.

According to the obtained symmetry graph, it can be observed that the most important characteristics followed by the panelists did not identify noticeable differences between the indices close to the center of the axis, these attributes having a balanced distribution in the analyzed samples. At the same time, the attributes found on the horizontal axis explain their low variability. At the same time, the analyzed samples are in close points, and there are correlations between them.

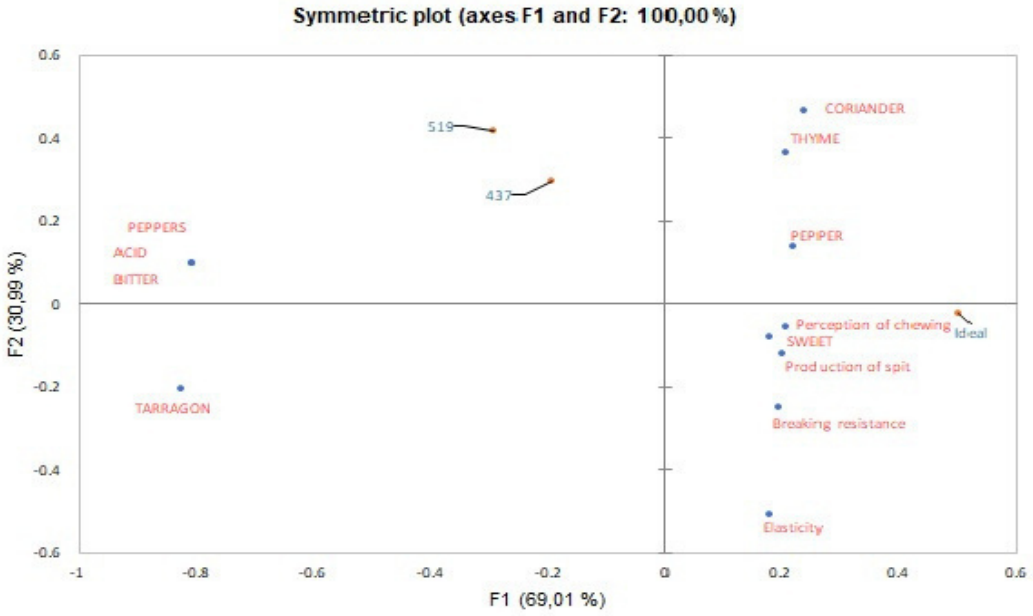

Figure 1 **Check-All-That-Apply (CATA) assessment results**

CONCLUSION

The present study aimed to highlight the characteristics of the gross chemical composition, the sensory characteristics, and the losses recorded on the technological flow between the two types of Italian salami obtained in the micro-production section of Iasi University of Life Sciences, applying two different technological methods.

The determinations approached revealed weakly significant differences between the two samples analyzed, for example, the percentage of protein resulting in the case of the current technology was 20.06% and in the sample in which the classical technology was applied the percentage of protein was 20.05%. At the same time, the product realization time, energy efficiency, as well as losses in the technological production flow, were more efficient by applying the current production technology, which eliminates the mincing step.

Continuous improvement advances have led the industry to move to higher production capacities; for example, helping to reduce production costs. It is interesting to note that relative meat prices today are lower than they were 50 years ago (adjusted for the cost of living index).

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STRATEGIES FOR PACKAGING OPTIMIZATION IN THE WINE INDUSTRY

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Abstract

This study addresses significant aspects of the wine industry, focusing on wine packaging and analyzing the environmental impact of materials used by producers. The circular economy, applied to waste minimization through the integration of sustainable solutions into the production cycle, along with innovations in this sector, represents important components in developing and ensuring a sustainable future. Identifying materials with a reduced environmental impact, such as recycled glass, biodegradable cardboard, or innovative materials like bioplastic, constitutes the first step in conducting a customized study aimed to create sustainable packaging. The second essential aspect is the analysis of the direct impact of these materials on the greenhouse gas emissions of the wine industry. The next step is validating the logistics chain to identify partners that use renewable energy sources in the production process, in order to ensure that indirect emissions do not negatively influence the company's carbon footprint. The final step involves the integration of the new packaging into the production cycle and optimizing it to foster consumer loyalty. Designing sustainable packaging for the wine industry requires careful analysis, integrating innovation, renewable energy sources, and eco-friendly materials. It is important to consider the entire product life cycle, from production to recycling, to ensure minimal environmental impact. Only by adopting these practices can the wine industry contribute to environmental protection and promote responsible consumption.

Keywords: sustainability, wine industry, eco-friendly packaging, circular economy

Packaging plays an essential role in the food supply, protecting and containing food from processing and manufacturing, through distribution, handling, and storage to the final consumer. Without packaging, food distribution would be inefficient and much more costly. Packaging functions may be described as protection and containment, preservation, information, and convenience and service. For most food products, the protection afforded by the package is an essential part of the preservation process.

Wine packaging, influences not only the quality, safety, and shelf life of the product but also consumer perception and behavior. However, traditional wine packaging poses significant environmental challenges, generating substantial waste and greenhouse gas emissions throughout its life cycle. This article explores the current state of wine packaging, the environmental impacts, and the potential benefits of adopting sustainable practices.

Traditional wine packaging, primarily glass bottles, has a considerable environmental footprint. The production and transportation of glass bottles are energy-intensive processes that contribute to greenhouse gas emissions. Additionally, the disposal of glass bottles generates significant waste, as recycling rates are often low.

The concept of a circular economy (CE) provides a framework for addressing these challenges by promoting the reduction, reuse, and recycling of packaging materials. Implementing CE principles in the wine industry can help minimize waste and reduce the environmental impact of wine packaging. The concept of circular economy (CE) is intensively discussed and addressed by different actors of value chains, politicians, and academia. It is frequently depicted as a combination of reducing, reusing, and recycling activities. It is recognized that CE requires a systemic shift and a transition from the traditional linear patterns of production, consumption, and disposal (Kirchherr J. *et al,* 2017). Barriers to this transition have been studied, focusing on specific geographies, business types, or industry sectors. They can be categorized as regulatory, technical, and economic barriers (Bening C.R. *et al,* 2021). These barriers are not independent, and cultural barriers, namely lack of consumer interest and awareness, hesitant company culture, and lack of synergistic governmental interventions, are considered important together with technological limitations (Kirchherr J. *et al*, 2017). However, limited

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progress has been accomplished regarding CE implementation, and only 8.6% of the total material used is cycled (Wit M.D., 2022). Between 2015 and 2021, the global economy consumed an additional half a trillion tons of virgin materials, namely minerals, ores, fossil fuels, and biomass. In only 50 years, global use of materials has nearly quadrupled—outpacing population growth, despite initiatives settled as the Club of Rome, Paris Agreement (COP21) (COP21, n.d.), and Glasgow Climate Pact (COP26) (COP26, n.d.). Rising waste levels accompany the rapid acceleration of consumption: over 90% of all materials extracted and used are wasted, and most environmental problems, from biodiversity loss, global warming, and air pollution to plastic soup, are connected to waste (Waste Report, 2022). This report indicates 21 measures (interventions) to allow the world to achieve the COP21 goal of keeping at 1.5°C of warming by 2032. One of these measures focuses on reducing excess consumption, and using less packaging on food products (Waste Report, 2022).

This involves using materials with a lower environmental footprint, such as recycled glass, biodegradable cardboard, or innovative materials like bioplastic.

Several innovative packaging solutions have emerged as alternatives to traditional glass bottles. Aluminum cans and plastic-lined boxes, for example, are gaining popularity due to their lower carbon footprint and ease of recycling. Bag-in-Box (BiB) and Tetra Pak are also viable options, significantly reducing carbon emissions compared to glass bottles. These alternatives not only offer environmental benefits but also cater to the growing consumer demand for sustainable products.

The adoption of sustainable wine packaging is influenced by regulatory frameworks that govern packaging materials and waste management. Compliance with these regulations is essential for market access and competitiveness. Wine producers must stay informed about the evolving regulatory landscape and adapt their packaging strategies accordingly.

The research aims to explore the direct correlation between the raw materials used in the production of wine packaging, the carbon footprint of the supply chain, and the market acceptance of the new packaging solutions. By examining the environmental impacts and market dynamics, the research seeks to identify sustainable packaging alternatives that not only reduce the carbon footprint but also meet consumer preferences within the regulatory requirements.

MATERIAL AND METHOD

Wine packaging is subject to various regulations and standards, which aim to ensure the quality, safety, and sustainability of the product and the packaging material. Regulations and standards can vary across different countries and regions, depending on the legal and institutional frameworks, the market conditions, and the consumer preferences. Some of the main regulatory aspects of wine packaging include the labeling requirements, the recycling schemes, and the criteria for recycled content. Labeling requirements specify the information that must be displayed on the wine packaging, such as the origin, the ingredients, the alcohol content, the allergens, and the environmental claims. Recycling schemes regulate the collection, sorting, and processing of packaging waste, as well as the responsibilities and obligations of the producers and consumers. Criteria for recycled content define the minimum percentage of recycled material that must be used in the production of new packaging material. These regulatory aspects can have significant implications for the wine industry, as they can affect the market access and competitiveness of wine products, the environmental performance and innovation of wine packaging, and the consumer awareness and behaviour (Van den Bosch M., Sang Å.O., 2017).

The Common Market Organization (CMO) is a regulatory framework established by the European Union (EU) to manage the production, marketing, and trade of agricultural products, including wine. The CMO aims to balance supply and demand, ensure market stability, and promote sustainable and competitive development within the EU wine sector.

The CMO for wine is governed by Regulation (EU) No 1308/2013, which establishes a common organization of the markets in agricultural products (Wine Legislation, n.d.). This regulation covers various aspects of the wine sector, including production rules, quality standards, labeling requirements, and trade measures. The CMO also includes measures to support wine producers, such as financial aid for restructuring vineyards, promoting wine in third countries, and supporting innovation and research in the wine sector (Eur Lex, n.d.). In addition to Regulation (EU) No 1308/2013 (Regulation EU, n.d.) the CMO for wine is also influenced by other EU regulations, such as Regulation (EU) 2021/2117, which amends the rules governing the common market organization in agricultural products and introduces changes to the EU quality schemes and support measures for remote regions (Eur Lex, n.d.). The CMO plays an important role in ensuring the quality and competitiveness of EU wines, as well as promoting sustainable practices within the wine sector. By adhering to the CMO regulations, wine producers can access financial support, improve their production processes, and

enhance their market presence both within the EU and internationally.

To be eligible for financial aid under the Common Market Organization (CMO) for restructuring vineyards, wine growers must meet certain criteria, such as purpose, support measures and sustainability. The purpose is for improvement of competitiveness and sustainability of vineyards. The support measures: is mainly integrated through national support programs (NSPs) in the wine sector. For sustainability offering support to improve sustainable production systems and the environmental footprint of wine growing (Green Vineyards, n.d.).

The article thoroughly investigates the regulations and standards that oversee wine packaging, including labeling requirements, recycling programs, and criteria for recycled content, emphasizing their substantial influence on market access, competitiveness, and environmental performance. Life Cycle Assessment (LCA) (Rajagopal D., 2023) methods to evaluate the environmental impacts of wine packaging throughout its life cycle (Ferrara C., De Feo G., 2018), focusing on key indicators such as carbon footprint, energy consumption, and waste generation associated with different packaging materials. The market analysis (sustainable packaging market report, n.d.) reveals a growing consumer preference for eco-friendly packaging solutions like aluminum cans, plastic-lined boxes, Bag-in-Box (BiB), and Tetra Pak, which reduce the carbon footprint while maintaining product quality and safety. Additionally, the supply chain analysis delves into the complexities of the wine packaging supply chain, examining environmental impacts at each stage from raw material extraction to end-of-life disposal, and identifies key areas for implementing sustainable practices to reduce the overall carbon footprint (Global Eco friendly packaging market, n.d.). The study emphasizes the importance of a holistic approach involving collaboration among various stakeholders, including suppliers, manufacturers, distributors, and consumers, to achieve a sustainable supply chain.

RESULTS AND DISCUSSIONS

The environmental impacts of wine packaging can be assessed by using life cycle assessment (LCA) methods, which measure the environmental burdens associated with the production, use, and disposal of packaging materials. LCA studies have shown that the main environmental impacts of wine packaging are related to the extraction and processing of raw materials, the transportation and distribution of packaged wine, and the end-of-life management of packaging waste. The choice of packaging material, size, shape, and weight can significantly affect the environmental performance of wine packaging, as well as the energy and water consumption, and the carbon footprint of the wine industry. According to Life Cycle Assessment studies, glass bottles are the most widely used and the most environmentally intensive packaging option for wine, accounting for up to 30% of the wine's carbon footprint (Rugani B. *et al*, 2013).

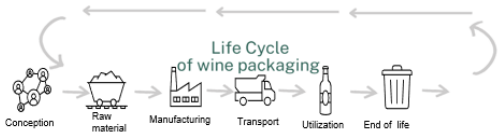

Figure 1 **Life cycle of wine packaging (adaptation after Rajagopal D., 2023)**

Glass bottles require large amounts of energy and resources to produce, and their weight and volume increase the fuel consumption and emissions during transportation. Glass recycling can reduce the environmental impacts of glass bottles, but it depends on the availability and efficiency of recycling facilities and consumer behavior. Other packaging options, such as plastic bottles, aseptic cartons, bag-in-box, and cans, have lower environmental impacts than glass bottles, mainly due to their lighter weight, smaller volume, and lower energy requirements.

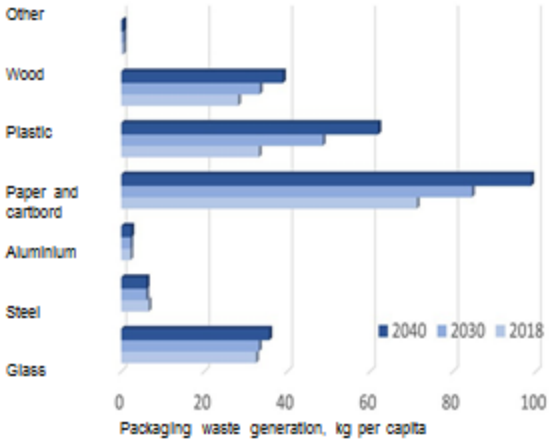

Figure 2 **Packaging waste generated in Europe per capita, for each packaging material and the estimates for 2030 and 2040 (Eurostat Waste packaging statistics, n.d.)**

However, these alternatives also have some drawbacks, such as lower recyclability, shorter shelf life, and potential quality and safety issues. Therefore, the environmental sustainability of wine packaging depends on a comprehensive and holistic evaluation of the advantages and disadvantages of each packaging option, considering the specific context and conditions of the wine supply chain (Alternative packaging, n.d.).

As an additional response to the environmentally conscious consumers, the wine industry has focused in all components of the packaging, exploring various alternatives for wine stoppers and their sustainability profiles

Cork is, an ideal material is cork, as it is harvested from the bark of the cork oak tree, which regenerates after each harvest, making it a renewable resource. The harvesting process is environmentally friendly, as the trees are not cut down being biodegradable and recyclable. Its natural properties, such as elasticity and impermeability, make it an ideal material for wine stoppers, ensuring a tight seal and preserving the quality of the wine.

Diam has developed a sustainable agent derived from plants to ensure that its corks are free of cork taint, a significant issue in the wine industry. This innovation guarantees that even organically farmed vineyards do not experience cork taint. Diam corks, made from natural granulated cork, are processed using revolutionary technology to maintain cork elasticity and control oxygen penetration during wine bottling and aging. This process ensures that the corks are free of cork taint, providing a consistent and reliable closure for wines.

Nomacorc is known for its plant-based closures (Normacorc, n.d.) produces engineered synthetic corks that manage the oxygen transfer rate for wine, reducing the risk of cork taint, offering various options such as Ocean cork, made from marine plastic waste, addressing environmental concerns while providing a reliable closure for wines.

Synthetic corks are typically made from food-grade polymers. They are designed to mimic the properties of natural cork while eliminating the risk of cork taint. Synthetic corks provide a consistent seal and are an alternative for producers looking for a reliable and uniform closure.

Screw Caps are made from aluminum, screw caps provide an airtight seal, preventing any oxygen ingress. They are recyclable and have gained popularity for their convenience and ability to preserve the wine's freshness. However, their sustainability can vary depending on the recycling practices in place.

Glass stoppers: are reusable and recyclable, offering a premium look and feel. Glass stoppers provide an airtight seal and are often used for high-end wines. Their environmental impact is relatively low, especially when reused multiple times.

Each of these options contributes to the sustainability efforts in the wine sector, offering varied solutions to the issue of packaging waste.

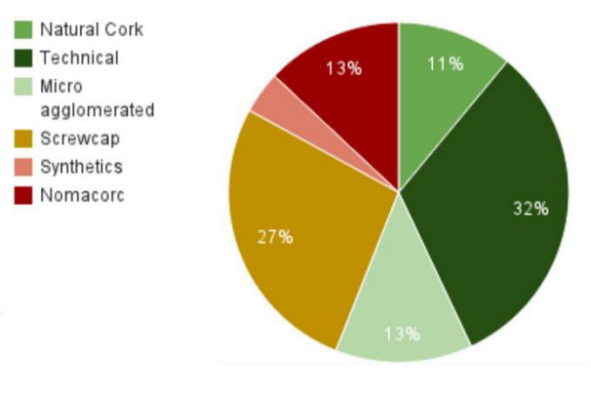

Figure 3 **Marketshare of wine stoppers per raw materials (source: Charts wine market shares, n.d.)**

The transition to sustainable wine packaging faces several barriers and challenges, which can be categorized as regulatory, technical, economic, and cultural. Regulatory barriers refer to the lack of harmonized and consistent policies and standards for packaging sustainability, which can create confusion and uncertainty among producers and consumers. For example, different countries and regions may have different labeling requirements, recycling schemes, and criteria for recycled content, which can affect the market access and competitiveness of wine products. Technical barriers refer to the limitations and difficulties of developing and implementing innovative and sustainable packaging solutions, which can meet the functional and quality requirements of wine packaging. For example, some alternative packaging materials may not provide adequate protection and preservation for wine, or may not be compatible with existing packaging equipment and infrastructure.

Green energy sources are known to play an important role in making wine packaging more sustainable, efforts not only contribute to environmental sustainability but also align with the growing consumer demand for greener products. In a German case study, a combined average of the total energy requirement from each study was used to analyze the energy mix of Germany. The study highlights a clear trend indicating that as the electricity mix increasingly originates from renewables and less from coal, and as more overall energy comes from electricity rather than heat, the overall environmental impact is reduced. The breakdown of German electricity includes renewables, natural gas, coal, lignite, and nuclear,, conducted under two models: one where most of the total energy used for production came from electricity and the rest from natural gas, and another where the energy split was half electricity and half natural gas, it was found that an additional 135,408 kg CO_2 would be added to the kg of CO_2,

significantly increase the product's Global Warming Potential.

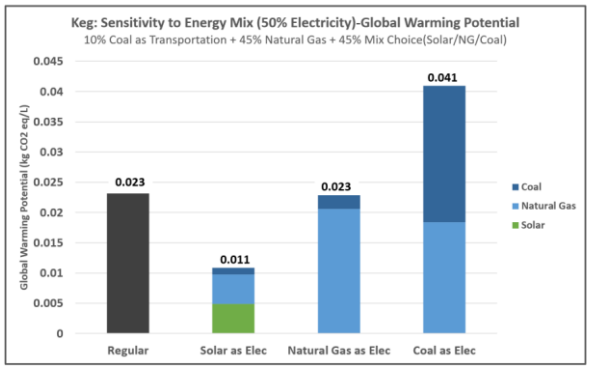

Figure 4 **Energy mix (source: Rajagopal D., 2023)**

Economic barriers refer to the costs and risks associated with the adoption of sustainable packaging practices, which can affect the profitability and viability of wine producers. For example, some sustainable packaging options may have higher initial or operational costs, lower consumer demand, or lower perceived value, which can reduce the economic incentives for wine producers (Martínez-Falcó J. *et al,* 2023).

Cultural barriers refer to the attitudes and behaviours of consumers and industry stakeholders, which can influence the acceptance and adoption of sustainable packaging practices. For example, some consumers and industry stakeholders may have strong preferences and traditions for glass bottles, or may have negative perceptions and misconceptions about alternative packaging options, which can hinder the diffusion and innovation of sustainable packaging practices (Amienyo D.G., 2013).

The adoption of sustainable wine packaging practices can offer several opportunities and benefits for the wine industry, as well as for the society and the environment. Sustainable wine packaging can reduce the environmental impacts and resource consumption of the wine industry, by minimizing the waste generation, energy use, and greenhouse gas emissions associated with packaging materials and processes (Wagner M. *et al,* 2023).

Another aspect is that through the packaging system the wines can also improve the quality and safety of wine products, by enhancing the protection and preservation of wine, extending the shelf life, and preventing the contamination and degradation of wine. Sustainable wine packaging can also increase the consumer satisfaction and loyalty, by meeting the consumer expectations and preferences for environmentally friendly and socially responsible products, providing more convenience and functionality, and conveying a positive image and reputation of the wine brand.

As important as the wine quality, the sustainable packaging can also create competitive advantages and new market opportunities for the wine industry, by complying with the regulatory requirements and standards for packaging sustainability, reducing the operational and transportation costs, and differentiating the wine products from the competitors.

Sustainable wine packaging can also contribute to the social and economic development of the wine industry and its stakeholders, by creating new jobs and businesses, supporting local communities and suppliers, and enhancing the innovation and collaboration among the wine industry actors.

CONCLUSIONS

The packaging of wine in a sustainable manner represents both challenges and opportunities for the wine industry. By embracing circular economy principles and exploring innovative packaging solutions, the industry can reduce its environmental impact and meet the growing consumer demand for sustainability. As the regulatory environment continues to evolve, wine producers must remain proactive in adopting sustainable practices to ensure long-term success.

Wine packaging is a key factor that affects the environmental, social, and economic sustainability of the wine industry. The concept of circular economy provides a framework to improve the sustainability of wine packaging, by promoting the reduction, reuse, and recycling of packaging materials, as well as the adoption of alternative, more sustainable packaging solutions. However, the transition to sustainable wine packaging faces several barriers and challenges, which require a comprehensive and holistic approach, involving the collaboration and coordination of all the wine industry actors, including producers, consumers, policy makers, and researchers. By implementing sustainable wine packaging practices, the wine industry can achieve multiple benefits and opportunities, such as reducing the environmental impacts and resource consumption, improving the quality and safety of wine products, increasing the consumer satisfaction and loyalty, creating competitive advantages and new market opportunities, and contributing to the social and economic development of the wine industry and its stakeholders.

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RESEARCH ON THE MATURATION OF MEAT FROM THE ILE-DE-FRANCE AND MERINOS DE PALAS BREEDS

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Abstract

This paper aims to conduct a comparative study on the wet aging process and evaluate its effects on the physical parameters of meat from Ile de France and Merinos de Palas sheep breeds. The study focused on two specific anatomical regions, the leg (*Musculus biceps femoris*), and the ribeye (*Musculus longissimus dorsi*), to identify differences and similarities in the evolution of meat quality based on breed and region. The research monitored pH fluctuations during the aging process for both breeds and evaluated their impact on meat quality. The study investigated the processes of oxidation and degradation of pigments and lipids in the meat, as well as methods for maintaining an appealing and stable color, which is essential for consumers' perception of meat freshness and quality. Comparing the physical parameters between the *Ile de France* and *Merinos de Palas* breeds allowed the identification of differences and similarities in the influence of wet aging on the leg and ribeye. The sheep meat industry can benefit from the implementation of an integrated system for monitoring and adjusting aging conditions, which should include pH parameters, sensory qualities, and color evolution. Educating consumers on how these factors affect meat quality, along with promoting sustainable production practices, can help increase appreciation and demand for high-quality sheep meat.

Keywords: sheep meat, Ile de France, Merinos de Palas

Sheep provide a diverse range of resources, including meat, milk, and wool, and have played a vital role in the global agricultural economy since the Neolithic era (Ceccobelli S. *et al*, 2023). The quality of sheep meat is influenced by various factors, including the animal's genotype, rearing, and feeding conditions, age at slaughter, and post-mortem processing methods such as aging (Hopkins D.L., Fogarty N.M., 1998; Safari E. *et al*, 2001). Genetic differences between breeds, such as *Ile de France* and *Merinos de Palas*, can significantly impact meat characteristics, including texture, flavor, and fat content (Young O.A. *et al*, 1997). Sheep meat is valued for its distinctive flavor, which can vary considerably depending on the animal's diet and breed (Priolo A. *et al*, 2001).

Additionally, sheep meat offers a rich nutritional profile, being an excellent source of iron, zinc, and B vitamins, which are essential for human health (Fisher A.V. *et al*, 2000). However, the fat content and fatty acid composition may influence consumers' perception of the meat's quality, affecting both its nutritional value and consumer preferences (Nute G.R. *et al,* 2007).

In addition to fatty acid composition, another important physicochemical characteristic of sheep meat is its myofibrillar and sarcoplasmic protein content, which is critical for meat texture. The enzymatic processes that occur during the aging of sheep meat can modify these proteins, thereby enhancing the tenderness and juiciness of the meat through the breakdown of protein structures and collagen (Hopkins D.L., Fogarty N.M., 1998).

Consumer preferences for sheep meat can vary significantly, influenced by cultural factors, sensory experiences, and awareness of health benefits. The demand for high-quality sheep meat is growing in many markets, as consumers become increasingly interested in food provenance, animal welfare, and sustainable production practices (Sanudo C. *et al*, 2000).

MATERIAL AND METHOD

The material used in the study consisted of loin and leg cuts from two sheep carcasses of the *Ile de France* and *Merinos de Palas* breeds, purchased from a breeders' association in the

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Moldova region. The loin and leg cuts are considered premium anatomical sections, with specific guidelines for their anatomical delineation.

The *Ile de France* sheep carcass weighed 39 kg. From this, two unboned legs were obtained, weighing a total of 11.25 kg, which were divided into eight boneless leg cuts, weighing 2.436 kg in total. Additionally, an unboned loin section weighing 7.7 kg was processed, yielding two loin pieces totaling 0.828 kg. The *Merinos de Palas* sheep carcass weighed 22 kg, from which two unboned legs weighing 5.7 kg were extracted, resulting in six boneless leg cuts with a total weight of 1.134 kg. An unboned loin section weighing 4.1 kg produced two loin pieces totaling 0.650 kg.

For Wet-Aging, the cuts were vacuum-sealed in special packaging bags. The materials used in this study included: sheep loin, sheep leg cuts, vacuum packaging bags, a vacuum-sealing machine, storage trays, and a refrigeration unit with appropriate storage parameters. Special care was taken to ensure that all sample preparation steps were carried out in the shortest possible time to minimize exposure of the meat to ambient temperature after purchase. Packaging and refrigeration at 3/4°C were performed immediately after division and weighing.

The instrumental color characteristics of the product were measured using a Chroma Meter CR-410 colorimeter from Konica Minolta Inc., Japan, based on the CIELAB color space. These characteristics were reported as L*, a*, and b* values. The primary color parameters—L* (lightness), a* (red-green coordinate), and b* (yellow-blue coordinate)—were evaluated according to the CIELAB [CIE (Commission Internationale de l'Éclairage)] system. Measurements were taken across the sample area, with the final values representing the average of readings from five evenly distributed points on the sample. For section analysis, a Hunter Minolta CM-2600d colorimeter was used, with a 2° observation angle and an 8 mm measurement aperture, illuminating a 50 mm diameter surface, following the protocol outlined by Manoliu *et al* (2023).

The pH value was determined by calibrating the device using two buffer solutions (standard solutions) with known pH values: an acidic solution with a pH of 4.01 and a neutral solution with a pH of 7.01. After calibration, the pH meter probe was rinsed with distilled water, inserted into the meat, and the pH value was recorded once the device stabilized. After each reading, the pH meter probe was cleaned by immersion in distilled water, and any excess water was removed by wiping it with a paper towel. Generally, the normal pH of fresh sheep meat immediately after slaughter (initial pH) is around 6.5-7.0. After a 24-hour post-slaughter period, the pH decreases to approximately 5.5-5.8, due to the post-mortem glycolysis process that produces lactic acid.

RESULTS AND DISCUSSIONS

In *table 1*, according to the pH analysis, there are no significant differences between the Merinos de Palace and Ile de France species in terms of pH values monitored during Wet-Aging in the Musculus longissimus dorsi anatomic zone. Though a trend appears in terms of the impact of maturation days, the differences are not significant.

Table 1

pH analysis in the antomic zone *Musculus Longissimus Dorsi*: Means ± Standard Deviation for Palace Merinos and Ile de France during Wet-Aging

Day of Aging	MP_1	IF_2
0	5.50±0.007	5.65±0.092
3	5.93±0.213	5.78±0.014
6	5.61±0.403	5.84±0.091
9	5.96±0.219	5.75±0.090
p-value		
Day of Aging	0.07	
Type of Species	0.94	

Values are given as means ± SE with five repeated determinations; MP_1 -*Merinos de Palas*; IF_2 -*Ile de France*

According to the results obtained from the pH analysis, presented in *table 1*, no significant differences were found between the two sheep breeds studied, *Merinos de Palace* and *Ile de France*, in terms of pH values recorded during the wet-aging process in the anatomical area *Musculus longissimus dorsi*. There is a general trend suggesting an influence of maturation duration on pH, this variation does not reach the threshold of statistical significance ($p > 0.05$). This finding suggests that the wet maturation process affects comparably the pH characteristics of muscle for both breeds, and the differences observed over time can be attributed to other factors but not to the sheep breed (Puie A. *et al,* 2018). Data in *table 2* shows that the day of maturation has a significant effect on pH values. This suggests that as maturation time progresses, the pH of the treated muscle undergoes significant changes. For example, for both breeds, pH increased from day 0 to day 9. This development is related to the natural processes that occur during meat maturation, such as protein breakdown and accumulation of metabolic products, which can alter the acid-base balance (Kim Y.H.B. *et al*, 2017).

The increase in pH during maturation is common in meat studies due to the release of compounds such as ammonia or other protein degradation products, which tend to alkalinize the environment (Bulgaru V. *et al*, 2022). Breed type has no significant effect on pH. In other words, regardless of whether the sheep belong to the

Merinos de Palace or *Ile de France* breed, there are no statistically relevant differences in mean pH values.

Table 2

pH analysis in the antomic area *Musculus biceps femoris*: Means ± Standard Deviation for Palace Merinos and Ile de France Merinos during Wet-Aging

Day of Aging	MP_1	IF_2
0	*5.41±0.135*	5.57±0.191
3	5.46±0.209	5.71±0.249
6	5.48±0.206	5.56±0.173
9	5.73±0.205	5.75±0.015
p-value		
Day of Aging	0.05 *	
Type of Species	0.80	

Values are given as means ± SE with five repeated determinations; MP_1 -*Merinos de Palas*; IF_2 -*Ile de France*.

Although small variations in pH between breeds are observable, they are not large enough to be considered significant. This may indicate that physiologically both breeds behave similarly in terms of changes in muscle pH during maturation. The fact that there is no major breed effect on pH may suggest that the biochemical processes influencing pH are similar in these two breeds (Murariu O.C. *et al*, 2023).

The results presented in *table 3* suggest that species type has a significant impact on color parameters evidenced by a p-value of 2.01738E-07, which indicates notable differences between the two types of species studied, *Ile de France* and *Merinos de Palas*. These differences are reflected in the means of the color parameters L*, a* and b*.

Table 3

Impact of Wet-Aging Time and Species on Color Parameters in *Musculus Longissimus Dorsi*

Type of Species	Aging time	L*	a*	b*
IF_2	0	38.71±0.799	21.27±0.402	6.85±0.486
IF_2	3	37.71±0.841	20.91±0.423	6.08±0.202
IF_2	6	39.41±1.777	20.19±1.208	6.45±0.690
IF_2	9	39.52±1.062	21.19±1.83	7.02±0.754
MP_1	0	41.00±0.867	19.92±0.935	7.73±0.754
MP_1	3	40.15±1.169	20.85±1.257	7.01±0.390
MP_1	6	40.91±0.83	20.235±0.589	7.66±0.451
MP_1	9	40.72±0.511	19.64±0.513	7±0.815
***p*-value**				
Day of Aging	0.483			
Type of Species	2.01738E-07			

Data are presented as means±standard deviation at a significance level of $p < 0.05$. MP_1 -*Merinos de Palas*; IF_2 -*Ile de France*.

The *p* value of 0.483 indicates that aging time does not have a significant influence on color parameters. This suggests that, during the observation period of 0, 3, 6 and 9 days, the changes in color characteristics are not sufficient to demonstrate a noticeable impact of aging. This finding may suggest a stability of coloration during this ripening period, which is a positive aspect as consumers may have consistent expectations regarding the visual appearance of the product. Color stability can contribute to consumer confidence in the product, as consistent color is often associated with quality. *Table 4* gives a look at the color characteristics (L*, a*, b*) of two species, *Ile de France* and *Merinos de Palas*, as a function of aging time 0, 3, 6 and 9 days. Values are presented as means ± standard deviation, with superscripts to indicate statistically significant differences.

Table 4

Impact of Wet-Aging Time and Species on Color Parameters in *Musculus Biceps femoris*

Type of Species	Aging time	L*	a*	b*
IF_2	0	40.13±1.469	22.18±0.537	7.21±1.089
IF_2	3	37.82±1.606	20.69±0.489	5.41±0.508
IF_2	6	41.02±1.808	19.98±1.196	7.07±1.954
IF_2	9	39.09±0.671	21.8±1.023	6.92±1.377
MP_1	0	39.22±2.647	16.34±0.311	6.05±0.576
MP_1	3	37.88±0.395	20.31±1.167	5.13±0.948
MP_1	6	39.21±0.734	20.28±0.901	6.22±1.421
MP_1	9	38.67±1.182	20.067±1.479	5.51±1.472
***p*-value**				
Day of Aging	0.066			
Type of Species	2.91E-18			

Data are presented as means±standard deviation at a significance level of $p < 0.05$. ; MP_1 -*Merinos de Palas*; IF_2 -*Ile de France*.

This value is greater than 0.05, which suggests that there is no significant influence of aging time on color parameters. This means that the color variations observed during aging are not sufficient to be considered statistically significant. The results suggest that species type has a significant

impact on color parameters, with significantly different values between *Ile de France* and *Merinos de Palas*. This could influence consumer preferences and overall perception of product quality. These findings may guide production and marketing decisions, indicating that attention should be focused on the choice of ingredients and processes that affect the species type to maximize the visual appeal of the final product.

CONCLUSIONS

The results of the pH analysis indicate that there are no significant differences between the *Merinos de Palas* and *Ile de France* breeds in the pH values recorded in Musculus longissimus dorsi and *Musculus biceps femori*s during wet maturation. Although a trend of pH variation with maturation duration is observed, it does not reach the threshold of statistical significance ($p > 0.05$), suggesting that both breeds show similar biochemical behavior during maturation. This stability in pH between the breeds studied suggests that any differences observed during maturation may be determined by external factors rather than by the breed of animal.

The study demonstrated that maturation time did not significantly influence meat color parameters during the observation period of 0, 3, 6 and 9 days. This suggests a stability of the color characteristics (L*, a*, b*) for both breeds studied, *Ile de France* and *Merinos de Palas*, during the maturation process. This stability is a positive aspect as consistent color is perceived by consumers as an indicator of quality. Consequently, the product can maintain a consistent visual appearance, which can contribute to consumer confidence and satisfaction.

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IMPACT OF INTENSIVE AND EXTENSIVE REARING SYSTEM ON POST-SLAUGHTER LOSSES IN RABBIT MEAT

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Abstract

This study investigates the impact of intensive and extensive rearing systems on post-slaughter losses and physicochemical parameters in rabbit meat. The rabbit carcasses were analyzed, one from an intensive growth system, sourced from a local producer, and the other from an extensive system, obtained according to Romania's National Hunting and Wildlife Protection Legislation (Law no. 407/2006) during the 2023-2024 winter hunting season in hunting ground no. 52, Mironeasa, Iași, Romania. The intensive system carcass followed ISO quality standards as outlined by the Meat Microproduction Department (IULS Iași), while the extensive system carcass was harvested as part of a population control measure. Samples from both carcasses were collected within 24 hours post-mortem, sex and age were recorded, and samples were sealed in sterile bags. They were transported to the laboratory in refrigerated conditions (0-5°C) in accordance with Regulation (EC) no. 853/2004. The research offers a comparative analysis of the post-slaughter losses between the two systems and highlights the differences in handling and processing outcomes based on the growth method. The findings provide valuable data for improving meat quality and minimizing losses in rabbit meat production.

Keywords: rabbit meat, intensive rearing system, extensive rearing system, quality

Rabbit meat offers multiple health benefits for the consumer. Rabbit meat is highly prized for its excellent nutritional characteristics, with less fat, less saturated fat and lower cholesterol levels compared to other commonly consumed meats (Frunză G. *et al*, 2023; Dalle Zotte A., Szendro Z., 2011). Intensive systems generally result in higher final body weight and better feed efficiency compared to free-range systems (Tufarelli V. *et al*, 2022). Alternatively housed rabbits tend to have lower slaughter weights and reduced carcass traits, such as lumbar and hind leg meat weights (Chodová D. *et al*, 2018).

Free-range systems produce meat that is less susceptible to lipid and protein oxidation, which can increase shelf life and reduce post-slaughter losses (Tufarelli V. *et al*, 2022). Extensive systems also result in higher polyunsaturated fatty acid (PUFA) content, which is beneficial for meat quality(Chodová D. *et al*., 2018). Intensive rearing can suppress immune function, which can increase the risk of diseases such as subcutaneous abscesses, a major cause of meat condemnation (Wu Z. *et al*, 2024; Ferreira A. *et al*, 2014).

Subcutaneous abscesses, often caused by *Pasteurella spp*. and *Staphylococcus aureus*, lead to significant economic losses due to meat rejection during post-mortem inspection (Ferreira A. *et al*, 2014). Extensive systems may result in lower meat quality, but reduce total losses after slaughter due to lower carcass numbers (Theau Clément M. *et al*, 2016). Intensive systems, although more productive, face economic losses due to meat quality issues (Ferreira A. *et al*., 2014).

Comparative analysis of post-slaughter rabbit meat losses between intensive and extensive farming systems reveals significant differences in carcass quality, meat characteristics and economic implications. Intensive systems, characterized by controlled environments and commercial feed, often produce heavier carcasses but may experience higher post-slaughter losses due to factors such as meat quality problems and disease prevalence. In contrast, extensive systems, which allow more natural living conditions, tend to produce weaker carcasses with lower overall losses (Ferreira A. *et al*., 2014; Chodová D. *et al*., 2018; Tufarelli V. *et al*., 2022).

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MATERIAL AND METHOD

In this study, the initial stage involved the collection of biological material, represented by two rabbit carcasses subjected to further analyses. The first carcass originated from an intensive farming system, purchased from a local producer. The second carcass was obtained from an extensive system, in accordance with the provisions of Law no. 407/2006 on hunting and the protection of game resources in Romania, and was harvested during the 2023–2024 winter hunting season from hunting ground no. 52, Mironeasa, Iași County. The carcasses were transported under controlled refrigerated conditions (4°C). The regions affected by gunshot wounds were excised to eliminate potential negative effects on sample quality. The selected anatomical regions were cleaned of connective tissue, bones, fat, and tendons.

Compositional analyses (fat, moisture, protein, and collagen content) were performed using the Omega Bruins Food-Check (NIR) spectrophotometer (Bruins Instruments GmbH, Puchheim, Germany). The NIR technique, which operates at wavelengths between 700 and 2500 nm, enables rapid and precise measurements through specific interactions between electromagnetic radiation and biological compounds. The pH values of the samples were determined using a Testo 206-pH1 digital pH meter equipped with an integrated temperature probe. Before each measurement, the electrode was calibrated and rinsed with distilled water to ensure accuracy. The pH data were recorded automatically, and each measurement was repeated for validation.

All experiments were conducted in five replicates. Results are presented as mean ± standard deviation. Statistical analysis was performed using two-way analysis of variance (TWO-WAY ANOVA) with IBM SPSS Statistics, version 21. Statistical differences were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

The results presented in *table 1* highlights the significant differences in the initial weight, final weight, and resulting losses across various anatomical regions of rabbit carcasses between intensive (I) and extensive (E) rearing systems. Rabbits from the intensive rearing system (I) consistently show significantly higher initial weights across all anatomical regions compared to those reared extensively (E). For instance, the forelimbs weigh 300.1 ± 0.47 g in the intensive system compared to 225.2 ± 2.20 g in the extensive system. Similar trends are observed for regions such as the hind shank, shoulder, and rib-eye/loin area. This difference may reflect the better-controlled feeding and growth conditions typical of intensive systems, which result in higher carcass development. He final weight after processing also favours the intensive system for all anatomical regions. For example, the rib-eye and loin area is 120.1 ± 0.447 g in the intensive system, whereas it is only 69.5 ± 0.045 g in the extensive system. The greater retention of weight post-slaughter in the intensive system may be attributed to improved muscle mass development and less pronounced tissue degradation.

Table 1

The initial weight of anatomical regions extracted from rabbit carcasses in intensive and extensive rearing systems, the final quantity and the resulting losses

Rearing system	Forelimbs	Hind shank	Shoulder	Breast	Neck	Flank	Rib-eye and loin area	Tenderloin
Initial weight (g)								
I	300.1± 0.47^{a}	700.8± 1.30^{a}	140± 0.70^{a}	400.8± 1.30^{a}	100.8± 1.30^{a}	160.8± 1.30^{a}	240.2± 0.447^{a}	101.4± 1.943^{a}
E	225.2± 2.20^{b}	431.4± 2.50^{b}	73.8± 1.78^{b}	275.4± 7.98^{b}	75.4± 1.14^{b}	121.6± 2.30^{b}	135.6± 0.045^{b}	60± 0.701^{b}
Carcass quantity after losses (g)								
I	184.6± 0.47^{a}	448.5± 1.30 ^{a}	104.8± 0.70^{a}	342.8± 1.30^{a}	76 ± 1.30^{a}	96.7± 1.30^{a}	120.1± 0.447^{a}	60.9± 1.943^{a}
E	117.4± 2.28^{b}	292.5± 2.50^{b}	55.8± 1.78^{b}	221.9± 7.98^{b}	66.9± 1.14^{b}	76.6± 2.30^{b}	69.5± 0.045^{b}	30.8± 0.701^{b}
Losses (g)								
I	115.4± 1.14a	252.2± 0.35^{a}	35.1± 0.23^{a}	57.9± 0.01^{a}	24.7± 1.35^{a}	64 ± 2.24^{a}	120.1± 2.14^{a}	40.4± 2.14^{a}
E	107.7± 0.56^{b}	138.8± 1.25^{b}	17.9± 0.36^{b}	53.4± 0.45^{b}	8.4± 1.71^{b}	44.9 ± 2.31^{b}	66 ± 2.31^{b}	29.1± 2.34^{b}
Losses (%)								
I	38.47	36	25.12	14.46	24.57	39.85	50	39.85
E	47.62	32.21	24.37	19.42	11.19	36.96	48.65	48.65

Data are presented as means±standard deviation at a significance level of $p < 0.05$. Subscripts on rows indicate significant differences between rearing systems (Intensive vs. Extensive) for each Anatomical Area. I-Intensive; E-Extensive.

Absolute losses are generally higher in the intensive system (e.g., 252.2 ± 0.35 g for hind shank) than in the extensive system (138.8 ± 1.25 g). However, the relative losses as a percentage of the initial weight differ: In the forelimbs, the extensive system shows a higher percentage loss (47.62%) compared to the intensive system (38.47%). This pattern indicates that while the intensive system has higher absolute losses due to larger carcass size, the relative losses are more controlled, reflecting better post-slaughter handling and preservation of carcass integrity. Significant differences in loss percentages across regions suggest varying impacts of rearing systems depending on the anatomical area.

For instance, neck and tenderloin areas show much lower losses in the extensive system (11.19% and 48.65%, respectively) compared to other regions.

Figure 1 shows the evolution of pH in different anatomical regions of the rabbit carcass from an intensive rearing system at specific intervals post-slaughter: 30 minutes, 6 hours, 12 hours, and 24 hours.

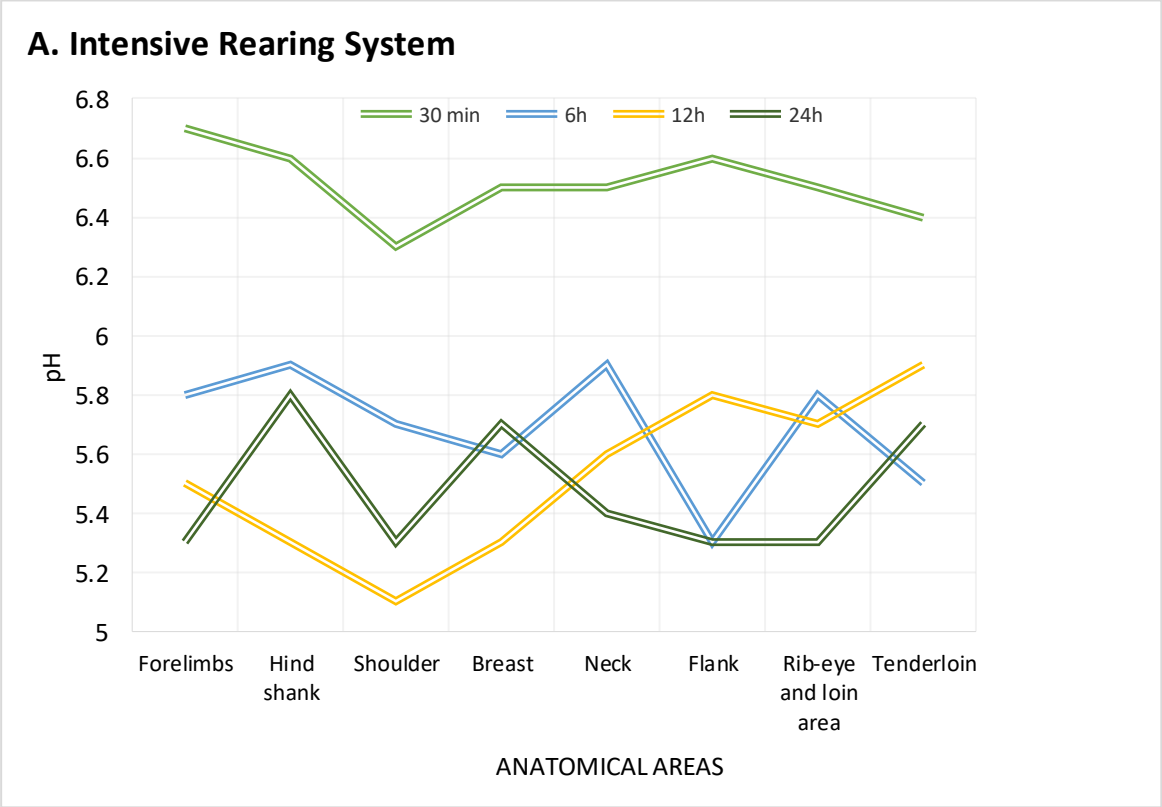

Figure 1 **24h post-sacrifice pH dynamics in intensive rearing system rabbit carcasses**

At 30 minutes post-slaughter, the pH is relatively high across all anatomical regions, ranging from 6.3 (shoulder) to 6.7 (forelimbs). A high pH immediately after slaughter is normal because the muscles are still well-oxygenated, and the process of anaerobic glycolysis (lactic acid production) has not yet significantly begun. Small differences between regions indicate variations in muscle structure and local metabolism. During the interval of up to 6 hours, a rapid decrease in pH is observed in all anatomical regions. For example, in the forelimbs, the pH drops from 6.7 to 5.8, while in the shoulder area, it decreases from 6.3 to 5.7. This decline is caused by the conversion of glycogen into lactic acid through anaerobic glycolysis, which occurs due to the lack of oxygen post-mortem. Differences in pH between regions suggest variations in muscle glycogen reserves and local enzymatic activity. At 12 hours, the pH reaches its lowest values in most regions, indicating the onset of rigor mortis (cadaveric rigidity). The shoulder area records a minimum pH of 5.1, while the flank reaches 5.3. In some regions, such as the tenderloin, the pH begins to increase slightly, suggesting protein degradation and buffering of lactic acid. By 24 hours, the pH stabilizes or increases slightly in some regions, such as the flank (5.3) or the hind shank (5.8). This stabilization is influenced by lactic acid buffering, protein breakdown, and muscle maturation. Forelimbs and rib-eye/loin show a continuous decrease in pH until 24 hours (reaching 5.3), indicating progressive acidification and uniform maturation. Flank and tenderloin display a slightly different trend, with an increase in pH after 12 hours. This behavior may be explained by differences in muscle fiber composition and enzymatic activity. Regions that

reach a pH of approximately 5.3 at 24 hours (such as forelimbs and rib-eye/loin) are ideal for obtaining high-quality meat. Higher pH values (>5.5) may be associated with water retention and a softer texture but could increase the risk of microbial spoilage. Regional differences in pH can influence subsequent meat processing. Regions with variable pH require specific adjustments depending on their final use (e.g., aging, preparation).

In *figure 2* the pH values across all regions range between 5.7 (forelimbs, neck) and 5.9 (shoulder, flank, rib eye, tenderloin) in first 30 minutes. This lower pH compared to intensive systems suggests that animals from extensive systems may have had reduced glycogen reserves due to increased physical activity or environmental stress prior to slaughter. Minimal variation between regions indicates relatively uniform muscle metabolism and structure at the onset of *rigor mortis*.

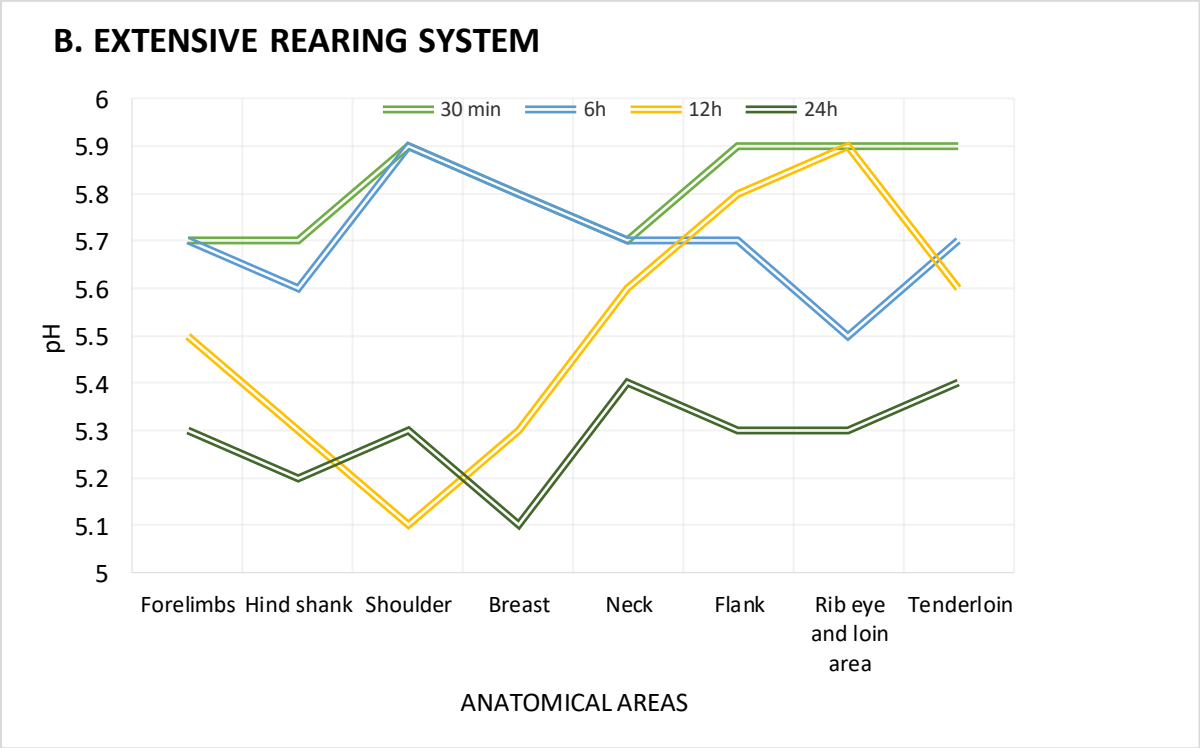

Figure 2 **24h post-sacrifice pH dynamics in extensive rearing system rabbit carcasses**

Between 30 minutes and 6 hours, most regions show little change or a slight decrease in pH. For example, in the forelimbs, the pH remains constant at 5.7, while in the rib eye and loin area, it drops from 5.9 to 5.5. This indicates the onset of anaerobic glycolysis, with lactic acid starting to accumulate due to the depletion of oxygen in the muscles. Differences between regions, such as a sharper decline in the rib eye and loin, may be attributed to variations in muscle fiber type, glycogen reserves, and enzymatic activity. At 12 hours, the pH reaches its lowest values in most regions, coinciding with the establishment of rigor mortis. The shoulder shows the lowest pH at 5.1, while the flank and rib eye and loin exhibit higher values (5.8 and 5.9, respectively). By 24 hours, the pH stabilizes or increases slightly in some regions. The forelimbs, breast, and flank reach a final pH of 5.3, which is suitable for high-quality meat. The tenderloin and neck stabilize at 5.4, while the hind shank declines further to 5.2. Stabilization is due to lactic acid buffering, protein degradation, and the onset of muscle maturation processes. Consistent decline to a final pH of 5.3, ideal for good meat quality. The forelimbs, breast, and rib-eye/loin area display a uniform glycolytic response and acidification. Flank and tenderloin, regions exhibit a delayed or irregular pH decline, potentially due to differences in muscle composition or slower enzymatic activity. The neck retains a slightly higher pH (5.4) due to its mixed muscle fibre composition and potentially lower glycolytic capacity.

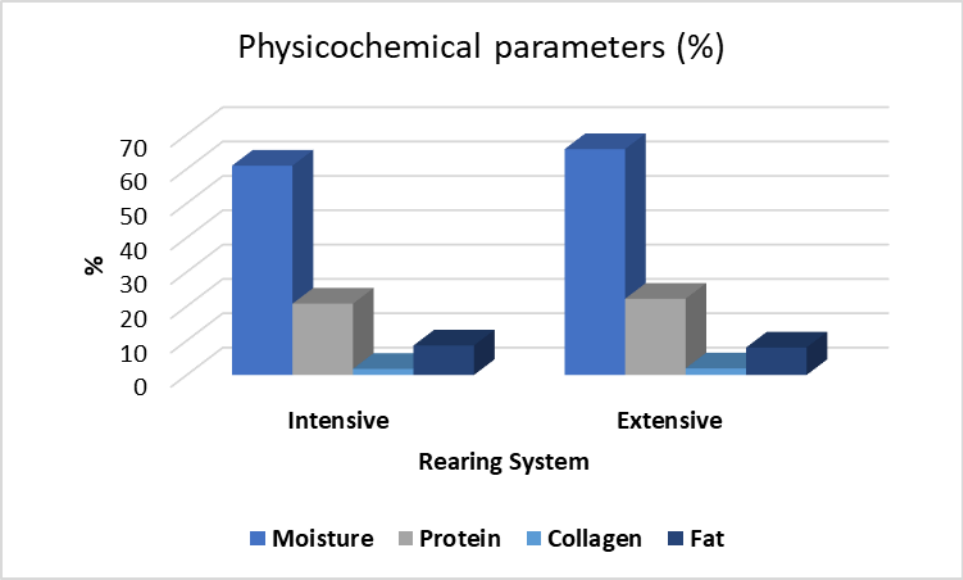

Figure 3 **Physico-chemical parameters in rabbit carcasses from Intensive and Extensive rearing systems**

Figure 3 presents data on the main physicochemical parameters (moisture, protein, collagen, and fat content) of rabbit meat from intensive and extensive rearing systems. These values are expressed as percentages and reflect differences in the nutritional and structural composition of the meat, influenced by the rearing methods.

Samples from rabbit carcasses raised in the intensive system show significantly lower moisture content (60%) compared to those from the extensive system (65%). The higher moisture content in extensively reared rabbits may result from increased physical activity and less developed musculature, leading to higher water retention in the meat. High moisture content can influence the texture and tenderness of the meat, making it softer and juicier. However, excessive moisture may reduce shelf life and increase susceptibility to microbial spoilage.

The highest protein content is observed in the extensive rearing system, which can be attributed to the animal's increased physical activity. Higher protein content is desirable for its nutritional value and indicates superior muscle quality, making meat from the extensive system more appealing to health-conscious consumers. Increased physical activity in extensive systems favors the development of connective tissue, reflected in a slightly higher collagen percentage in samples from the extensive rearing system.

Intensive systems often involve feed with a high-energy content, leading to greater fat deposition. In contrast, extensive systems promote leaner meat due to a lower-energy diet and increased physical activity (Ciobanu M.M. *et al*, 2023).

CONCLUSIONS

In conclusion, the extensive rearing system offers superior nutritional quality meat, with higher protein and collagen content, making it preferred by consumers who emphasize health and sustainability. On the other hand, the intensive system produces meat with a higher fat content, resulting in a more intense flavor, but is less attractive to those who prefer leaner meat. These differences suggest the need for adjustments in the production process and marketing strategies, depending on consumer preferences and market demands. Anatomical regions from carcasses originating in both intensive and extensive rearing systems with variable pH require specific adjustments depending on the final destination of the meat (e.g., during maturation or preparation processes). The intensive rearing system produces larger and heavier carcasses, resulting in more meat yield after slaughter, but also leads to higher absolute losses due to the initial size of the carcasses. The extensive rearing system, on the other hand, shows comparatively lower absolute and relative losses in certain anatomical regions, which may indicate a slower growth rate and denser tissue composition. These findings underline the importance of choosing the rearing system based on specific production goals—whether maximizing yield or focusing on lower post-slaughter losses in certain regions.

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SUSTAINABLE AND MODERN METHODS FOR THE LOGISTICS OF AGRICULTURAL PRODUCTS

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Abstract

Agricultural production proves to be a priority in the market analysis. In the current economy, the interest for a diversified and increased production remains at a high level, starting primarily from the basic needs that agricultural products satisfy and the increased demand. Commercial, financial, technological, logistical interests are also added to this, all being components of market studies. The present paper approaches, in an interdisciplinary manner, three directions of agricultural products market analysis: sustainable marketing, logistics and the need-production-consumption relationship. The data used for the analysis are from official sources such as Eurostat and NIS, and data from the companies that are subjects of the analysis: Agricover, PrimeAgiculture, Kompass, Agromontana. The results highlighted that adapting production to market requirements is a vital component of the marketing plan, and the distribution and commercialization pillars directly impact on production, even if the consumer is in the foreground as a focus. The lack of efficiency in the logistic system leads to loss of capital and image, so ensuring the sustainability of these pillars is a way to ensure the success of companies present on the agricultural products market.

Key words: agricultural products, marketing, logistics, sustainability, efficiency

Agricultural production activity has been and remains vital for economic growth and development, regardless of the evolution of socio-economic systems or market orientations. However, in order for production to reach the consumer market, namely the final customer who needs agricultural products, the rigorous organization of the production-consumption market route is mandatory. The marketing components that prove to be vital for supporting, in conditions of sustainability of this path, are the logistics & distribution of agricultural production. Without a functional, efficient and rigorously organized distribution system, the production-consumption chain becomes inoperable or is burdened with unjustified costs.

The main pillars mentioned above target both production and distribution activities, being increasingly influenced by sustainability rules. From the perspective of globalization and to respect the sustainable development rules, the logistic steps have become the nucleus of attention in both market research, and planning processes.

Although, the agricultural production still remains a priority in the market and consumption investigations, in the same time the production is becoming increasingly dependent on the distribution rules and its functionality. On the one hand, production depends entirely on inputs provided through an operative and rigorous distribution, respectively it depends entirely on the distribution systems that ensure sales and sales to intermediary or final customers. The interest for a diversified and increased production remains at a high level, but new commercial, financial, technological and logistical interests are added, being a particularity of a developed economy.

This paper approaches the three directions of the nowadays agricultural products market analysis: sustainable marketing, logistics and distribution, and the need-production-consumption relationship. Some supplementary requirements are related to respecting the sustainability rules in the logistic steps. Why? Because the technology and means of distribution are very well developed and the commercial policies take them into account. Also, globalization is another factor with big influence for the market analysis, mainly for the production planning processes, logistics adaptation, and relationship between market actors.

The main objective of this paper is to analyse the conceptual and practical framework

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regarding the sustainable dimensions of logistic and distribution as the vital branches of marketing specific for the agricultural products. The data used for the analysis are collected from official sources and from the following Romanian companies, which are subjects of the analysis: Agricover S.A., Prime Agiculture S.R.L., Kompass România S.R.L. și Agro Montana S.R.L.

The research carried out is part of the observation, synthesis and analysis category and aims to highlight the role and involvement of the agricultural product distribution system within large agricultural production companies. It is also considered for investigation and adaptation to both the demands of the consumer market, as well as to the requirements associated with the principles of ensuring sustainability. The empirical idea on the basis of which the working hypothesis was built is that adapting production to market requirements is a vital component of any marketing plan, especially in a free, highly competitive economy.

In the light of these aspects, it is observed that the distribution and marketing pillars directly and significantly impact production, even if the final target, the consumer, is in the foreground or constitutes a focal point. Another hypothesis analyzed in this paper is the following: the lack of efficiency of the logistics and distribution system, as a marketing pillar, leads to both loss of capital and profit, as well as the image of the production unit. Thus, ensuring the sustainability of these marketing pillars is a guaranteed way to ensure the success of agricultural production companies.

Essentially, the functionality of logistics and distribution systems within the production-consumption chain must be perceived as a healthy organism, in which each process, sub-process and mechanism correlates in a functional interdependence, without significant errors.

MATERIAL AND METHOD

The analysis of the distribution system within the marketing mechanism, as well as the implicit logistics chain, is embodied in an analysis of the supply or the offer dependent by production.

In particular, the offer of agricultural products is characterized by features that influence the market dynamics: seasonality zoning, perishability, inconstancy, uncertainty, zonal specificity, gradual reduction/increase in consumption, long production cycle time, agricultural policies.

The concept of logistics, both theoretically and practically, is present and active in the literature, being in the area of interest of numerous studies for more than 50 years; in the activity of companies, it is a major necessity, and adaptation to the latest requirements and developments is imperative for the smooth running of the activity, in conditions of profitability.

The concept of "logistics chain" refers to "the grouping of companies involved in providing products and services on the consumer market" (Lambert D.M. *et al*, 1998), respectively "a logistics chain is formed by all parties involved, directly or indirectly, in fulfilling a customer request". (Chopra S., Meindl P., 2007) The functions of the logistics chain include: new product development, marketing, operations, distribution, finance and customer service." (Albăstroiu I., Felea M., 2013). Kotler (2006) stated that “logistics involves the planning, realization and physical control of materials and finished products, from points of origin to points of use, in order to satisfy consumer needs, while obtaining profit.” But, the unprecedented evolution of technology and management systems, have made it possible for “logistics to be a tool for increasing the competitiveness and positioning of an organization on the market, globally becoming one of the essential areas of the organization’s activity”. (Golea P., 2020)

Currently, one of the newest and major challenges of logistics and distribution in the agricultural sector is the advancement to the Logistics 4.0 system. This involves the integration and alignment of companies’ supply chains with the progress of digital technologies, based on automation and digital connectivity. Logistics 4.0 aims to optimize workflows through automation, leading to better efficiency and profitability.

The factors that make up the complex Logistics 4.0 system and influence its functionality and performance are highlighted in *Figure 1*.

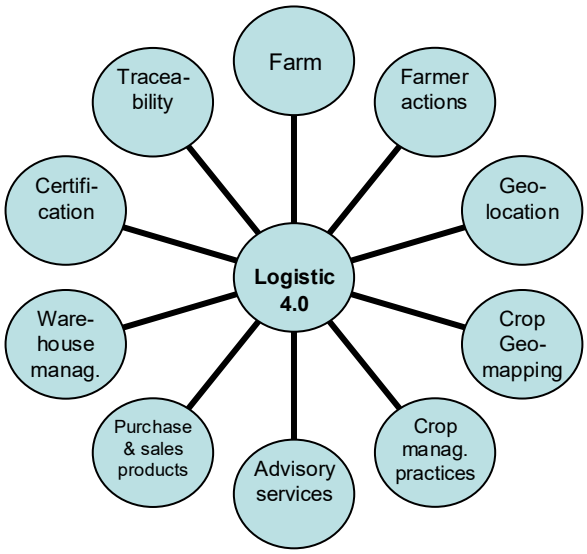

Figure 1 **Component factors of the Logistics 4.0 system.**

Source: adapted from Javaid *et al*, 2022

The basic characteristics of this modern and complex logistics system are connected with the following aspects:

- transport systems: it is considered the most important part of efficient agriculture;
- the main role: to deliver agricultural products from farms to markets and consumers;
- correct logistics: is the key to managing the assets from the point of origin to the consumers;
- the national well-being depends on transport, logistics and distribution.

If from a theoretical and conceptual point of view, the literature is rich especially on the topic of marketing and distribution, when it comes to sustainable marketing, we believe that there is still room for new approaches.

Essentially, logistics refers to a way of management, as a process through which a company's resources are transferred between points of interest on the map of the respective business. Given that the supply of agricultural products is characterized by fragmentation, dispersion and irregularity, the distribution process and logistical organization are vital for the protection of production, producer profitability, market stability and consumer satisfaction.

In this sense, the role of the paper is to emphasize the importance of sustainability in organizing logistics and distribution systems in the agricultural sector, since sustainable marketing guarantees efficiency and stability in the production and consumption market.

The orientation towards sustainable practices not only in the production and consumption sectors, but also in those of logistics and distribution, is materialized in consolidating the market position and ensuring competitiveness through a qualitatively superior production possible to achieve through the use of new, modern and high-performance technologies, the use of means of transport and storage with a protective role for agricultural goods, enrolment in international trade and an increasingly active presence on the international market, including the stimulation of advantageous import-export relations.

Methodologically, the paper is an empirical, descriptive analysis, which has as its foundation the incursion into conceptual and practical literature. The working methods are observation, selection, grouping and synthesis, starting from the hypotheses mentioned above.

RESULTS AND DISCUSSIONS

The future of logistics and farm transportation should pivot towards technology and innovation, focusing on sustainability and efficient transport. But, in this regard, a question arises: are the companies ready for these changes and challenges? We must take into account new approaches and challenges: novelty, impact on the environment, new technologies, mentality etc.

One of the most relevant pillars of the sustainable marketing is sustainable logistics, observed as an increasingly important topic in the logistics industry and recognized as a need to balance economic growth with environmental and social responsibility (Beredugo M., 2024).

”The sustainable practice of multinational logistics service providers is an effective means of achieving the sustainable transformation of supply chains in the context of sustainable development.” (Li *et al*, 2021 cited by Su *et al*, 2022).

We consider that the benefits of sustainable logistics consist of: more investment for packaging methods and storage systems, increased production, reaching international markets, expanding business, etc. Otherwise, there is a risk of damaging the merchandise, lack of efficiency, decrease of reputation etc.

A main request in this context is to improve the agricultural logistics and distribution systems. With the rise of e-commerce, transportation providers must operate more efficiently and quickly to meet the increasing consumer demand. Many logistics companies are still adjusting to the new circumstances.

Also, to stay in the market, it is important to use new technologies as they become more and more popular. Farms will be more profitable, efficient, safe, by developing sustainable agriculture based on advanced devices, precision farming and robotic systems.

The aim was to highlight that these companies, regardless of size, age or nature of the shareholding, are oriented towards supporting a high-performance logistics system that will position them advantageously on the production and consumption market.

Table 1 present a set of characteristics and parameters with high significance for the adaptation of the analysed companies to the sustainable requirements of modern logistics. In the same time, it was summarized that the interest to be competitive on the market is still a priority.

The table below summarizes the logistics activity of some of the largest operators on the Romanian agricultural market. Following the collection of information from these companies regarding the adaptation of the logistics and distribution system to the latest technological and market requirements, we have carried out a SWOT analysis.

Table 1

Parameters and characteristics of modern logistics for the analyzed companies

Agricover Distribution S.A.	- prompt delivery of products and high level product quality - purchasing inputs for farms, quickly and easily - opening the ”Agricover” online shop - modern digital ecosystems - more than 10.000 partners and a net consolidated profit of 44 million lei in 2023 - creating the ”Agricover Distribution” division as a customer base consolidation, with 4% more farmers served in 2023 compared to 2022 - even if 2022 was a year marked by instability and major disruptions of logistics chains worldwide, Agricover Distribution obtained an EBITDA of 37.6 million lei
Prime Agiculture S.R.L.	- grain storage, - silos, conveyors, cleaners - varied range of equipment related to storage activity, transport and conditioning of cereals - solutions for the efficiency of the cereals flow - modern equipment in accordance with the Logistics 4.0 system: grain silos, conveyors, grain bucket elevators, grain dryers and cleaners, laboratories equipped for grain samples, modern weighing systems, equipment for monitoring grain temperature, modern ventilation systems, maintenance and upkeep services
Agro Montana S.R.L.	- distribution of HoReCa products - 200 products and 50 partners - a distribution company - a portfolio of products aimed at collective consumption and HoReCa, covering the Bucharest and Ilfov areas
Kompass România S.R.L.	- online promotion and visibility of the company and its offer of products and services - targeted advertising - databases and online applications dedicated to sales and marketing - access to public tenders from Romania and other 210 countries - telemarketing and lead generation campaigns - ”EasyBusiness” an online application, built using the most accurate and complete database of companies, products and services and managers from over 70 countries - the Kompass database includes 50,000 companies, profiled in detail, providing more than 800,000 products and services and more than 130,000 managers - international distribution in Europe (91%), Pacific Asia (6%), Africa (2%), Middle East (1%).

Source: personal processing and synthesis based on data collected from companies

It can be seen the orientation towards a sustainable performance of the logistics system as a priority in which a lot of investment is made.

CONCLUSIONS

Nowadays, both the quality of products and the quality of transport are essential for the buyer's satisfaction. Harvesting, threshing, winnowing, bagging, processing, and storage are all steps in the process of gathering a harvest, each requiring meticulous quality control to ensure transportation quality is as crucial as its availability. Given that the supply of agricultural products can register significant variations in the short term, understanding and planning the supply by considering the logistics chain is essential for the efficient management of the supply chain and the overall activity of the company. The authors' contribution focuses on identifying a common core for the concepts of marketing, logistics and sustainability: efficiency in operating on the agricultural production market by directly reporting to the need for consumption.

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CONSUMPTION OF NATURAL JUICES: A COMPARATIVE MULTICRITERIAL ANALYSIS

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Abstract

The issue of consumption of specific food products, such as natural juices, is increasingly in the attention of both producers and marketing analysts. Predominantly, consumers from generations Y and Z (Millennials and IGen) are increasingly interested in quality food products that support health, proper nutrition and a healthy lifestyle. The research is based on some objective directions, and others subjective. On the consumption market, speculative capitalization is felt by producers who are tempted to deliver juices in accordance with the new subjective consumption requirements, but with minimum production costs.

The present paper considers the analysis of consumption preferences for natural juices, by young Romanian consumers, and constitutes a multicriteria market study using the survey. The results indicate that, in most cases, consumers do not know the content of what they are consuming, but they prefer juices that present a complete image of naturalness. The study was carried out through a market investigation, based on a questionnaire, applied at national level, and the results were based on a multivariate factorial analysis.

Key words: consumption preferences, natural juices, influence, speculation, healthy needs

The consumption of secondary food products, that is, those that do not directly satisfy nutritional requirements and are based more on the desire to consume, is increasing rapidly. Juices are one of these products, and consumption is present in almost all age groups. The issue we raise for analysis is the motivation for juice consumption, with an emphasis on the differentiation between natural juices and those that have no connection with the concept of "natural". The reality of the markets indicates: the topic related to consumption of specific food products, such as natural juices, is increasingly catching the attention of producers and marketing analysts, but also of consumers.

A relevant aspect for the analysis of the consumption of food products that are not strictly necessary is that of the social age categories in the modern approach: Baby Boomers, Generation X, Millennials, Generation Z. Is important that the analysis of food consumption, particularized in this paper on natural juices, be done by social age categories, considering the society and economic period from which they come, because depending on these, consumption preferences and goals in life are different. From this perspective, it is observed that, predominantly, consumers from generations Millennials and Z are increasingly interested in quality food products that support health, proper nutrition and a healthy lifestyle.

Another concept: the preference, a widely debated topic in specialized studies. Preference is a concept of psycho-social origin, because it is supported by influencing factors that relate to both the consumer himself and the environment, he is part of. Thus, both for the producer and for defining individual objectives it is extremely important to know "why" a certain type of food product is preferred for consumption. Natural juices are within the scope of these consumption concerns, and the analysis is based on several varied criteria. Preference is a consequence of perception, so a preference analysis study also involves perception analysis, that is, "what the consumer thinks", "what he sees/seems", "what he hopes" when he is oriented towards a certain product. For the food products, perception of the importance of the quality of food products consists in: consumer satisfaction, pleasure of consumption, market competitiveness assessed by price and brand, health guarantee, etc.

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MATERIAL AND METHOD

Concerns for the analysis of food consumption, including reports of consumption patterns and balance sheets, are increasingly extensive and more elaborate, for at least two reasons: the food market is overcrowded with an impressive variety and diversity both quantitatively and qualitatively, respectively, the general health of the population indicates some concerns given the expansion of diseases associated with the style of food consumption. Therefore, the interest in knowing why individuals consume products that do not have a favorable impact on health or why they consume products of inferior quality or lacking nutritional intake has become increasingly acute.

Numerous current studies have focused on the conceptual analysis of food consumption based on social ages, which refers not only to the biological age of the individual, but also to the specificities of the generation to which he belongs. These categories are (Park G. *et al*, 2021):

- Baby Boomers: born between 1946-1964, appreciated as a generational archetype of "prophets" who have a clear consensus on the social order, with an emphasis on morality and solid and healthy principles of life;
- Generation X: born between 1965-1980, called "nomads" in the generational archetype; they are considered to be alienated adults, lacking the pampering of adults busy with social change;
- Millennials: born between 1981-1996, represent the "hero" archetype; it is a generation of pragmatism and individualism, they are very protected by their parents, becoming optimistic and energetic adults.
- Generation Z: born between 1997-2010, archetypically they are "artists" marked by an ethic of personal sacrifice.

Another concept associated with the previous one is that of consumption preference, which is found predominantly in the international marketing and consumer behavior literature, with the aim of understanding what makes an individual choose and consume one product over another. (Allen M.W., Ng S.H., 2004; Njite D. *et al*, 2008). According to Metcalfe (2001), "The shaping of preferences by firms would fall naturally into place in such a knowledge accumulation framework, so that the activities of firms in making markets take on a more positive role than is frequently assumed."

The autochthonous literature, as Iordache (2004) mention about the psychophysiological mechanism of consumer preference, explaining what determines the preference for a product or service. By preference we understand the final step of rational-emotional process completion, so the decision to purchase and consume a product.

Still for a long time, the international literature (Vaughn R., 1986) mention about the strategies considered by producers and sellers to create the preference of consumers for a certain product. And, for the natural (or unnatural) juices there are no exception. In this regard, the grid is one of those models that can be used to explain the consumer involvement in the services or products procurement based on a preliminary preference induced with various attributes (price, taste, color, advertising, offers, habit etc.). The Company "Foote, Cone & Belding" based on the Vaughn theories introduces the FCB Grid, based on the main following strategies:

- *Information strategy*: for the important purchasing that needs a difficult decision;
- *Affective strategy*: specific for the products or services that stimulates or invigorate the ego and self-esteem;
- *Habit strategy*: products for daily routine that don't require much thought for decision;
- *Satisfaction strategy*: based on the social models and the impulse to show and the share the consumption experience.

Synthesising and focusing on the natural juices consumption, the preferences issue means:

- aware of the importance of a healthy diet, the consumers are increasingly interested in the impact of their diet on their health;
- in search of convenient and nutritious alternatives, the preference for natural juices is perceived as a quick and healthy solutions for busy and dynamic lifestyles;
- quality of the source/producer and retailer are considered, consumers being aware of the importance of the source of juices;
- the essential characteristics of natural juices are: authenticity, freshness, nutrient content;
- the nutritional benefits of natural juices are: concern for health, nutritionally balanced, alleviating hunger in diets, pleasure.

This paper consists in an analysis of consumption preferences for natural juices, by Romanian consumers, from the Millennials generation. It is based on multicriteria market study and investigation. The tool used is the questionnaire, applied at national level, and the results were based on a multivariate factorial analysis. The purpose of the paper is to analyze the consumer preferences and their influence on the dynamics of the natural juice market. The main objectives: O1. identification of preferred types of natural juices and frequency of consumption; O2. analysis of motivational factors of consumption.

Methodologically, the paper is a quantitative analysis, a descriptive and corelative one, based on a market survey on a sample of 120 people, aged 18-45, with varying levels of education and income. For application Google Forms platform and pen-and-paper method were used.

A priori hypothesis formulated based on the previous observations:

H1. in most cases, consumers do not know the content of what they are consuming, but they prefer juices that present an image of naturalness;

H2. the motivation to consume is in conflict with actual consumption, since although they seek health, the subjects predominantly consume "unnatural" juices;

H3. consumption preferences are rather based on reference to the external environment, such as areas of consumption and marketing sales techniques, influence of social groups, price, etc. and much less on personal beliefs and intrinsic values.

RESULTS AND DISCUSSIONS

Based on the responses collected from the 120 available questionnaires, the most relevant results are below, by mentioning 6 questions with the corresponding answers and interpretation.

The profile of the respondents obtained through the processing of the recorded data is: 18-25 years age (85.1%), under 1500 lei income (47.1%), female (76.9%), university studies (46.3%) as educational level. For each table, the sources are the results of the authors' processing of the collected data. The questions selected as relevant for the analysis of preference and motivation among millennials have as variables: fruit categories for consumed juices, favorite brand, frequency of consumption, place of purchase, determinant attributes of the purchase decision, reaction to future consumption in case of financial constraint.

Q1. Types of natural juices consumed. As it can be observed in *table 1*, the ranges are as follows.

Table 1

Fruits preferred for the juices taste

Oranges	71.1%
Peaches	47.1%
Apples	47.1%
Grapefruits	20.7%
Ananas	20.7%
Strawberries	26.4%
Kiwi	5.8%
Bananas	5.8%
Other as pears and cherries	0.8%

It can be noted that almost exclusively orange juices are preferred, most likely being present on the market due to easier production or cost-effective production costs, and the appreciated taste and the favorable contribution to health.

Q2. Favorite natural juice brands. As it can be observed in the *table 2*.

Table 2

The favorite brand

Cappy	38.8%
Tymbark	24.8%
Santal	19.8%
Prigat	9.9%
Granini	5%
Others: Solevita, Nestea, etc.	1.7%

The preferred brands: Cappy, followed by Tymbark. One of the most interesting aspects of these preferences is that, from a qualitative point of view, these brands are far more oriented towards the production of natural juices, at least compared to Santal or Granini. Thus, the preference is most likely induced by the influence of price and the intensively used promotional means.

Q3. Frequency of natural juice consumption. The responses obtained indicate the following consumption frequencies (*table 3*):

Table 3

Frequency of consumption

2-3 times a week	36.2%
Occasionally	28.4%
Once a week	25.8%
Daily	9.6%

It can be seen that young people from the Millennial generation do not consume juices with great frequency (without considering them to be natural), only 9.6% being those who consume them daily. Most consume them 2-3 times a week and occasionally (36% of these answers). This aspect seems to be beneficial for the health of young people, provided that the statements are honest and the difference between natural juices and other categories of juices is understood.

Q4. Place to buy natural juices. Given the predominant areas of sales and advertising of juices, we considered this question to be important, as the place where juices can be purchased can prove to be a stimulating factor for consumption. The results indicate, as it can see in the *table 4*.

Table 4

Place of purchasing the juices

Supermarkets	71.9%
Hypermarkets	14.9%
Convenience stores	11.6%
Other: small producers or an acquaintance	1.6%

Young millennials choose to buy natural juices mainly from supermarkets, most likely for proximity and ease of product identification on the shelf, respectively the purchasing process. Most likely, hypermarkets are located at a great distance, and convenience stores have higher prices.

Q5. Purchasing criteria. Regarding the criteria for choosing natural juices, that stimulate consumption preference, the results are noted in *table 5*.

Table 5

Purchasing and consumption criteria

Price	38%
Quality	33.9%
Offers	14.9%
Promotions	11.6%
Flavors	1.6%

Almost equally important in the preference for consumption of natural juices are: price – considering a very low price, quality - considering that respondents can differentiate between natural and unnatural juices, offers and promotions - as stimulating factors in food consumption.

Q6. Under financial constraints, will they still purchase their favorite natural juice brands?

Table 6

Continuing natural juices consumption in case of financial constraints

Less often	53.7%
Yes	33.9%
Totally	8.3%
Not at all	2.5%
Rarely	0.8%
No	0.8%

Regarding the correlation of age with favorite juice brands, the results indicate: Cappy & Tymbark are preferred by young people of 18–25-year-olds and, Cappy & Prigat by those of 25–35-year-olds. About the gender, females prefer orange & peaches, and the males prefer orange and apples.

CONCLUSIONS

The consumption of natural juices is a food priority among young people of the Millennial generation, but the recorded and processed responses show that this consumption occurs rather out of habit, on impulse or under the influence of social and marketing factors. However, the interest in consuming natural juices for taste pleasure or nutritional satisfaction is evident. A preference for quality and affordability is remarked, too, alongside the important role of supermarkets in promotion and distribution. On the consumption market, speculative capitalization is felt by producers who are tempted to deliver juices in accordance with the new subjective consumption requirements, but with minimum production costs.

Natural juices are within the scope of these consumption concerns, and its analysis requires and involves several varied criteria, being an interdisciplinary topic. The motivation to consume the natural juices it seen to be in conflict with the actual consumption, since although they want health, the subjects predominantly consume unnatural juices, and consumption preferences are rather based on reference to the external environment, such as areas of consumption and marketing techniques for sales, influence of social groups, price, sometimes addiction or habit, disabled awareness capacity, etc. and much less on personal beliefs and intrinsic values.

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RESILIENCE AND FOOD SECURITY: ADDRESSING GLOBAL RISKS

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Abstract

Food security is dependent on social, economic and biological systems that are interconnected to meet people's nutritional needs. Managing risks is crucial to strengthening the resilience of food systems and ensuring long-term food security. Some of the biggest challenges are climate change, financial risks and political instability. Resilience, the ability to overcome shocks, is becoming increasingly important. To improve long-term food security, we need to build better food systems that can absorb and adapt to climate change and other risks. A proposed study aims to assess adjustments to the Global Food Security Index and provide recommendations for improving global food security policy. Identifying gaps in the index and accurately reflecting the complexity of the global food system are important findings. Access to food at reasonable prices is essential for social well-being and stability. High-income households are better able to absorb temporary price increases, while low-income households need a safety net.

Key words: food security, resilience, risks, Global Food Security Index (GFSI)

The ability of social, economic and biophysical systems to meet people's nutritional requirements is central to food security, and understanding and addressing these risks is essential to building the resilience of food systems and ensuring long-term food security.

The Global Food Security Index uses indicators to assess threats and resilience, providing a snapshot of a nation's food security. Understanding how a nation is exposed to specific risks and how resilient its food systems are is critical to creating effective policies, investments and interventions.

Resilience, the ability to bounce back and better overcome a shock or disaster, is becoming increasingly important in the current context (Teryutina M.M., 2021), so building better food systems that can absorb and adapt to climate change and other risks is key to ensuring long-term food security (Tursunov B.O., Uktamov K.F., Tukhtamuratova A., 2022).

This study aims to critically assess and analyze changes in the proposed Global Food Security Index to better understand how these changes influence the assessment and approach to food security in terms of food affordability and other global risks. In order to increase the food output required to feed a world population that is predicted to exceed 9.10 billion people by 2050, the health of the globe's freshwater, seas, and fertile land are all directly related to food security. However, urbanisation, population increase, and shifting consumption patterns are putting further strain on these vital resources. A large amount of the world's land is used for agriculture, and as it grows, especially in emerging nations, it encounters degraded land, which puts further strain on the world's resources. The amount and quality of land are essential to the world's ability to produce food (Gavrilescu C., 2021). Because there is a limited amount of land that can be used for agriculture and soil depletion from intensifying agricultural practices is a serious problem, soil health helps food systems remain resilient by preventing erosion and nutrient loss, preserving moisture, and reducing soil erosion. As populations and incomes rise, competition for agricultural land, feed, and fuel will only increase, placing further strain on the amount and quality of land available for food production. To ensure long-term food security in the face of these challenges, sustainable agricultural practices and the preservation of natural resources are necessary (Altieri M. *et al,* 2015). Weather patterns and broader economic issues, such changes in energy prices and agricultural policies, are factors that contribute to rising food costs. Reliance on imports for supplies can make these price rises much more severe, especially in lower-income nations. Diversifying support methods, such as cash transfers, vouchers, and physical food distribution, is crucial for food security nets. As such, these programs must be attentive to the needs and livelihoods of recipients, with a focus on women's participation in decision-

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making. Investment in food security programs not only protects against food insecurity but also fosters community resilience and sustainable economic development.

MATERIAL AND METHOD

Finding and choosing indicators and sub-indicators that are used in the GFSI to evaluate various aspects of food security, as well as gathering and analysing pertinent GFSI data on food security, are all part of the suggested methodology for evaluating the effects of changes to the Global Food Security Index on the assessment and approach to food security. The proposed methodology for assessing the impact of adjustments to the Global Food Security Index on the assessment and approach to food security includes also:

The examination of the evolution of indicators and sub-indicators over time and identifying pertinent trends in food security, the 2022 edition of the GFSI is compared to earlier versions in order to identify and evaluate modifications and adjustments made.

The comparation and contrasting how various nations utilise and interpret the Global Food Security Index, it is possible to evaluate how the new GFSI changes affect how food security is perceived and managed in the particular context.

RESULTS AND DISCUSSIONS

Food security is essential for social well-being and social stability, and access to affordable food is the foundation of food security. Higher-income households that allocate a smaller proportion of their expenditure to food are more likely to cope with temporary price increases, while low-income households require short-term safety nets to ensure that food remains affordable, especially in the face of food price shocks. In terms of the global food security environment, the Global Food Security Index 2022 reveals visible differences across countries. It can be seen that in terms of food security in 2022, countries in Europe, the North American continent and Australia *(figure 1)* score over 70 points, while at the opposite pole, with less than 55 points, the vast majority of countries on the African continent are located:

In terms of food accessibility, eight of the top ten countries benefited most from the opportunity to reduce food prices, while for Oman and Cambodia, the launch of a safety net was key, and for the top six countries, improved market access was key to increasing food accessibility.

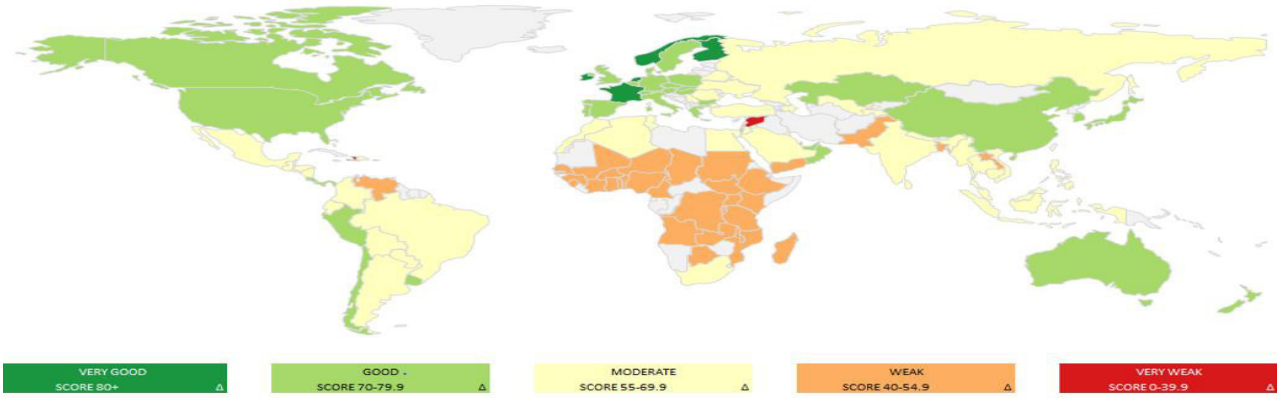

Figure 1 **2022 Country score map regarding food security environment (scores are normalized 0-100, where 100=best conditions). *Source:* Own calculations based on GFSI 2022 Report**

The United Arab Emirates, Algeria and Niger have seen the biggest increase in food availability, due to their approach to volatile food production and commitment to food security policies, with many of these countries achieving better results by strengthening infrastructure and investing in agricultural research and development. Increased food availability is associated with significant reductions in hunger in countries such as Bolivia, Ethiopia and Angola, which have gone from less than 100 per cent to more than 100 per cent adequate food supply, with these improvements being due to poverty reduction and investment in farmer productivity, while Sudan, Serbia and Uruguay have distinguished themselves by improving food quality and safety, with the application of nutritional standards being the main reason for this development. Increased food availability has been accompanied by significant reductions in hunger in countries such as Bolivia, Ethiopia and Angola, which have gone from less than 100% to more than 100% of adequate food supply. These improvements have been driven by poverty reduction and investments in farmer productivity, while Sudan, Serbia and Uruguay stood out in improving food quality and safety,

with the implementation of nutrition standards being the main driver of this development. The shocks of 2020-2022 have highlighted the fragility of the global food system and increased concerns about food security. These events, including the COVID-19 pandemic, conflict, extreme weather events and rising costs, have exacerbated systemic problems, leading to a decline in food security and a weakening of the resilience of the system as a whole. With the invasion of Ukraine by Russia and the increase in conflict, the number of such events continues to increase, according to the Oslo Peace Research Institute. The situation is similar for climate change shocks such as droughts and floods, which have become more frequent and intense in the 21st century, according to a 2019 report by the Food and Agriculture Organization (FAO). This confluence of shocks and their increasing frequency is putting increasing pressure on an already fragile food system, pushing more people into hunger and food prices to unprecedented levels.

In terms of global food security, the 2022 Global Food Security Index shows notable differences across countries. For example, based on GFSI data for 2022, Romania has made progress in food security. However, there are areas that require additional attention *(figure 2):*

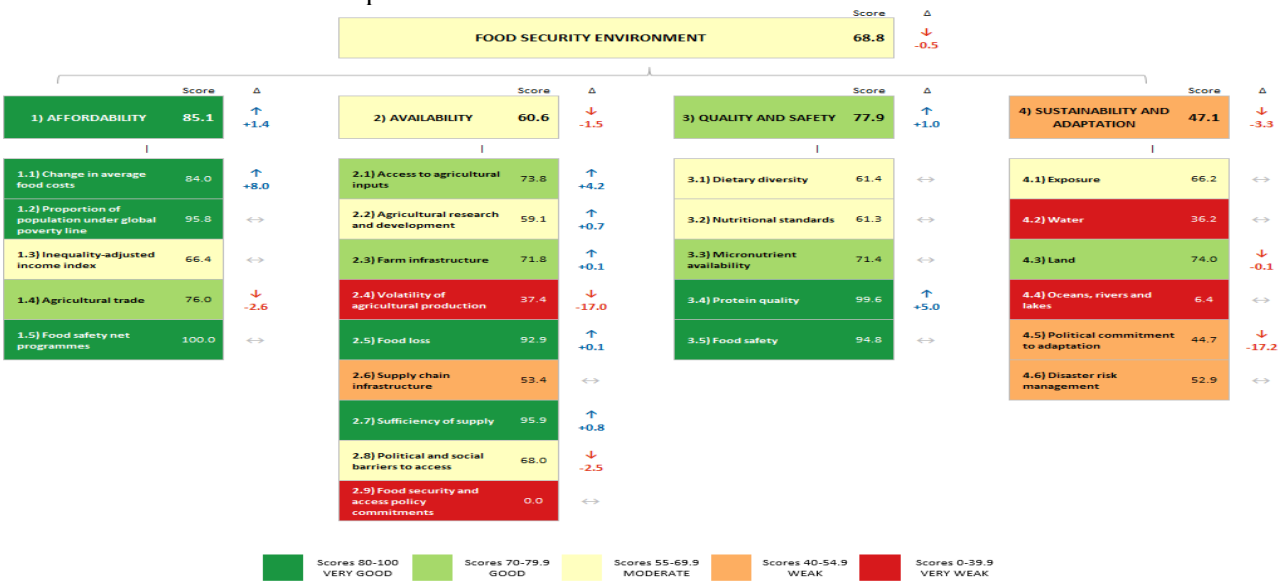

Figure 2 **Romania - score regarding food security environment (scores are normalized 0-100, where 100=best conditions). *Source:* Own calculations based on GFSI 2022 Report**

The Global Food Security Index (GFSI) in its 11th edition (2022) includes four dimensions: affordability; availability; quality and safety; sustainability and adaptation. During the GFSI analysis period (2012–2022), Romania had a good performance in food security, in the sense that all four dimensions recorded improvements, but with a slight decrease in the last three years (2020–2022) in terms of food availability, sustainability and adaptation. This is a general trend as a result of the COVID-19 pandemic and the war in Ukraine. The 11th edition of the GFSI shows a deterioration of the global food environment for the third consecutive year, which may pose a threat to food security. In a global context, the food security situation of Romania, reflected by the scores awarded four dimensions, had an overall "moderate" rating (with a score of 68.8 out of 100 points) in 2022. Italy had a score of 74.0, Poland 75.5, and France 80.2 (very good).

The "moderate" rating is the result of higher scores in accessibility ("very good" rating) and in quality and safety ("good"). These scores suggest that food security vulnerabilities in Romania may arise from these two directions, namely from food supply and environmental conditions. According to the GFSI methodology, the breakdown of scores by indicators reveals in more detail the very good and good scores as well as the weaknesses in food security. By comparison, in France, Italy and Poland, the food security situation is similar to that of Romania in terms of Affordability. The overall rating is "very good", with more than 80 points. France performs better, with over 90. Strictly analyzing Romania's situation, the weak point of accessibility is the adjusted income index inequality, whose evolution is justified by the economic and social events of recent years, aggravated by the climate and health crisis.

For the availability indicator, all four Member States have a score ranging from 60 to 69,

i.e. a "moderate" rating. In this case, Romania has 60 points and France 69 points out of 100. Romania's low score has two main causes:

Volatility of agricultural production. Weather conditions and The COVID19 pandemic has caused increased volatility on an international level commodity markets, while the agricultural sector faced challenges related to the availability of grain and other agricultural commodities used both for food and fodder. Food security and political commitments on access. A food a security strategy is needed (currently Romania has no food assumed security at the official level) and a government agency for implementation of this strategy.

In terms of quality and safety, Romania and Italy have a good score (above 70), while France and Poland in particular have a very good score (over 80). From this point of view, Romania has a less favorable situation regarding: food diversity, measures the weight of non-carbohydrate foods (cereals, edible roots and potatoes) in total human consumption expressed in calories. A higher proportion of foods containing fewer carbohydrates is considered a premise of greater food diversity; nutrition standards is a qualitative indicator that evaluates the existence of national nutrition programs, nutritional recommendations at national level, as well as the existence of a monitoring system a population categories with nutritional risk.

From 2022, food safety also included legislative aspects compared to 2021. Regarding the dimension of food security Sustainability and adaptation (formerly known as "Natural Resources and Resilience"), the situation is different: France has a good score, Italy and Poland have a moderate score, while Romania has a poor score, showing that he is not prepared enough to cope structural crises of the system or conjunctural socio-economic crises.

CONCLUSIONS

The research underscores the pivotal significance of addressing food security through comprehensive and scientifically informed methodologies. The FAO Food Price Index reached an all-time high in March 2022, with persistently elevated levels thereafter, demonstrating the volatility of global food prices and underscoring the necessity for resilient strategies to mitigate these impacts. The global trend of decreasing food affordability and increasing reliance on food aid from 2019 to 2022 further reflects the adverse impacts of recent global shocks on food security, reinforcing the imperative for policies that enhance affordability and reduce dependency on aid.

The performance of countries in the Global Food Security Index, particularly improvements in agricultural inputs, policy commitments to sustainability, and nutritional standards, indicates that strategic investments in these areas can yield significant benefits. However, persistent challenges, such as low soil organic content and inadequate irrigation infrastructure, underscore the necessity for concentrated attention and resources.

The research findings collectively indicate that ensuring food security necessitates an integrated, multifaceted approach that addresses both immediate and long-term challenges. It is imperative to promote trade freedom, provide support to farmers and ensure the availability of financing facilities for countries with large food import requirements. Furthermore, it is of the utmost importance to avoid trade restrictions and minimise price volatility in order to maintain food affordability. The development of systemic resilience through sustainable land management, the increase of soil organic carbon, the adoption of sustainable sources and the reduction of food pollution and waste are vital for the adaptation to climate change and the promotion of agricultural resilience.

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URBAN AGRICULTURE AND INNOVATIVE ENTREPRENEURSHIP

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Abstract

Urban agriculture (or urban farming) is a new and innovative field in business development, bridging the gap between the producer and the local urban community, being an area where the entrepreneurship can have diverse initiatives and approaches. Urban agriculture generally refers to the cultivation, processing and distribution of agricultural products in urban and suburban settings, including directions like vertical production, warehouse farms, community gardens, rooftop farms, hydroponic, aeroponic and aquaponic facilities or other innovations.

This type of farming adapted to the limited space available in the city has various advantages but it faces also challenges. The benefits of setting-up an urban farm consist in creating jobs for local low-income communities, waste reduction, urban revitalization, community education and development, while the main challenges refer to the lack of policy and regulations addressing urban farming in statutory plans and zoning bylaws, possible noise or restrictions on farm structures such as greenhouses and storage sheds.

This paper aims to highlight ways to improve entrepreneurial skills through innovative ideas on agricultural activities in urban and peri-urban areas, exemplifying different initiatives associated with effective management in this regard and describing this sector less known and in Romania but with a high growth potential.

Key words: urban agriculture, urban farming, agribusiness, innovative entrepreneurship

The move toward urban agriculture and urban farming is one of the patterns noted in the evolution of agriculture as an economic sector and of cities as structural components in the dynamics of societal development.

The term "urban agriculture" broadly refers to the production, distribution, and processing of agricultural goods in urban and suburban environments. Examples of such practices include vertical production, warehouse farms, rooftop farms, community gardens, hydroponic, aeroponic, and aquaponic systems, among other innovations. Urban gardeners and farmers collaborate with a variety of communities to increase the availability of wholesome meals, promote community involvement, create jobs, teach people about farming, and create more green space. Urban food production encompasses several forms such as roadside urban fringe agriculture, backyard, rooftop, and balcony gardening, community gardening in vacant lots and parks (sometimes spanning multiple city blocks), cattle grazing in open spaces, and intensive indoor hydroponic or aquaculture facilities. One of the key strategies for minimizing harm to the urban ecosystem and its inhabitants is urban agriculture (Yücedağ C., Çiçek N., Gul A., 2023). Urban agriculture eases access to food, reconnects communities to the practice of growing food, and engages the community on a variety of levels.

Urban agriculture facilitates food access, reintroduces the practice of food cultivation to communities, and fosters multifaceted community engagement.

Urban agriculture (UA) has a vital role in promoting local economic growth, reducing poverty, enabling women and the impoverished to participate in society, enhancing the city's greenery, and repurposing waste materials in useful ways. Urban agriculture is still primarily an unorganized industry that is poorly integrated into agricultural policies or urban planning, despite increased awareness of its importance in ensuring food security and reducing poverty for urban inhabitants. The inadequacy of current, high-quality data regarding the advantages and limitations of urban agriculture hinders the development of pertinent policies and interventions that could augment the favorable effects on public health, urban livelihoods, and the environment.

Urban agriculture has become a familiar term in many towns, usually conjuring images of edible landscapes or community gardens (Orsini F., D'Ostuni M., 2022). On the other hand, growing food in the city for commercial purposes is known as urban farming. In order to grow food for wholesale and retail sales to urban consumers,

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farmers must find space in the city, such as backyards, vacant lots, parking lots, rooftops, parks, or other private or public areas. The urban farming industry's ability to generate income presents both local governments and farmers with a whole new range of options and challenges.

An entrepreneur is someone who starts, expands, and grows a business (Brezuleanu S. *et al*, 2019); in doing so, they take on risks in the hopes of making money. A person who builds an enterprise around an idea is called an entrepreneur. The verb *entreprendre*, which means "to undertake" in French, is the root of the English term "entrepreneur". Though there are many essential skills in entrepreneurship, these are some fundamental ones you should check for in your staff the next time a competency assessment is conducted (*figure 1*).

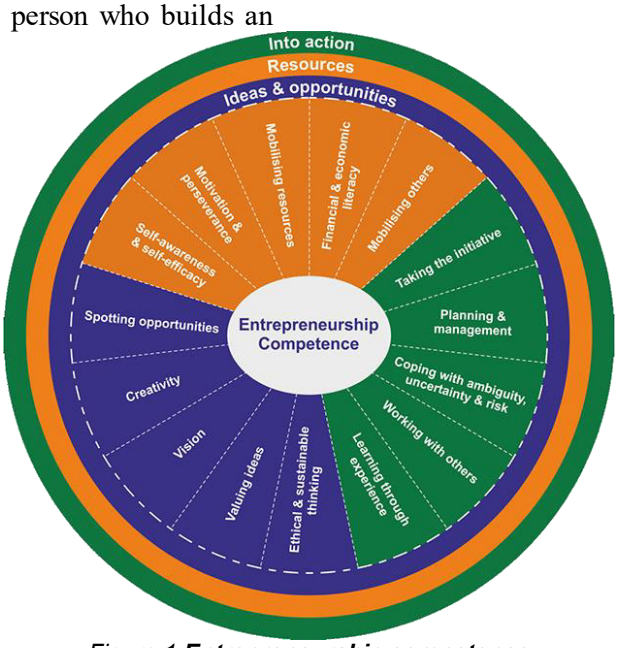

Figure 1 ***Entrepreneurship competence***

The process of establishing and effectively running a business idea, generating revenue, and fostering the expansion of the enterprise is referred to as entrepreneurship. Any person or people who run a business are ideally entrepreneurs, and those who work for them are employees.

The act of starting a firm, or enterprises, and taking all the risks in the hopes of turning a profit is known as entrepreneurship. In addition, entrepreneurship offers self-driven people the chance to design their own professional path and source of income by working for themselves to provide goods or services that consumers need or want.

Research and innovation are crucial tools to achieve a smarter and sustainable agriculture sector (Dovleac Lavinia, Bălăşescu, M., 2016) and the innovation is represented by the ability to continuously transform knowledge and ideas into new products, processes and systems, to the benefit of both the organization and the shareholders. (Popa I. *et al*, 2010).

Innovation represents the potential for creating wealth from already existing means. In other words, innovation can be defined as that ability whereby a means (in economic or social sense) is found to be used for something new. Innovation is the specific function of the business initiative; it is the means by which the entrepreneur either creates new wealth-producing resources or endows the existing ones with an increased wealth creation potential (Viziteu Șt., 2019).

MATERIAL AND METHOD

In order to carry out this work, the resources related to urban agriculture from Erasmus+ KA220-ADU-ECC37414 – Cooperation partnerships in adult education, “AgroBusiness in Urban areaS” – AgroBUS were used. The international project AgroBUS, funded by Erasmus+ is Formed by partner organisations: Proportional Message - Lisbon (Portugal); Creative Innovative Business Incubation Centre - Roznov (Romania); DRPD- Novo-Mesto (Slovenia) And Innovation Frontiers - Athens (Greece).

The AgroBUS project aims to promote entrepreneurship by developing a training programme and bringing knowledge and concepts from the field of Agro-Business to urban areas with the objectives of sustainable community development, continuous training for people who want to set up a start-up in urban agriculture and identifying best practice models for future European urban farmers.

RESULTS AND DISCUSSIONS

Urban farming has many inherent challenges, like distribution, space and production

capacity limitations, concerns with neighbors, and financing challenges.

By considering the barriers up front, you'll have fewer surprises as you get started. The main steps are:

1. Find Training. There is a great deal of knowledge and expertise involved with starting a farm. Consider finding a learning opportunity near you.

2. Make a plan for your business. Producing goods that are in demand or that can be readily marketed is crucial for farmers. To achieve this, find out where there are gaps or marketing opportunities by speaking with local food producers, farmers' market managers, grocery shops, restaurants, and community members. Think about value-added items and the potential impact they could have on your company. Find out the expenses and procedure. Make a business plan with a budget and marketing tactics included.

3. Find Appropriate Land. If you are looking for space, check out your local utility agencies, parks and recreation departments, or research existing vacant lots. Consider local zoning codes and how they may apply to the type of urban farm you have in mind.

4. Test Soil. Some urban soil has elevated levels of heavy metals, such as lead, or other contaminants. Make sure to test your soil and remediate accordingly.

5. Study the Fundamentals of Production. According to our research, a lot of new urban farmers have trouble with the fundamentals of growing crops or keeping animals as they establish themselves. Get as much knowledge as you can about irrigation, planting, controlling pests, and soil. Learn all there is to know about taking care of animals and bees if you intend to keep them.

6. Ensure Food Safety. Learn about how to make sure that the crops you grow are harvested, stored and processed safely, according to best practices.

7. Learn about Other Urban Farms. Read about urban agriculture projects throughout California here, and find out about their challenges and successes.

8.Explore Resources for Beginning Farmers.

Dimensions of urban farming include: land and land access, production, processing and distribution, celebration and education, waste recovery etc (*figure 2*).

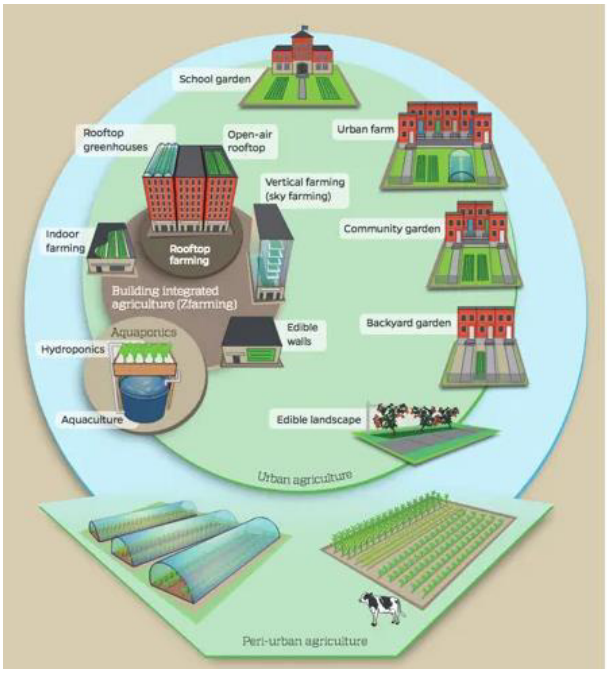

Figure 2 **UA fields**

The Benefits of Urban Agriculture /Urban Farming

The companies that make up the developing urban farming industry assist the community in many ways. Fresh food products are directly sold and supplied to food merchants, farmer's markets, restaurants, and other establishments through alternative or low-carbon transportation systems. Food is often cultivated with little chemical inputs. Farms can serve as a channel for waste recovery, meeting the market's need for organic soil that has been composted. Additionally, the farm's presence is frequently very noticeable to the general public, increasing awareness of food and farming as well as offering chances for teaching regarding the cultivation and consumption of fresh produce.

Green Jobs and Innovation. Urban farms foster innovation and support entrepreneurs. With

limited growing areas, urban farmers are developing creative solutions to generate good harvests at a fair price. Innovations in urban farming include models like aquaponics, vertical farming, micro-green operations, and rooftop greenhouses. Despite their infancy, a lot of these initiatives are gaining support from the community's companies and consumers as well as media attention, which is helping to establish urban farming as a major industry. Urban farming is generating jobs, and employment training in urban settings is enabling aspiring farmers to expand their scope and relocate to larger farms.Urban farms can be set up as a social enterprise to generate revenue and create jobs for local low income communities.

Waste Reduction. Food waste from urban farms might be turned into compost to be used in food production. Since more hydrocarbon energy is required to produce food energy, reusing organics for farming is a sort of energy recovery and a crucial step toward making agriculture more sustainable. In order to promote food waste reduction, urban farms can also educate the public about composting. Reducing the distance traveled to the place of purchase for heavier foods, such vegetables high in water, lowers greenhouse gas emissions and makes more mobility options possible, like cycling.

Urban Revitalization. Many urban farms are located in under-utilized urban spaces such as vacant lots or under-used parks. What was once a derelict space can become a lush green space and hub of activity for the community and urban farmers.

Community education and development. Urban farms have the potential to develop into social hubs that promote and celebrate regional food. DIY projects including cheese production, beekeeping, cooking, and food preparation might be sparked by occasions like festivals, harvest meals, culinary or gardening demos, and educational programs. Certain populations are served by certain programs, including elders, kids, low-income families, and ethnic communities. Urban farmers often host public events that involve other organizations or industry sectors including local chefs and food and farm organizations.

Many farmers are also asked to speak about local farming or teach growing techniques. Some urban farmers are also technically savvy with websites, blogs, Twitter and Facebook accounts dedicated to promoting their farm and educating the virtual world about local food

Challenges in Urban Agriculture

Agriculture in urban spaces can pose a number of unique challenges for both regulators and farmers. However, modern urban farms tend to be smaller scale and focused on higher value crops and lowimpact growing techniques, thereby avoiding some of the historical problems of integrating agriculture where people live, work, learn, and play. Key policy, land use, and administrative barriers for urban farmers:

- A lack of policy and regulations addressing urban farming in statutory plans and zoning bylaws
- Possible noise, dust, traffic, pesticide use, and odour associated with farming activities
- An increase in real or perceived risks to health and safety
- A lack of appreciation of the regulatory and farming realities
- A lack of licensing specific to the nature and operations of farming businesses
- • Restrictions on the selling of produce from farm sites
- Restrictions on keeping small livestock and farm animals (e.g., chickens and bees)
- Restrictions on farm structures such as greenhouses and storage sheds (*figure 3*).

Characteristic	Urban Realities
Crops: Vegetables Micro greens Fruit Berries Chickens (can you sell eggs?) Bees	» Limited space for viable production » Chicken bylaws » Regulations against sale of processed foods (honey, jam, etc) » Community complaints about farm aesthetics
Growing medium: Compost Imported soil Raised planter boxes	» Soil contamination » Limited space for compost production » Community complaints about manure or compost smells
Water City water	» Irrigating with potable water » Water costs (if metered)
Equipment Rototiller Hand tools Bike and cart	» Noise complaints » Sp
Facilities Storage sheds Greenhouse	» Building permits » Limited space

Figure 3 **Urban agriculture restrictions**

Start-up costs in Urban Agriculture. Start-up expenses for an urban farm will vary widely by location because many of the components (such as land or utilities) are site-specific. Start-up expenses can be broken down into a few categories:

Location. This involves purchasing the land, ensuring that it is zoned appropriately, obtaining the required permissions, and having an environmental study completed. Soil tests and land access are frequently eligible for subsidies.

Site Preparation. The farmer must get the land ready for growth after buying or renting it and making sure all the tests and permits are in order for it to function as an urban farm. Soil will be the biggest associated cost—and most likely the biggest cost of the overall operation—but soil costs will differ depending on location and volume. Fencing, signs, and supplying enough water to the location are additional expenses.

Structures. This includes both infrastructure necessary for growing (such as high tunnels) and storing (such as a cooler). What types of structures will be needed will be dependent on location, types of crops grown, and desired length of growing season.

Growing and Selling. These are the expenses that you will expect to incur in your first year of operation (as opposed to true start-up costs, which may involve additional expenses). They include traditional farming costs such as tools, growing supplies and utilities, as well as business costs like advertising and website design.

Administrative Expenses and Operating Costs. These will be ongoing costs associated with your operation, but they are critical to take into account in year one, when you will be getting systems in place.

Costs for Indoor Growing Facilities. The start-up costs for aquaculture and hydroponic systems, as well as other indoor growing facilities, will differ significantly from those of beginning an urban outdoor agricultural enterprise. They will also differ significantly based on the kind of facility you want to construct. A small aquaponics system housed in a greenhouse might be created for a few thousand dollars, or even less if you are able to use recycled components. A large-scale aquaponic facility located in a warehouse-type building may require a multi-million dollar investment.

Examples of good practices for startups in urban agriculture/farming

1. Agricoolm Paris (France). French startup Guillaume Fourdinier and Gonzague Gru created Agricool in 2015. In developed regions of Paris and Dubai, the company cultivates produce like lettuce, strawberries, basil, coriander, and parsley. The produce is then sold in stores within a 15-kilometer radius of the farms.

The startup grows fruit, vegetables, and herbs under LED lights in shipping containers with adjustable humidity and temperature. The start-up wants to reduce water usage and transportation expenses while making it easier to cultivate seasonal crops year-round without using pesticides. To date, Agricool has raised over $39 million. By 2021, the company hopes to have 100 containers in Paris and Dubai in addition to the eight it now has at four urban farms.

2. Infarm, Berlin (Germany). Infarm is a start-up company situated in Berlin that was established in 2013 by Erez and Guy Galonska, as well as Osnat Michaeli. Infarm, like the other startups on this list, aims to close the gap between the farm and the customer's plate. The start-up has placed its produce in Marks & Spencer in the UK, Intermarché in Paris, Irma in Copenhagen, and Kroger in Seattle in addition to sites throughout Germany. The startup creates what it refers to as "smart modular farms" for metropolitan areas by fusing IoT, machine learning, and vertical farming. Because Infarm's solution is cloud-based, a central control hub may be used to monitor and manage the farms.

3. Aquapioneers – Urban Aquaponics, Barcelona (Spain). Urban aquaponics creates a smart water environment that combines hydroponic crop gardening with aquaculture fish production to meet land scarcity challenges in smart cities. With a closed water loop, compact aquaponic farms aim to produce as much food as possible in a very small urban area, including fish and vegetables, sustainably and without the need for water for operation. Aquapioneers, a Spanish firm, creates kits for aquaculture that turn a 54-liter aquarium into an aquaponic ecosystem for year-round food production in homes, workplaces, coworking spaces, hotels, and schools. Their open-source kit is constructed from wood.

4. BIGH Farms, Brussels (Belgium). A Brussels-based start-up called BIGH (Building Integrated Greenhouses) Farms aims to connect urban farms across Europe in order to highlight the potential contribution of urban agriculture to the circular economy. BIGH's designs lessen the environmental effect of a location by integrating aquaponics with existing structures. The first pilot features a fish farm, a greenhouse, and more than 2,000 square meters of outdoor vegetable gardens. It is situated in the heart of Brussels, above the ancient Abattoir. In 2018, they began growing striped bass, tomatoes, herbs, and microgreens.

Additionally, BIGH Farms collaborates with nearby companies and farmers to ensure that the farm's output enhances the current food chain.

5. RotterZwam, Rotterdam (The Netherlands). An urban mushroom farm called RotterZwam spreads knowledge about the circular economy's potential to solve environmental problems. Using spent coffee grounds that are gathered from nearby companies, the farm's closed-loop system converts residual flows into food. The farm's operations and the e-vehicles that transport goods are powered by solar energy at the mushroom nursery, which is constructed out of recycled containers. The staff of the farm trains those who want to launch a mushroom farm and provides tours to the public to teach them about circular systems. Entrepreneurship has an important impact on the economy in several ways, including:

1. Entrepreneurship increases employment. By going into business for themselves, entrepreneurs create their own employment. If they are successful, they may also employ others and help to increase employment related to their operations.

2. Entrepreneurship opens up new markets and stimulates the economy. Entrepreneurs create new businesses all the time by inventing new goods and services or improving on existing ones. By creating new products and services regularly entrepreneurs help to keep the economy healthy and innovative.

3. Entrepreneurship helps to increase national income. Entrepreneurship is a critical driver in creating a healthy economy, and an essential aspect of many economies.

4. Entrepreneurship furthers social change in society. Entrepreneurs break with tradition to push the economy in new and exciting directions. Often, entrepreneurs are responsible for the development of the latest, greatest products. They can also bring more awareness to a gap in social services or goods.

5. An economy in balance and health is produced by entrepreneurship. The governments of practically every nation frequently contribute to the growth of entrepreneurial ecosystems by offering initiatives to encourage business owners in maintaining a strong, stable economy. In order to promote entrepreneurship, the government also funds company incubators, entrepreneur education initiatives, and other initiatives.

There are two categories of factors that drive entrepreneurs: internal and external. Generally speaking, motivations stem from Maslow's hierarchy, with entrepreneurship mostly focusing on the demands at the top needs synthesized by Maslow, entrepreneurship mainly targeting the needs at the top of the pyramid (figure 4).

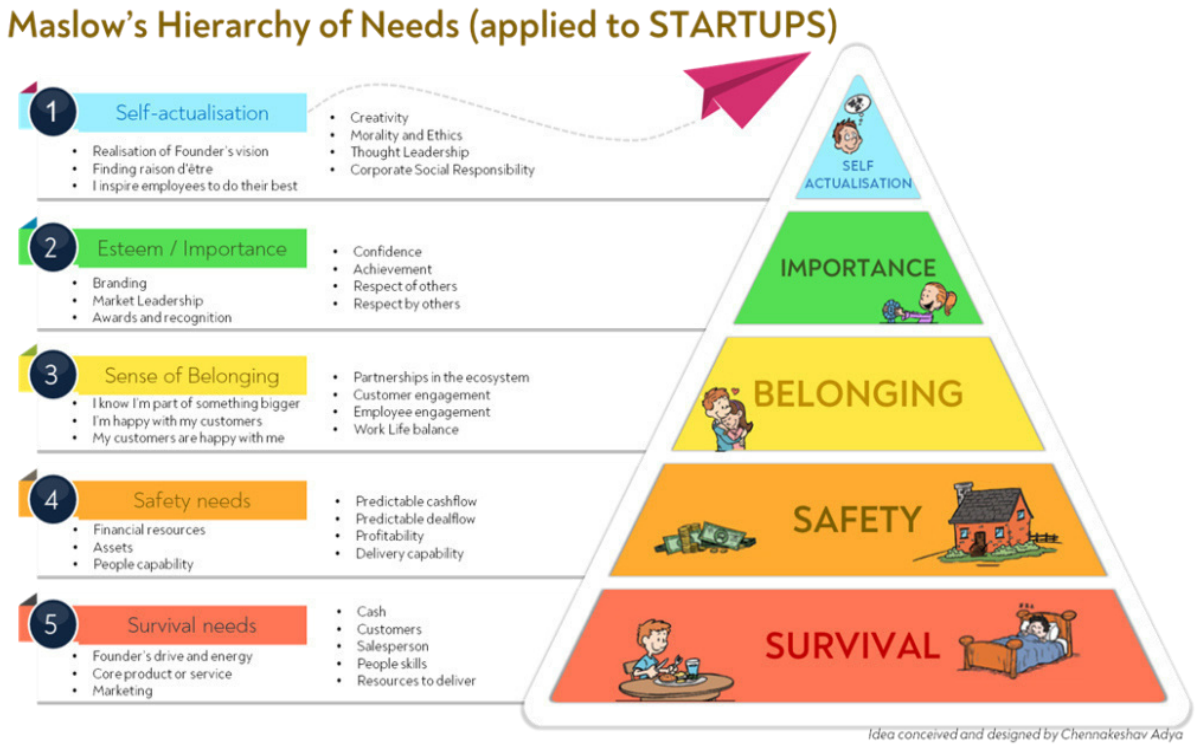

Figure 4 **Maslow's hierarchy for STARTUPS**

Revenue from urban farming is predicted to rise globally by USD 261.1 million by 2032 (*figure*

5), with a compound annual growth rate of 2.7% from 2023 to 2032 (Urban Farming Market Size, 2023).

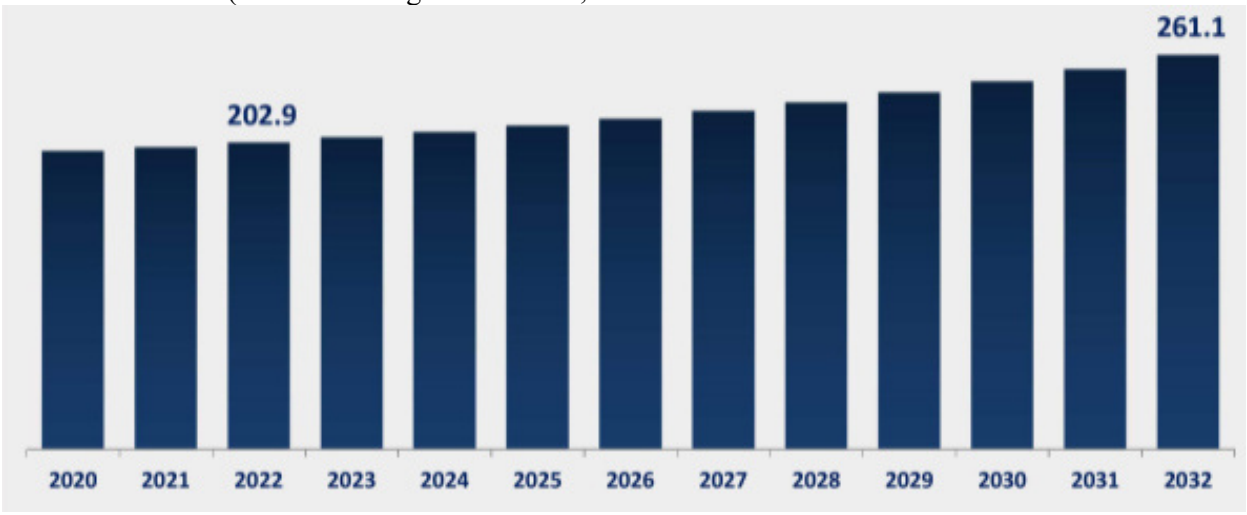

Figure 5 **UA Revenue predictions**

In 2022, the Asia-Pacific area accounted for about 42% of the global market share for urban farming (*figure 6*). Europe is predicted to have the fastest rate of growth between 2023 and 2032.

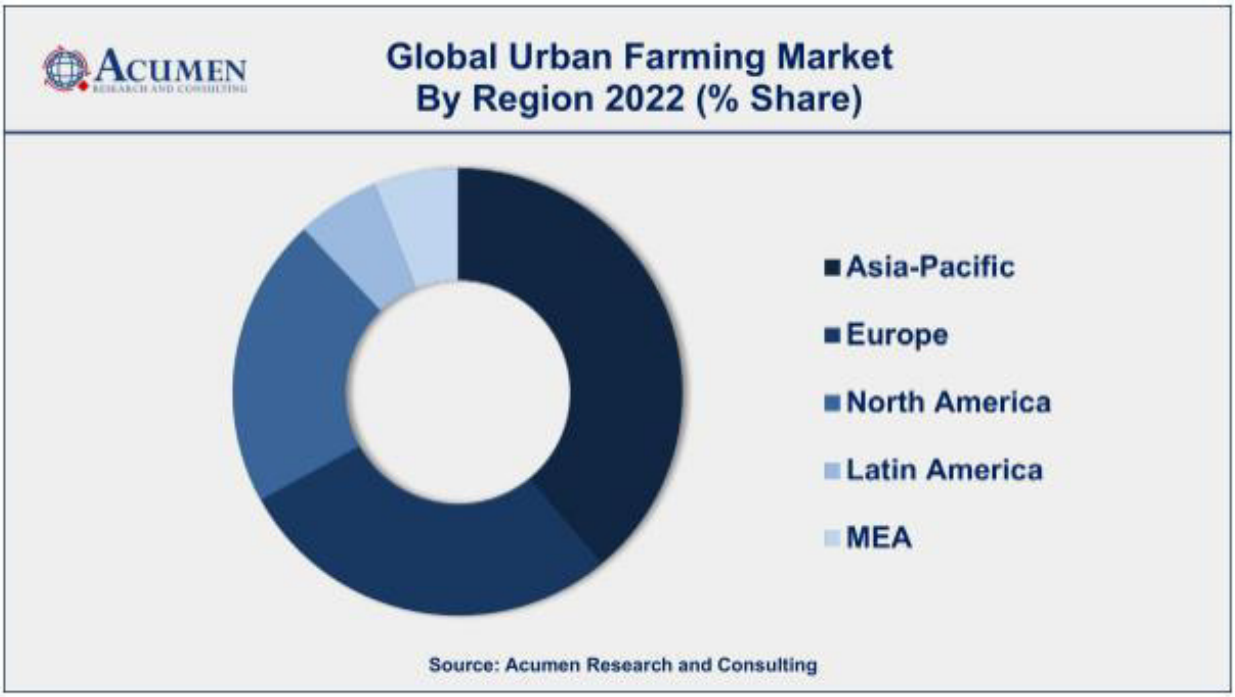

Figure 6 **UA global market – 2022**

It is projected that 68% of people on Earth will reside in cities by 2050, underscoring the importance of urban agriculture. Up to 15% of the world's food supply may come from urban gardening, enhancing food security. Growing consumer desire for fresh, nutrient-dense, locally produced produce is what drives the value of the urban farming industry.

CONCLUSIONS

As presented in the material, with the general characteristics and specifications, urban agriculture is a field for innovative entrepreneurship with a very broad spectrum of activities that can be carried out.

Innovations in production technologies, use of drones or robotic elements, electronic control of vegetation factors or feeding substrate can be successfully implemented.

Through the pleasing landscape appearance and design of urban gardens, the sustainability of cities and the development of smart cities can be managed and developed, with a clean environment and quickly delivered food within reach of all local communities.

ACKNOWLEGMENTS

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RISKS GENERATED BY THE PARTICIPATION OF PUBLIC ENTITIES IN INTERNATIONAL TRANSACTIONS IN THE CASE OF PUBLIC - PRIVATE PARTNERSHIPS

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Abstract

The factual records and the contributions from the specialized literature highlight the role of the public-private partnership as a viable alternative intended to replace the lack of financial resources of the government, the gaps in the management of the administration of large infrastructure projects, bringing at the same time an important contribution to the technological dissemination. Most of the time, the implementation of large financing projects cannot be conceived without the participation of foreign capital. However, there are numerous cases when such partnerships are not completed successfully, given some aspects such as the ineffective allocation of risks between partners, a poor management approach, overly optimistic forecasts. Moreover, the unprecedented opening of national economies to international exchanges creates consistent premises for the propagation of shock waves characteristic of recessionary phases at the national level, contributing to the aggravation of existing macroeconomic problems, at least for developing countries. Our study, through an integrative qualitative approach and filling a relative lack in the field of scientific concerns, aims to analyze what are the main risks arising for public entities in the case of public-private partnerships, formulating relevant recommendations to overcome them.

Key words: public-private partnership, risks, public entity, international transactions.

The factual records and the contributions from the specialized literature highlight the role of the public-private partnership (PPP) as a viable alternative aimed at replacing the lack of financial resources of the state, the gaps in the management of the administration of large infrastructure projects, bringing at the same time an important contribution in technological dissemination.

This approach is not new, some authors finding the institutional beginnings even in antiquity (Grimsey D., Lewis M.K, 2004) while others attribute an effective role to them demonstrated in the construction of the London Underground since 1894. (Đorđević A, Rakić B, 2020).

During the historical evolution of the increasing responsibility of states in the field of public infrastructure financing and against the backdrop of budget deficits doubled by economic recession, disturbances in the supply chain of companies at international level, resorting to such partnerships represents an effective solution in principle, which can explain their proliferation. According to the existing data on the E.P.E.C. portal. within B.E.I., the number of public-private partnerships that had financial closure in 2021 was 1,913, with a value of 403.2 billion euros, mainly targeting fields such as education (461), transport (411), health (397), average (154).

The E.P.E.C. report from B.E.I. relating to the year 2023, which analyzes the partnerships concluded in EU-27 countries, the United Kingdom, Israel, Turkey and countries of the Western Balkans (Albania, Bosnia and Herzegovina, North Macedonia, Kosovo, Montenegro and Serbia), places Germany in first place, both in terms of number of partnerships and value (11 partnerships worth 3.3 billion euros), followed by France (in terms of number of projects - 6 projects), which was overtaken by Israel in terms of the value of partnerships (*figure 1*) (European Investment Bank, 2024).

Regarding their value, Lithuania and Kosovo are in the last places, but in terms of number, seven states have concluded at least two partnerships, and 13 countries have one, in the conditions where, as previously shown, the developed economies hold the weight. In terms of

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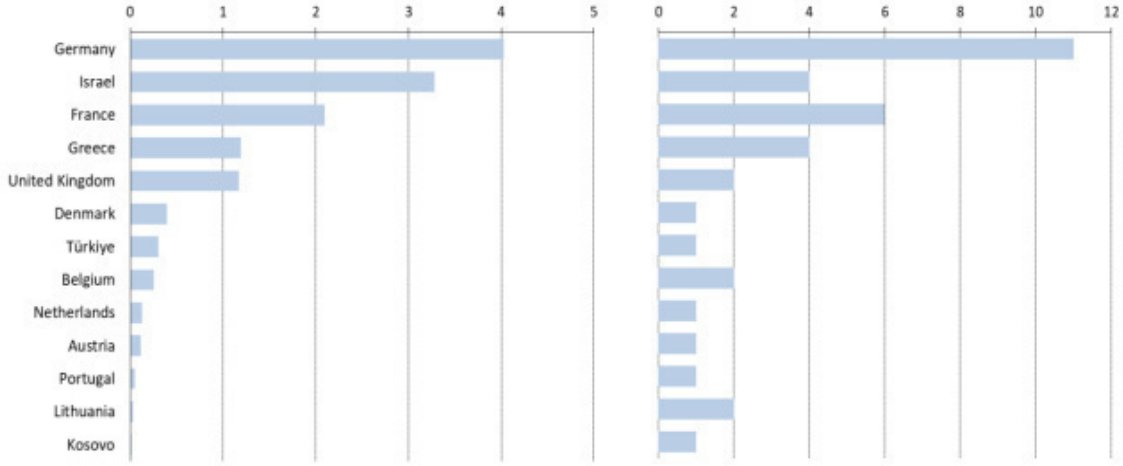

Figure 1 **Country breakdown by value and number of public-private partnership projects 2023**
[European Investment Bank, 2024]

sectoral orientation and value, the same report shows that the first sector targeted was transport, followed by environment, safety and public order. The share of developed states can be explained both by the learning curve and the experience gained over the years, at the same time the partnerships created by them are no longer necessarily aimed at solving some problems at the macroeconomic level, tending towards the meso and microeconomic sphere.

Specialized literature highlights the permanent recourse to such constructs with the participation of public institutions. It has been estimated that over the past quarter of a century at least 134 countries have had such initiatives, with a larger resurgence after the sub-prime crisis of 2007-2008, accounting for around 20% of infrastructure investment. (Inderst G., Stewart F, 2014). Their conceptualization is heterogeneous, some authors insisting on the fact that they represent a way to cooperate between public and private law partners in order to deliver public services that were mainly the prerogative of the state, against the background of assuming some shared risks, costs and future profits (Klijn E.H., Teisman G.R., 2003). Other authors have pointed out that such institutional structures enable a mobilization of private finance catalyzed by technological progress and the superior managerial expertise of private law entities. (Grimsey D., Lewis,M.K., 2004).

In essence, the intrinsic construction of the PPP involves a series of contractual arrangements (*figure 2*) structured on multiple levels, which is intended to value the idiosyncrasies resulting from the interaction of the managerial/competitive capabilities of private and public law actors.

Thus, at a first level we find the national states, which by virtue of an articulated strategy that transcends from micro to macroeconomic, should identify the main areas of interest and fields to which future projects will be subsumed, as well as the driving effect as a whole, in the scope of ensuring future public goods and services. Not without interest will be the way in which such resulting investments will integrate into the whole of the already existing ones and will remove some regional disparities, ultimately contributing to the increase of the standard of living of the final consumer.

At the same time, it is the prerogative of the state to articulate an adequate legal framework and create a stable climate that attracts foreign direct investments, given that the PPP claims a high financing requirement and the participation of several investors, from bodies with the vocation of international financiers (Bank European Investment Fund, EU) to private investors, other private shareholders, insurance and reinsurance agencies, builders, subcontractors, etc.

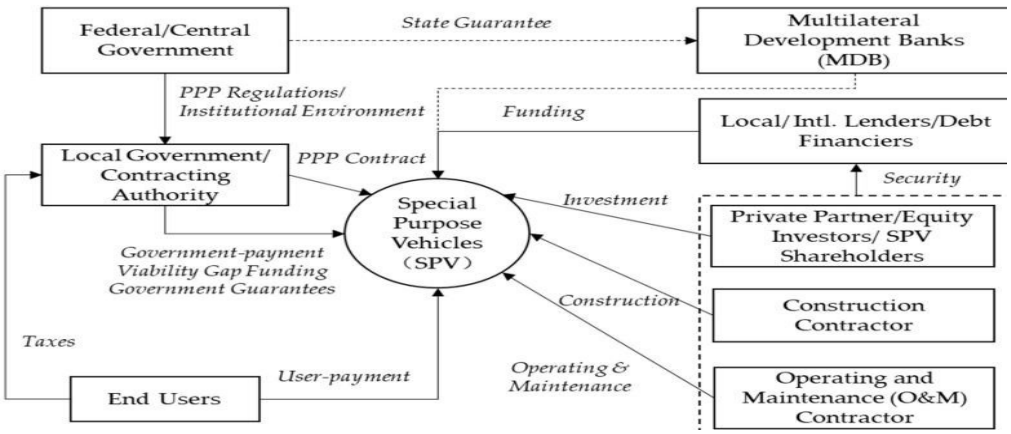

Figure 2 **PPP contractual architecture**
Source: Adapted from (Li Z., Wang H., 2023; Schüle U. *et al*, 2018)

The whole state is subsequently responsible for choosing a project variant from those resulting from the analyzes carried out, as well as for offering guarantees to private partners regarding the possibility of long-term operation of the investmen-ts, obtaining profit, avoiding subsequent nationalizations, congruence with the environmental objectives. The involvement of the state can be carried out on various levels, from the central level of the main authorizing officer of credits (ministries), through specialized agencies (secondary/tertiary authorizing officers) or decentralized, at the level of territorial administrative units. The choice of the project variant in the case of decentralized institutions needs to be circumscribed by the national strategy in the field. In this context, the central authorities can refer to international funding bodies regarding the creditworthiness of regional/local public law actors.

From the point of view of the concrete way of realization, the partnership can be contractual. In this case, the public-private partnership is based on a contract concluded between the public partner, on the one hand, and the private partner, on the other. The contract is to be implemented through a project company that is fully owned by the private partner and the institutional public-private partnership. In this sense, a new company is established, which will act as a project company (Special Purpose Vehicle - S.P.V.), as provided by O.U.G. 31/2018 regarding the public-private partnership in Romania. Establishment of S.P.V. it is carried out after a competitive procedure for awarding the project, in which a number of economic agents participate. The winning offer is the one that optimally meets the criteria established by the contracting authority (*figure 2).*

Shareholders of S.P.V. can be the contracting authority, represented by public entities, the private partner designated as winner, other private law entities, financiers, investors, builders, etc. In principle, the state, by means of a concession for the provision of public services, understands to give up some of its prerogatives (against a royalty), following that later, after the end of the contract (medium to long time interval), the good will enter the public domain. The adjudicator of the competitive procedure will have the benefit of granting subsidies for the realization of the project, also collecting specific fees from the final users of the investment.

In order to materialize the investment objective, the S.P.V. enters into contractual relations with a series of private entities, those assigned to actually build (with the possibility of having subcontractors), those in charge of managing/operating the works, respectively those that ensure subsequent maintenance.

Eloquent for what was shown previously is the example of PPP aimed at building a highway where we find all the elements described previously. Thus, at the central level, the benefits of its construction for end users are considered (cost-benefit analysis, feasibility study), the way in which the new investment objective will be reintegrated into the already existing network, the designation of a public entity to define the main elements of the future project related to costs, their actual recovery time compared to the expenses incurred by the end users (the purchase of the vignette), the main risks and how they will be allocated between the public and private partners, taking into account the experience of each one.

Partnerships are also an important premise for achieving some of the sustainable development goals adopted in 2015 by the UN member states, by ensuring resilience and long-term socio-economic development, contributing through their deliverables to mitigating disparities regarding access to public utilities, environmental protection, quality education, etc.

Although they reduce the public budget pressure, they do not necessarily lead to the reduction of transaction costs, if we consider the existing risks, the dynamics of the international business environment, some important actors investing in such partnerships such as multinational companies that internalize the world market (Zhao J., 2019).

Transaction costs (generated from the perspective of the emergence of opportunistic behaviors) can be explained by the paradigm of the institutional architecture of such partnerships, which involve participants with different interests, which need to be harmonized. Thus, the central government must ensure that the project is grafted onto its general policy in the field of infrastructure (public utilities – water-sewerage, electricity, heating, roads), considering the costs it incurs, the need to offer guarantees for international financiers and operators, establishing a viable communication with the other state institutions with legal powers in the area targeted by the investment. For private partners, the guarantees given by the government, the macroeconomic climate of a country, the sharing of risks constitute the key trigger of the decision to invest, especially from the point of view of multinational companies. (Nielsen B.B *et al*, 2017). Each of the involved partners seeks to maximize their own benefits, thanks to information asymmetry, and the experience and negotiation ability of each one plays an important role, even if it often comes down to a zero-sum game.

Thus, there are numerous cases when such partnerships are not completed successfully, given some aspects related to the inefficient allocation of risks between partners, a deficient managerial approach, overly optimistic forecasts.

Moreover, the unprecedented opening of national economies to international exchanges creates consistent premises for the propagation of shock waves characteristic of recessionary phases at the national level, contributing to the aggravation of existing macroeconomic problems, at least for developing countries.

MATERIAL AND METHOD

Our study, through an integrative qualitative approach and filling a relative lack in the field of scientific concerns, aims to analyze what are the main risks arising for public entities in the case of public private partnerships, formulating pertinent recommendations to overcome them.

RESULTS AND DISCUSSIONS

At a first level of the analysis of the relationship between the participation of public entities in international transactions and the generated risks, we find a series of risks of a geopolitical nature that can lead to a contraction of future investment flows. We include here some political tensions between states, wars, events that lead to a geographical reorientation of investments and which multinational companies can hardly overcome.

If the national political risk (expropriation) can be relatively easily overcome by creating a mixed company between the foreign capital and the national company (joint-venture), things are not as easy in the case of the existence of supranational regional tensions, the defusing of which would require a concerted action between several states. (Henisz W.J., Zelner B.A., 2005). For that national economy, the outcome will reflect unavailable foreign capital, or at best foreign capital at a higher cost, imagined to cover the risk. In response to the imminence of such risks, states could opt for some strategic alliances, non-aggression agreements, membership of some supranational military blocs. At the same time, improving the quality of own institutions will create a stable environment, aimed at counterbalancing the amplitude of such tensions, encouraging potential investors by ensuring the predictability of the internal climate. (Bussy A., Zheng H, 2023).

On the other hand, infrastructure investments demand high expenses from private law actors, projected in a medium to long time horizon. The recovery of these expenses is carried out gradually, even incrementally, and the specificity of the assets removes the possibility of a possible reallocation of resources. As a consequence, some overly optimistic visions of the government regarding the potential end users (for example the number of those who will use a highway paying the vignette) may lead to the need for renegotiations of the initial contractual clauses, respectively of the benefits in the sense of either extending the duration the contract, or the granting of subsidies by the state to cover the gaps created between the financial expectations and the real ones. (Wibowo A., Alfen H.W., 2013).

From the point of view of the involvement of political factors, several adverse effects can be analyzed. The one that seems most important to us is materialized by the possibility of the appearance of eventual white elephants (they represent some investments made in infrastructure, which do not find their usefulness for the final consumer, do not contribute to a driving effect at the level of the national economy and do not fit in a proper articulated strategic perspective - for example a road that connects the center of a territorial

administrative unit to the home of a local elected official.) (Albalate D. *et al*, 2019). The effect can also be manifested when the resources are allocated suboptimally, without taking into account all the options available to satisfy the demand – building a hydropower plant that serves certain consumers whose number will remain relatively constant in the future and abandoning an option that would involve clean energy through photovoltaic systems. Thus, not only will that investment be reflected in high final prices (for energy in order to recover costs) for final consumers, but it will also contribute to the dimming of actions aimed at achieving the SDGs. (Sustainable Development Goals), even emphasizing existing disparities.

Moreover, we can even expect substitution effects in terms of demand; end users can opt out of using the respective road infrastructure (and as such paying the vignette), choosing a longer but free detour. In this sense, the way in which public institutions involved in PPP understand to evaluate some aspects related to a potential future demand, remains decisive for the success of the project. The lack of experience in the preparation of such projects can eventually be repaid by calling on some external specialists (with different professions), especially in the phase of preparing the pre-feasibility studies, which will materialize a better determination and distribution of the incident risks. (Demirel H.C., 2022).

Recent reports, analyzing the performance of some PPPs financed with European funds, draw attention to the fact that although such contractual constructs are used when higher earnings are expected by public authorities compared to traditional procurement procedures, no pertinent analyzes have been carried out regarding the opportunity of such a choice by using an appropriate tool. In this sense, the public sector comparator (P.S.C.) can be used, which provides relevant information on the actual costs of PPPs in relation to classic procurement procedures. The P.S.C. is relevant if we admit that private entities, considering the possibility of long-term operation of the investment, to lower the subsequent maintenance costs, tend to overestimate the expenses related to the actual construction by using much more expensive materials. This leads to the amplification of the total project cost, superior to the variant in which the public contracting authority would have purchased only construction works, without giving the possibility to the private contractor to operate and maintain the investment. (E.C.A., 2018).

At the same time, the respective reports also foresee a series of deficiencies for the member states in the sense that in some cases the competition was distorted, allowing only contractors with high financial potential to participate, it was opted for the extension of the execution terms and the escalation of the contract price due to insufficient preparations, registering consistent gaps between the forecasted and the actual final demand level.

A peculiarity of partnerships, from a financial and accounting point of view, is the fact that they can be recorded as off-balance sheet elements (public sector expenses), which contributes to the erroneous reflection of the service of the national public debt, an aspect that for the moment beautifies the public debts, but exercises a significant pressure on subsequent budgetary financial years and alters the principle of accrual accounting. (Engel E. *et al*, 2020).

Typical for PPP is the contractual arrangement articulated over a long time horizon, an aspect that can in turn generate pressure on public budgets due to the escalation of the initial price of the contract based on exogenous and endogenous considerations. [Jonathan L. *et al.*, 2024]. From an endogenous point of view, the manifestation of the opportunism of private law agents is relevant, which, thanks to the gaps of public management in the administration of the contract, the imperfections of the contractual clauses regarding the execution of obligations, as well as some lax legal frameworks, increases the cost of the initial objective, after the award stage , sometimes with the participation of the public authority (corruption).

Some exogenous variables may have an objective character. In this sense, we mention important fluctuations in terms of the exchange rate (if it is not achieved through the intervention of the state in the sense of encouraging national exporters, intentional devaluation), the compression of demand as a result of the decrease in purchasing power or accentuated unemployment. As a consequence, the thorough preparation of PPP negotiations by public agencies, the estimation of actual demand, potential fluctuations, the provision of a coherent legal framework, the drafting of unambiguous contractual clauses, contribute to reducing the risks associated with changing the contract price.

Translating from formal institutions (law, rule of law) to informal ones (morality, tradition, culture), some authors highlight the risks generated by information asymmetry due to different national perceptions, showing that foreign investments in the formation of public-private partnerships tend to gravitate towards national environments where there are cultural similarities, familiarity and a

congruence of principles. (Chan J.M.L., Zheng H., 2019). As a consequence, the role of the receiving countries would transpose articulated approaches to the creation of a national branding and the intensification of commercial relations with private investors belonging to similar cultures.

The emergence of disputes whose solution remains uncertain represents another important risk deriving from the participation of public entities in PPPs and the interaction with foreign direct investments. Studies carried out in this field emphasize some of the generating causes, among which we note public opposition, delays in decision-making, improper operation of the investment objective, legislative changes, opacity of information (Zheng X. *et al*, 2021).

Possible public opposition can be anticipated by quickly analyzing the implications of the partnership (noise pollution, site-related inconveniences), while promptness in decision-making can be ensured by involving experienced consultants, establishing clear responsibilities for each of the partners. Analyzing the ecological implications related to the operation and maintenance phases by imagining alternatives less likely to create such negative phenomena represents a significant course of action. At the same time, the strengthening of informational symmetry can be created by calling for adequate communication and promoting ubiquitous mutual trust between participants. (Wang D. *et al*, 2019).

CONCLUSIONS

PPP represents a viable alternative intended to replace the lack of financial resources of the state, the gaps in the management of the administration of large infrastructure projects, bringing at the same time an important contribution in technological dissemination. Achieving SDG objectives is a way to cooperate between public and private law partners in order to deliver public services that were mainly the prerogative of the government.

The intrinsic construction of the PPP involves a series of contractual arrangements structured on multiple levels, which is intended to value the idiosyncrasies resulting from the interaction of the managerial/competitive capabilities of private and public law actors. States, through government agencies, are responsible for identifying the areas of interest to which future projects will be subsumed and how such investments will remove some regional disparities, ultimately contributing to increasing the standard of living of the final consumer.

At the same time, it is the prerogative of the state to articulate an adequate legal framework, to create a stable climate that attracts foreign direct investments, as well as to offer guarantees to private partners regarding the possibility of their long-term operation of the investments made, obtaining profit, avoiding further nationalizations. It is necessary to specify that the choice of the project variant in the case of decentralized institutions must be circumscribed by the national strategy in the field.

Although partnerships reduce public budget pressure, they do not necessarily lead to the reduction of transaction costs, generated from the perspective of the emergence of opportunistic behaviors. This is due to the fact that their institutional architecture involves the presence of participants with different interests.

The operation of such partnerships generated by private foreign investments also involves a number of risks. Thus, geopolitical risks can lead to a contraction of future investment flows by making foreign capital unavailable. Strategic alliances, non-aggression agreements, membership of some supranational military blocs and improving the quality of state institutions will create a stable environment, encouraging potential investors by ensuring the predictability of the domestic climate.

On the other hand, infrastructure investments demand high expenses from private law actors, projected in a medium to long time horizon, the recovery of which is achieved gradually. The state's overly optimistic view of potential end users may lead to the need for renegotiations of contractual clauses.

From the point of view of the involvement of political factors, several adverse effects can be analyzed: the appearance of white elephants, the suboptimal allocation of resources without taking into account all the options available to satisfy the demand. At the same time, some substitution effects may occur in terms of demand, and the call to some external specialists can dismantle these risks.

Some partnerships that assumed the contribution of the E.U. were concluded in the absence of relevant analyzes regarding the appropriateness of such a choice, distorting competition, thus necessitating recourse to the specific instruments designated by the PSC.

From a financial and accounting point of view, although these can be recorded as off-balance sheet elements, there is a distortion of the service of the national public debt, which will exert a significant pressure on the subsequent budgetary financial years and alter the principle of accrual-

based accounting, recommending a more great caution about this approach.

The escalation of the initial price of the contract based on exogenous and endogenous considerations is an indisputable aspect, which can be avoided by meticulously preparing the negotiations, estimating the actual demand, its potential fluctuations, ensuring a coherent legal framework and drafting unequivocal contractual clauses.

It cannot be omitted the appearance of disputes brought to the courts, whose resolution methods derive from the participation of public entities in the PPP and the interaction with foreign direct investments, generated by public opposition, delays in decision-making, improper operation of the investment objective, changes legislation, the opacity of information. Rapid analysis of the implications of the partnership, promptness in decision-making by involving experienced consultants, establishing clear responsibilities for each of the partners, adequate communication, represent possible approaches that reduce such risks.

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RESEARCH ON SUSTAINABLE AGRICULTURE IN ROMANIA UNDER THE AEGIS OF THE ROMANIAN CODE OF SUSTAINABILITY

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Abstract

Sustainable agriculture is crucial for the management of natural resources, the protection of biodiversity, and combating climate change. In Romania, the Romanian Code of Sustainability provides a regulatory framework for promoting ecological agricultural practices aligned with European requirements. The adoption of sustainable practices, such as crop rotation and pesticide reduction, contributes to improved productivity and environmental protection. Although the transition involves obstacles related to access to resources and education, financial support and European programs are essential for success. Farmers who have adopted these practices have recorded significant improvements in soil quality and biodiversity. The authors conducted a bibliographic study analyzing the impact of the Code of Sustainability on Romanian agriculture, highlighting its challenges and benefits.

Key words: Sustainable Agriculture, Romanian Code of Sustainability, Ecological Practices, Biodiversity

In the current global context, sustainable agriculture has become a priority for economic development and environmental protection, especially in light of population growth and climate change. Agriculture plays a central role in ensuring food security; however, conventional agricultural practices can lead to soil degradation, water pollution, and a reduction in biodiversity. These issues are particularly relevant in Romania, where agriculture has a significant impact on the environment and the rural economy.

The Romanian Code of Sustainability represents an essential step in promoting sustainable agriculture, aiming to implement agricultural practices that minimize environmental impact, conserve natural resources, and support rural economic development. The Code aligns with European and international sustainability objectives, including the European Green Deal and the 2030 Agenda for Sustainable Development.

One of the main objectives of the Code is to integrate sustainability into agriculture through concrete measures such as crop rotation, the use of organic fertilizers, and the reduction of pesticides. These practices aim not only to protect the environment but also to increase long-term productivity without compromising the viability of resources for future generations.

Furthermore, the Romanian Code of Sustainability offers Romanian farmers the opportunity to access international markets by adopting organic production standards. These measures are supported by European funds and governmental subsidies, facilitating the transition toward a green and competitive agriculture.

However, the implementation of these practices requires an integrated approach that combines financial support, agricultural education, and the adoption of modern technologies. Such a transition will enable Romania to consolidate its position in the international agricultural market, while also contributing to the reduction of greenhouse gas emissions and the protection of local ecosystems.

Approaches in the specialized literature

Sustainable agriculture has become an intensively researched topic in recent decades, given the need to protect the environment and ensure global food security. Globally, some of the most relevant scientific works explore the impact of intensive agricultural practices on the environment and outline solutions for transitioning toward a more sustainable agricultural model.

The classic study by Tilman *et al.* (2002) is an essential reference, as it analyzes the global challenges facing agriculture in the context of population growth and climate change. Tilman demonstrated that unsustainable agricultural practices contribute to soil degradation, water pollution, and loss of biodiversity, concluding that the urgent adoption of sustainable agriculture is necessary to ensure long-term productivity without

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compromising the environment. In another influential study, Pretty *et al. (*2008) explored the benefits of sustainable agriculture on natural resources, emphasizing that sustainable practices can reduce carbon emissions and increase the resilience of agricultural systems to climate change.

In the European context, Altieri (1995) was one of the pioneers of the agroecology concept, arguing that sustainable agriculture is not only about environmental protection but also about maintaining ecological balance on farms through the use of integrated systems that support biodiversity. His work directly influenced research on sustainable agriculture in Romania, where the transition from conventional to sustainable agriculture has become a priority objective in national agricultural policy.

In Romania, recent research conducted by Popescu *et al.* (2019) showed that conventional agriculture, based on chemical inputs and monoculture, has had negative effects on soil quality and biodiversity, especially in vulnerable rural areas. These studies highlight the urgent need to adopt ecological methods such as crop rotation and reducing pesticide use. Additionally, Dumitrașcu *et al.* (2021*)* highlighted the positive impact of implementing the Romanian Code of Sustainability, showing that the sustainable agricultural practices recommended by this code have improved soil quality and reduced carbon emissions in certain regions of Romania.

Gaps in Current knowledge

Although global and national research has provided a solid knowledge base regarding the impact of sustainable agriculture on the environment, significant gaps remain. One of the main underexplored areas is the long-term impact of these practices on small-scale farmers. For example, in a study on the role of social capital in agriculture argues that farmers who adopt sustainable practices can benefit not only from ecological advantages but also from community and economic support, which can facilitate the transition to green agriculture. In Romania, however, these social and economic aspects are less researched.

Moreover, longitudinal studies that could assess the long-term impact of sustainable agriculture on agricultural productivity and soil quality are almost entirely absent from the specialized literature in Romania. For instance, Barbu *et al.* (2018) emphasized, in an extensive international study, the necessity of continuous evaluations to measure the cumulative effects of sustainable practices, especially crop rotation and integrated pest management. Such an evaluation framework would also be useful for Romania, where most studies focus on the immediate impact of sustainable agriculture without considering long-term changes.

Another insufficiently documented area of interest in Romania is the education and training of farmers in sustainable agriculture. Although Pretty *et al.* (2010) have demonstrated that continuous education is essential for the long-term success of sustainable agriculture, there is little research in Romania analyzing the effectiveness of training programs in this field. These gaps should be addressed to fully understand how Romanian farmers can adopt and maintain ecological agricultural practices.

MATERIALS AND METHODS

1. Experimental Methods

The experimental methods involved direct measurements on agricultural lands in various regions of Romania where the practices promoted by the **Romanian Code of Sustainability** were implemented. These practices included:

- **Crop Rotation**: Observations were conducted on agricultural fields where crop rotation was applied to evaluate the impact of this technique on soil fertility and biodiversity.
- **Organic Fertilizers**: In the farms included in the study, organic fertilizers were used instead of synthetic ones, measuring improvements in soil quality and the impact on agricultural production.
- **Reduction of Pesticides**: Integrated Pest Management (IPM) practices were applied to assess the efficiency of reducing pesticides through natural methods, such as the use of natural predators and crop rotation.

The data obtained through these methods were compared with data from farms using conventional agricultural methods to observe differences in productivity, soil quality, and environmental impact.

2. Theoretical Methods

A review of specialized literature was essential to establish a solid theoretical framework supporting the evaluation of sustainable agriculture in Romania. Relevant international scientific studies were utilized, such as those by Tilman *et al.* (2002) and Pretty *et al.* (2008), which demonstrated the long-term impact of sustainable agricultural practices on agricultural ecosystems and the reduction of the carbon footprint.

In addition, national studies were analyzed, including those by Popescu *et al.* (2019), which evaluated the impact of conventional agriculture on the environment in Romania. This theoretical basis provided the necessary context for assessing the results obtained through experimental methods.

3. Equipment and Software

Environmental monitoring was carried out using sensors to measure soil and water quality. The following equipment was used:

- **Soil Moisture Sensors**: These were installed in various farms to measure moisture variations and evaluate the efficiency of irrigation within sustainable practices.
- **Water Pollution Sensors**: This equipment was used to monitor water pollution with pesticides and chemical fertilizers in farms that had not yet implemented ecological practices.

Data analysis was performed using advanced software:

- **ArcGIS**: Used for mapping agricultural lands and spatial analysis of the impact of sustainable practices on biodiversity and land productivity.
- **SPSS**: This software was utilized for the statistical analysis of field-collected data, especially to compare the performance of sustainable agriculture with that of conventional agriculture.

4. Participants

The study involved **50 farms** from various regions of Romania, representing both small farmers and medium-sized farms. Participants were selected based on criteria of cultural diversity and the degree of adoption of sustainable practices. They were interviewed about their experiences in adopting the Romanian Code of Sustainability, the challenges encountered, and the benefits obtained. Additionally, farmers were trained in the use of monitoring equipment and the adoption of the recommended new practices.

5. Data Processing and Interpretation

Data obtained from experimental monitoring and conducted interviews were processed using statistical methods and compared with specialized literature. The results were then discussed in the context of implementing the Romanian Code of Sustainability to evaluate the real impact on Romanian agriculture and the environment.

RESULTS AND DISCUSSIONS

The research on the impact of sustainable agriculture, within the implementation of the Romanian Code of Sustainability, has generated a series of significant results that highlight the benefits of adopting sustainable agricultural practices from both ecological and economic perspectives. The study included experimental analysis of farms applying sustainable methods, monitoring of soil and water quality, as well as detailed interviews with the farmers involved.

Improvement of Soil Quality and Agricultural Productivity

One of the main conclusions of the research was that farmers who implemented crop rotation, the use of organic fertilizers, and the reduction of pesticides registered a significant improvement in soil quality. Measurements conducted using monitoring sensors indicated that the soil in these farms had a higher organic matter content and an increased water retention capacity, leading to enhanced fertility and more effective erosion control.

In comparison to conventional farms, where the use of synthetic fertilizers led to accelerated soil degradation, sustainable practices demonstrated that protecting natural resources can be combined with more stable long-term productivity. Additionally, farmers observed an increase of up to 20% in production following the use of these techniques, especially in regions that previously faced soil infertility problems.

Reduction of Water Pollution

Another important result of the research was the significant reduction of water pollution in sustainable farms. By applying Integrated Pest Management (IPM), which reduced the use of pesticides and chemical products, the study demonstrated a 30% decrease in groundwater pollution levels in the monitored areas. Farms that adopted these measures employed natural techniques, such as introducing beneficial predators for pest control, thus replacing harmful chemical products.

Measurements conducted with modern water quality monitoring equipment confirmed a reduction in contamination with toxic substances, contributing to the protection of aquatic ecosystems surrounding the farms. These results confirmed theoretical hypotheses and previous research regarding the beneficial effects of sustainable practices on the environment.

Conservation of Biodiversity

The adoption of shelterbelts and cover crops within sustainable farms had a positive impact on local biodiversity. The study showed that farmers who planted shelterbelts for the protection of agricultural lands managed to conserve natural habitats for pollinators, birds, and other fauna species. This approach led to a rebalancing of agricultural ecosystems and contributed to maintaining a healthy and productive environment in the long term.

Moreover, soil biodiversity improved due to the use of organic fertilizers, which favored the development of beneficial microorganisms for soil health. Through these measures, farmers succeeded in creating a balance between agricultural production and the conservation of natural

resources, thus confirming the conclusions of studies by Altieri (1995) and Pretty *et al.* (2008).

Economic Benefits

In addition to ecological benefits, the research highlighted a series of economic advantages. Although the initial implementation of sustainable practices involved higher costs, especially for precision irrigation and monitoring equipment, farmers recorded substantial reductions in long-term operational expenses. The reduction of pesticides and synthetic fertilizers significantly decreased production costs, thereby increasing the long-term profitability of farms.

Furthermore, access to international markets for organic products increased the revenues of farmers who obtained organic certifications. The growing demand for organic products both in domestic and international markets offered farmers new opportunities for development and expansion of agricultural businesses.

The research results demonstrate that the implementation of sustainable agriculture practices in Romania under the aegis of the Romanian Code of Sustainability brings significant benefits, both ecologically and economically. Improvement of soil and water quality, conservation of biodiversity, and increased farm profitability are indicators of the long-term success of these practices. These results provide a solid foundation for promoting and expanding sustainable agriculture in Romania, contributing thus to a greener and more sustainable agricultural future.

The interpretation of this study's results reveals that the sustainable agricultural practices promoted by the **Romanian Code of Sustainability** have a clearly positive impact on the environment, in alignment with existing literature. International studies, such as those by Tilman *et al.* (2002) and Pretty *et al.* (2008), support that the adoption of ecological practices contributes to the improvement of soil quality, water, and biodiversity—conclusions that are also confirmed by data obtained in Romania. The use of organic fertilizers and the reduction of chemical inputs have proven effective, and the increase in biodiversity through practices like crop rotation and the utilization of shelterbelts directly reflects the recommendations of agroecological studies.

Implications and Scientific Relevance

The study makes significant contributions to the understanding of sustainable agriculture in the Romanian context, where the practical application of these principles is in an early stage. The results confirm that the transition to sustainable practices can generate long-term ecological benefits, especially in agricultural regions affected by soil erosion and water pollution. These findings are relevant for future agricultural policies and offer a model applicable to other similar regions.

Possible Limitations of the Study

An important limitation of this study is the relatively short duration of monitoring the effects on the environment and agricultural economy. Additionally, the study focuses on a limited number of farms, which may influence the generalization of the conclusions. Another limitation is related to the high initial costs for implementing sustainable practices, an aspect that could be analyzed in more detail in future long-term studies.

CONCLUSIONS

This study has demonstrated that the implementation of the Romanian Code of Sustainability in Romanian agriculture brings clear benefits both ecologically and economically. Sustainable practices such as crop rotation, the use of organic fertilizers, and the reduction of chemical inputs have contributed to improving soil quality, conserving biodiversity, and reducing water pollution. These results are in line with international research, confirming that widespread adoption of these practices can have a significantly positive long-term impact on Romanian agriculture.

From an economic standpoint, the reduction of production costs and access to organic product markets offer farmers an opportunity to increase competitiveness and achieve higher profits. However, the transition to sustainable agriculture may involve high initial costs, which suggests the necessity for continuous financial support from governmental and European policies.

In conclusion, the study confirms the relevance of the Romanian Code of Sustainability as an instrument for promoting sustainable agriculture in Romania, emphasizing the importance of integrating it into a long-term agricultural strategy. Nevertheless, to maximize the positive impact, extensive and continuous monitoring of long-term effects is necessary, along with expanded research on the economic and social aspects associated with the transition to sustainability.

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PERFORMATIVITY IN ECONOMICS

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Abstract

Introducing the theme of performativity and placing it within the field of cultural economics makes the role that performativity plays in economics a logical place to start and acknowledge. The idea that economics does not describe an existing external "economy" but brings that economy into being: economics realizes economics, creating the phenomena it describes. This idea is now recognized by many authors as one of the major contributions to economic sociology and has been accompanied by heated debates in the social sciences about the actual influence of economics and economists on economic practices and, more generally, on society and political processes. But when one considers the 'cultural' dimension - that is: when one moves beyond economic sociology to the wider intellectual domain of the social sciences and humanities in general - then an interest in performativity has developed as a way of approaching issues whose importance it goes far beyond the pure processes of language. Since some authors have outlined the philosophical proposition that speech is not primarily or exclusively "constative", that is, it does not just "state" facts, but, under certain happy conditions, "acts" or "realizes" certain realities, the idea of performativity has attracted theorists involved in political and social science, philosophy and economic theory.

Key words: performativity, economics, politics

The problem of performativity is now widespread in the social sciences. At first glance, the claim that economics is performative asserts that it shapes the social world rather than simply describing it. Coming from the field of sociology, notably from the work of Michel Callon, this topic has sparked several debates. One of them concerns the problem of the relativity of social theories. In a Popperian style, performativity can be seen as a critique of the scientific nature of economic theories. If a theory can become true, there is no real theory per se because there is no pre-existing economy to describe. The performativity of economics has been at the center of attention over the last decade in economic methodology and economic sociology. Initiated by Michel Callon, the thesis of performativity, the idea that economics, more than the description of an external social world, shapes it in its image, directly challenges economics and social sciences that have pushed its desire to become an objective science to the extreme. The fundamental problem of performativity by asking to what extent a theory can be performative. The question at stake is mainly how to explore the limits of performativity in order to understand what a true theory could be, or why one theory is capable of affecting the social world and another is not. This way of thinking about the performativity of economic theory leads to a methodological and normative question: what conditions must a theory meet to be performative or to have an impact on the world? Economics is a logical starting point. Callon's point was that "economics does not describe an existing external 'economy', but brings this economy into being: economics realizes the economy, creating the phenomena it describes. This idea is now recognized by many authors as one of the major contributions to economic sociology and has been accompanied by heated debates in the social sciences on the real influence of economics and economists on economic practices and, more generally, on society and political processes. Some authors introduce the notion of performativity through a neurolinguistic approach and go beyond this specific link by focusing on the most general actors and social reality.

Because performativity demonstrates how economic theory is embedded in its subject matter (whatever economic niche it may interact with, from derivatives markets to auction markets), the process calls into question the extent to which economics is able to maintain its scientific independence from its subject matter. The increasing integration of theory into markets, informed by performativity research, makes clear that economics influences its subject matter in ways that the physical sciences cannot. It is not controversial to assert that many objects of the physical sciences exist independently of theory;

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however theory chooses to manipulate its variables, it is much more complex with the objects of economics.

MATERIAL AND METHOD

But when we consider the "cultural" dimension, that is, when we move beyond economic sociology to the broader intellectual domain of the social sciences and humanities in general, we also remember that Callon was not the first scholar to engage with performativity as a way of approaching problems whose importance goes far beyond the pure processes of language. Ever since Austin expounded the philosophical proposition that speech is not primarily or exclusively "contactive," that is, that it does not simply "affirm" facts but, under certain fortunate conditions, "acts" or "realizes" certain realities, the idea of performativity has included theorists involved in political and social science, philosophy, and gender theory. Butler's initial and decisive intervention was to deploy a reorganized version of performativity to counter the sexist approaches adopted in feminist and social theory. In Butler's hands, a flexible and fully developed Foucauldian vision of performativity described sex and gender neither as essences nor as pure constructions, but as possible outcomes of how they are performed and reiterated. In its wake has followed a large literature showing ongoing efforts to apply, refine, and challenge performative perspectives to a wide range of political objects and questions. Given the breadth and scope of this impact, three surprising and challenging questions arise for economic sociology: Why has it taken so long in this field, relative to others, for performativity to be adopted as a means of shedding new light on its subject? What relevance, if any, does this framework have in an era of acute global financial and political crises? Ultimately, what is really at stake in the debate, and is the concern with performativity a useful tool or a mere distraction when it comes to the "big" economic and political questions? Another hypothesis can be added, namely that the contrast between the relative novelty of performativity in economic sociology and its long and rich use elsewhere in academia could be based on a much older division between two opposing worlds: the world of economics on the one hand (considered as a system of things in which language is secondary) and the political world on the other (thought of as a set of words in which things are often forgotten). This great division is the result of the historical struggle of economics as a discipline to construct and present itself as a distinct science and as an alternative to politics.

RESULTS AND DISCUSSIONS

Through market mechanisms, social order would no longer depend on forced control by human institutions such as religion or government, but rather on the "natural" adjustment of private needs, goods, and money. More precisely, the aim was to replace "spiritual civil war" with "world civil peace" by channeling the potential disorder of human passions into the pursuit of market interests. The dangerous human interactions that had led to decades of bloody civil war across Europe were instead to be diverted into material entities and converted into a single passion that serves as the equivalent of all others: the pursuit of self-interest. Since then, economics has attempted first to connect human echanges to economic processes and, second, to connect these processes to laws defined as natural rather than political, or to the force of problems rather than to the falsehoods of language—interest being economic. In other words, from the beginning, economics has tried to define itself as a purely constative science describing the economy. The economy is supposed to exist and function "out there" according to certain "positive" physical mechanisms, as opposed to the more "talkative" and relativistic functioning of politics. From Durkheim to Granovetter, economic sociologists have constantly tried to counteract the point of view of economists by questioning the "unrealistic" character of their hypotheses and the "false character" of their descriptions. But the paradox is that by limiting the debate to the constant dimension of economic theories, economic sociology, instead of producing a convincing critique, has forgotten to explore how economies are shaped by economic science. Economic sociology thus reinforces the radical autonomy of the discipline that it seeks to correct. This explains why economic sociologists have devoted so much time to exploring the performative character of economics beyond its constant assertions. If classical economics and sociology are opposed as to the "correct" description of the world—each of them could only represent the two opposite sides of the great divide between nature and culture, economics and politics—both conceived their task as "describing" the world at stake, rather than "doing" through this very description—hence their blocked opposition. Of course, such a modernist opposition between two distinct worlds can be understood, as Latour explains, as the very condition of their clandestine hybridization. In this sense, it is no accident that Michel Callon has revealed the performative character of economics. Focusing on the performativity of economics implies studying the hybridization between the political language of economics, on the one hand,

and the functioning of economic devices, processes, and facts, on the other. Such a study helps to overcome the useless critique of the constitutive nature of economics and, more importantly, to understand the crucial point that economic things remain stable and meaningful thanks to economic words. This approach gives the Polanyian idea **(Polanyi K., 2001**) – that economics is a political institution and a social project – the very theoretical schema it lacked. Once economics becomes a matter of performative language (and politics a matter of things done), the great divide between economics and politics, economics and society, is revealed as the partial and provisional result of a long historical project of separation. and economies are not so much separated as they are made to be separated.

An approach to performativity as politics could open up debates around economic performativity beyond their current place in economic sociology and thus contribute to: (1) the development of a more robust and general theory of performativity; (2) revisiting the politics of performativity to help strengthen political analyses of markets and market formation; and (3) the intersection of economic sociology with other fields of sociology.

It is important to emphasize that the literature so far has indicated rather than ultimately demonstrated the performative character of economics. The idea of performativity in economic sociology was not to make the discipline a kind of sociolinguistics, but rather to shed new light on economics. This sometimes involves considering performativity as an axiom rather than an object. If the aim of the idea of performativity in economic sociology was to grasp economics in its pragmatic dimension and to study both what it does and what it says, this does not exhaust the need to review and reassess the assumptions inherent in economics. in the project itself. For Paul du Gay, the problem is not so much to situate or defend politics within the performativity program as to interrogate the underlying ideas of politics and political action that inform Butler's thought and, to some extent, Callon's. One of the difficulties with the theoretical definition of performative failure, he argues, is the concomitant subordination of contingent empirical questions to higher philosophical truths. But describing what, "it all depends," insists du Gay, is a necessary element of practical practice. rather than a philosophical political commitment. The dangers he detects in a politics based on higher philosophical truths resonate with those that motivated the early pragmatist philosophers' disavowal of philosophical and scientific certainties for their historical cause. provisionally and partially, but also, and above all, because of their failure to prevent the destruction of civil war. Another author continues the debate on politics, practice, and the meaning of the empirical, but with a change of direction. Performances, Licoppe agrees with Butler, can fail or provoke surprising responses, but there is a particular benefit to be gained from the emphasis in sociotechnical accounts on what not only words are but things, or more precisely words in combination with things I can do. The focus on this method of politically engineering markets, Mitchell points out, draws attention both to some of the unexpected outcomes produced by the properties of commodities and to the experimental computational techniques on which the process actually depends. Behind his account lies the way in which certain ideas, forces, or movements seem, for a time, global, possessing a translocal logic, or an apparent irresistibility, that nevertheless fails to fully forestall unforeseen challenges. It is a question of questioning how the theoretical separation between politics and economics has played out historically, while addressing how, in practice, the devices, processes, and practices of markets and economies are deeply imbued with the political language of economics. This simultaneous separation and hybridization is never, in any context, whole and complete forever. Another political potential for economic performativity may also exist in what Callon has recently described as "performance struggles." A series of questions concerning performativity are raised. That is, how are battles between competing possible worlds to be explained? What are the political regimes that govern the choice between some economic worlds and others? And what role does economic sociology play in such politics? Does the performativity paradigm depart from economic sociology further (or elsewhere) than from the new economic sociology? The range of performativity analysis can also be extended upstream, by taking into account the variety of theories and scientific "disciplines" that can be implemented within economies. It is emphasized how conservative the theory of performativity is when it claims, contrary to most critiques of rationality, that homo economicus exists because of the incorporation of economics into economics. If economics shapes the world, there are no longer any true or false theories per se, and there is no longer any possibility of factual contestation. Other authors argue that if economics matters in the construction of reality, we must explain how and why. We must understand why, in a situation of competition between several economic theories, one is adopted and not the other.

CONCLUSIONS

The concept of economic performativity defines a particular link between economic theory and the social world. To understand the use of the notion of performativity in Michel Callon's economic sociology, it follows that the power of economists' discourse does not only rest on its linguistic force, but also on the practical conditions in which this discourse is used. Callon's general reasoning is that an economic theory shapes the world when agents use it in their interactions on the markets. Thus, "the real economy is not anchored in society, but in the economy". The sociology of performativity focuses on the links of action and especially techniques to explain how the economy constructs the world. Here, the sociology of performativity differs from other sociological approaches to the influence of the economy on the economy, for example, according to the idea that scientific work as a prescription leads the social world to behave in the way it is described. In Callonian thought, economic knowledge is embodied in action, which leads individuals to behave in accordance with this knowledge, even if they do not know the economic theory that it "imitates". On the other hand, some authors have it in mind and the capacity of the economy to shape the economy has been both neglected by economists and overestimated by Callon. The problem of relativity is a major problem in performativity theory. Following Lewis's definition of conventions, a theory could take into account the social world and others could not. The discussion can be followed along three paths. First, to function in the world, a theory must provide an empirical classification of phenomena. Second, some elements, risk, cannot always be modeled by the representation of agents. Third, to have an impact on the world, a theory must be inserted into the institutional world. The literature uses the case study of social branding to show how social norms influence the implementation of new structures. These are the three limits to performativity in economic theory. Such a framework could be useful in the future development of this notion, because it provides a definition of performativity that includes the possibility of failure.

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KEY FACTORS IN DEVELOPING SUSTAINABLE AGRITOURISM

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Abstract

The objective of this paper was to identify the main factors that contribute to the development of agritourism in terms of sustainability. For this purpose, the method of systematic review of specialized literature was applied, which addressed the linkage between sustainability and agritourism activities. The findings indicate that agritourism can offer sustainability advantages under all three basic aspects of sustainable development (economic, ecological, social). The current state of literature shows that among the most important factors that positively affect agritourism sustainability are: good skills and competences, hight level of hygiene of facilities, green technology innovations, good infrastructure and accessibility, landscape design, reducing water and energy consumption, family involvement, women empowerment, quality products and services at affordable prices, education and training, collaboration and partnerships.

Keywords: agritourism, sustainability, key factors, development

Agritourism farms carry out various recreational, educational and commercial activities in order to attract tourists and ensure their economic profitability. The need to meet the requirements of an ever-increasing number of visitors to rural regions determines the establishment of new tourist accommodation places, facilities and small tourism-related businesses (Cortez N.J. *et al*, 2024). The excessive expansion of tourism in the rural areas has the potential to disarrange local social structures, increase the stress on daily rural life and threaten the natural environment and local resources due to overcrowding and overconsumption (Roman M. *et al*, 2020).

In order to protect the rural area from tourist activities and the risks associated with them, agritourism must be based on sustainable practices that preserve natural resources and local cultures and traditions. Through responsible agritourism, a balance can be achieved between the needs of tourists and those of the host communities (Ammirato S. *et al*, 2020). Identifying the key factors that contribute to the agritourism sustainability and understanding how they operate, helps to plan appropriate agritourism development, taking into account economic, social and ecological realities specific to the countryside.

MATERIAL AND METHOD

The purpose of this paper was to highlight the elements that have the potential to contribute to a sustainable development of agritourism. In order to achieve the objective, a review of the specialized literature was carried out, and the articles published online in the field of agritourism were analyzed. The main search keywords were "agritourism development", "sustainable agritourism development", "agritourism sustainability". The databases used are diverse, but Francis and Tylor, Elsevier, Scopus were preferred due to their prestige among researchers. The analysis of the digital library allowed the identification of a number of 13 main factors which, according to the studies various researchers and scholars, could influence the sustainability of agritourism. Some of them are composed of several sub-factors. After a brief general description of the determinants in question, several aspects related to their action were presented, classified according to the three dimensions of sustainability: social, economic and environmental.

RESULTS AND DISCUSSIONS

For any tourist destination, sustainability is the main success factor, regardless of the nature of the tourist activities carried out (Cortez N.J. *et al*, 2024). Sustainability is a way of maintaining the existence of tourism by minimizing the negative effects on the natural environment and society, while providing opportunities for the local economy and benefits for all stakeholders (Baipai R. *et al*, 2021).

In the last decade, agritourism has been promoted as a model of sustainable tourism (Grillini G. *et al*, 2023). There are many reasons to

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be considered more sustainable than other types of tourism, its potential impact being more favorable along all dimensions of sustainability: farm profitability, social responsibility and environmental protection (Santucci F.M., 2017).

The current state of specialized literature on the factors that ensure the sustainable development of agritourism shows that the most important are those presented in *figure 1*. Some of them have been grouped into a single composite factor by combining individual determinants that are linked by related aspects.

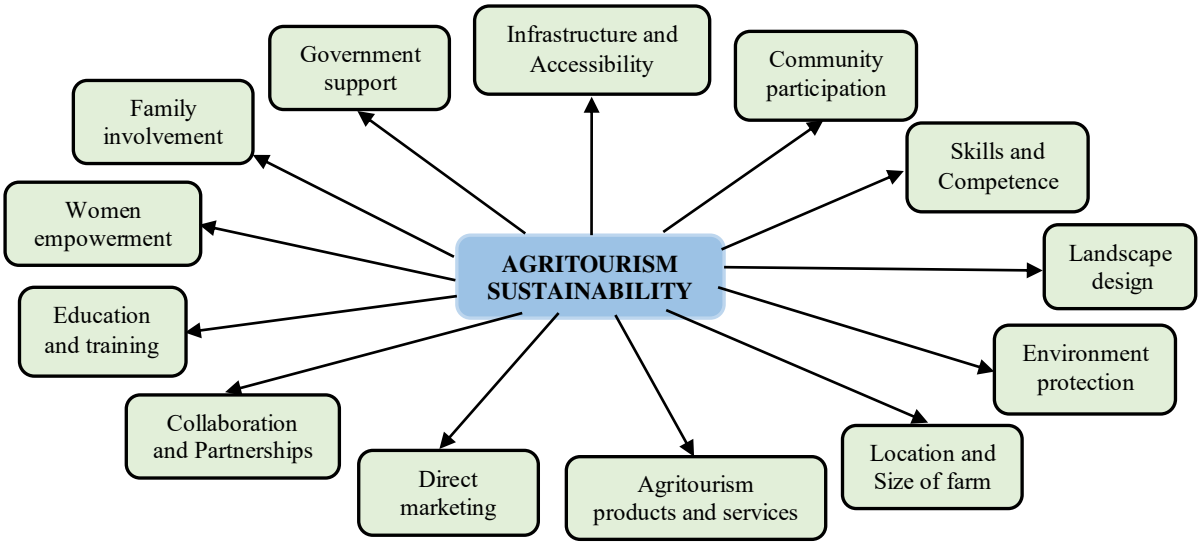

Figure 1: The main sustainability factors of agritourism

The most frequently factor mentioned in the literature is the "*agritourism products and services*" (Baipai R. *et al*, 2021), which refers to the range, quality and authenticity of the agritourism offer (tourist attractions, amenities, activities etc.). Together with a good *"infrastructure and accessibility",* constitute the basis of the tourist motivation to visit a certain agritourism farm and a certain rural region (Bagi F.S., Reeder R.J., 2012). Another essential factor to attract visitors and gain their loyalty is "*landscape design"*, tourists being very interested in the beauty of the natural and cultural landscape, that decisively contribute to the success of a tourist destination (Barbieri C., 2013). "*Location and farm size"* are factors that could also influence the tourist flow and, thereby, the success and sustainability of the agritourism guesthouse (Schilling B.J., Sullivan K.P., 2014). In adittion, the "*collaboration and partnerships"* factor could contribute to increase the number of tourists even more. This involves collaboration with other agritourism guesthouses as well as the establishment of partnerships with other players in the tourism industry (hotels, restaurants, tour-operators), in order to facilitate the marketing of agritourism products (Sumardi R.S. *et al*, 2023). A higher tourist flow means more opportunities to sell the agro-food production of the agritourism farms directly to consumers ("*direct marketing*" factor) (Grillini G. *et al*, 2023).

The ecological component is very important for sustainability, with agritourism having great potential to help "*environment protection*". This factor encompassed the activities that ensure the conservation of the environment both by farmers (minimizing the production of waste and the consumption of water and energy, environmentally friendly farming methods, the use of renewable energy (Tew C., Barbieri C., 2012), the promotion of recycling and reuse, etc.) and by tourists (their behavior during the stay, regarding the conservation of natural resources and biodiversity) (Ingrassia M. *et al*, 2023).

"*Skills and competence"* factor refers to the fact that farmers must have knowledge that will help them in running their business (management, marketing, planning, accounting etc.) as well as skills regarding the relationship with tourists (communication, hospitality, etc.) (Grillini G. *et al*, 2023). To this fact may also contribute the "*education and training"* factor, which involves the efforts of the government or the private sector to transfer to farmers information and knowledge regarding the responsible management of agritourism businesses.

The main aid provided by the state is represented by "*government support"* factor and includes start-up financing, the creation of the legal environment and the promotion of policies necessary to adopt appropriate strategies for the development of agritourism activities (Baipai R. *et*

al, 2021). Also, the long-term viability of agritourism farms is supported by the local "*community participation",* by facilitating farmers' access to resources and market opportunities (Cortez N.J. *et al*, 2024) and providing labor and various tourist attractions (art, culture, folklore, traditions and customs, etc.) (Baipai R. *et al*, 2021). But more important is the. "*family involvement"* factor, which entails the participation of the farmer's family members in the activities of welcoming guests, preparing and serving meals, promoting the business, cleaning and other hospitality services. Especially the female labor force is involved in these activities (Stotten R. *et al,* 2019). Agritourism is considered a suitable means to ensure their independence and jobs correlated with their skills and abilities. Most often, the touristic activity within the farms remains under the care of women, as they fulfill to the best extent all the competence requirements for interacting with tourists (Brandth B., Haugen M.S., 2011). The role and contribution of women from the rural community to coordinate the tourism initiatives is included in the "*women empowerment*" factor.

Between these relevant determinants for sustainability, interdependence relationships are established, their degree of importance depending on the characteristics of the agritourism household and the specific conditions of the rural area where it is located (Ammirato S. *et al*, 2020). According to the opinions of some researchers, the most suitable farms for involvement in tourist activities are horticultural and livestock farms (Brown D.M., Reeder R.J., 2007), small lifestyle farms (Schilling B.J. *et al*, 2014), farms with increased labor resources (Barbieri C. *et al*, 2008) and farms using conservation practices (Schilling B.J., Sullivan K.P., 2014).

Economic sustainability of agritourism.

As stated in the extant body of literature, there are many economic motivations for agritourism. For the local rural community, the economic benefits of the development of agritourism are empowerment of rural areas, creation of jobs, preventing the decline of the rural population due to urban migration, development of infrastructure and tourism-related businesses (Mahmoodi M. *et al*, 2022). The main reasons for the adoption of tourism by farmers consists of improving of the farm's economic conditions, solving problems with employment, improving farm productivity and sustainability of agricultural businesses (Halim M.F. *et al*, 2020; Srisomyong N., Meyer D., 2015). Agritourism farms benefit from opportunities for economic diversification, generating cash flows and increasing gross income (Hochuli A. *et al*, 2021), which allows to mitigate seasonal fluctuations in farm income (Ammirato S. *et al*, 2020). This could reduce the excessive dependence of farms on agricultural production, offering, at the same time, more opportunities for marketing (Nematpour M., Khodadadi M., 2021).

The association of tourism-related activities with agriculture could contribute to increase the volume of sales of agricultural goods, to facilitate farm adjust to market requirements, to gain new market segments (Nickerson N. *et al*, 2001), as well as to promote and increase the farm visibility (Tew C., Barbieri C., 2012). Agritourism is also seen as a way to reduce the influence of some factors that are independent of the farmer (such as the weather, for example) (Veeck G. *et al*, 2006), the income from tourism having the role of supporting agricultural production and mitigating the risk factor in agriculture (Bagi F.S., Reeder R.J., 2012).

A comparison of the financial results obtained by the farms shows that the incomes of the agro-tourism ones grew faster than the non-agro-tourism ones, but the agricultural production decreased (Grillini G. *et al*, 2023). Agritourism can be a significant source of additional income for farming families (Schmitt M., 2014), there being a positive correlation between the development of various leisure and entertainment activities at the farm and its income (Giaccio V. *et al*, 2018).

As a rule, the incomes from agriculture are higher than those from tourism (Koutsouris A. *et al*, 2014), but there are also situations when the agricultural activity generates only up to 20% of the total income of the farm, as it appears from the study by Stotten R. *et al* (2019). However, as shown by the study carried out by Arru B. *et al* (2021), it is difficult to maintain a balance between agricultural and tourist activity. Some farms involved in tourism give priority to agricultural production (Schermer M. *et al*, 2007), but others wish to expand their tourist activities. (Ammirato S., Felicetti A.M., 2014). Many times, agricultural and tourist activities end up competing with each other for some limited farm resources, such as available space and time (Fischer G., 2019). The efforts to respond to the special requests of the visitors, make the daily operations of the farm to be, sometimes, disturbed. In addition, agritourism farms tend to expand their tourist facilities by restricting the surface of agricultural areas, a fact that disadvantages agrifood production (Grillini G. *et al*, 2023).

Ecological sustainability of agritourism.

The critical drivers of environmental sustainability are rural economic conditions and sustainable business performance (Cortez N.J. *et*

al, 2024). Of essential importance, this component of sustainability includes multiple aspects. Agritourism contributes to the promotion of sustainable practices and environmentally friendly production, in line with tourists expectations (Mastronardi L *et al*, 2015; Abadi A., Khakzand M., 2022; Grillini G. *et al*, 2023; Ingrassia M. *et al,* 2023). The success of these sustainable practices depends on the cooperation between farmers and the rural community (Cortez N.J. *et al*, 2024). In order to meet tourists demand for a diversified range of products, the farmers use sustainable production techniques that have beneficial effects on the landscape and natural resources (Ammirato S. *et al*, 2020). Increasing interest in quality and healthy food has stimulated agritourism farms to be more involved in organic production (Mastronardi L. *et al*, 2015; Shen C.C. *et al*, 2020) and environmental and biodiversity conservation (Kuo N.W *et al*, 2006; Ammirato S. *et al*, 2020) than those not engaged in tourism.

Agritourism guesthouses tend to implement programs to reduce the consumption of energy, water (Ispas A. *et al*, 2019) and raw materials (Shen F. *et al*, 2009), landscape preservation (Ammirato S. *et al*, 2020), revalorizing some agricultural products that cannot be used in classic ways (Brandth B., Haugen M.S., 2011), minimizing the generation of waste by promoting recovery, reuse and recovery activities (Choo H, Jamal T., 2009), as well as the use of renewable energy sources (especially solar energy) (Paniccia P.M.A., Baiocco S., 2020). Some studies have signaled contribution regarding soil protection and the reduction of the use of chemicals in agriculture practiced by farmers involved in tourist activities (Ollenburg C., Buckley R., 2007).

In some cases, the farmers have turned to green technological innovations (Pimonenko T. *et al.,* 2021), were oriented towards the application of integrated pest management or have taken measures to improve wildlife habitats (Barbieri C., 2013). Also, agritourism could have a positive impact on the farm animals. Because it exerts a strong attraction on tourists, farmers would be tempted to provide them increased attention and better care conditions than in non-agritourism farms (Hansen B.G., Østerås O., 2019). That will be reflected in the improvement of animal welfare. On the other hand, the noise and active presence of visitors can stress the animals, requiring appropriate behavior and careful management of the contact between tourists and livestock (Grillini G. *et al*., 2023).

Agritourism offers also the opportunity to educate tourists about agricultural production nature and conservation practices (Choo H., Jamal T., 2009). By interacting with life on the farm, rural visitors become more aware of the need to reduce the consumption of natural resources and to protect the natural environment (Barry J., Hellerstein D., 2004).

Social sustainability of agritourism.

Agritourism could affect the quality of life of farmers both negatively and positively. Although the management of agritourism activities requires additional effort and time, most studies indicate that the positive impact is superior to the negative effects. (Chase L. *et al*, 2013; Ciolac R. *et al*, 2020; Grillini G. *et al*, 2023) Farmers can get satisfaction in their work and enjoy sharing with tourists a lifestyle that combines human relationships with agriculture, but visitors' intrusion into personal life is not always a pleasant experience (Sharpley R., Vass A., 2006). Despite these shortcomings, farmers are satisfied that through agritourism they can maintain their traditional lifestyle, engaged in agricultural production, and keep the farm running to secure their livelihood (Schilling B.J. *et al*, 2014; Stotten R. *et al,* 2019).

Agritourism may have, also, a strong positive impact on local community life and well-being: alternative incomes; attracting more local investments; improve the standard of living (López-Sanz J.M. *et al,* 2021) and the quality of recreational facilities (Barbieri C., Mshenga P.M., 2008); new jobs and employment opportunities for women (Ollenburg C., Buckley R., 2007); infrastructure improvement (modernization of roads, better sanitation, etc.); conservation of local heritage and local cultural practices (López-Sanz J.M. *et al*, 2021). All these advantages participate in preventing the depopulation of the villages, and especially the migration of the youth to the urban area. farms (Ollenburg C., Buckley R., 2007).

Tourists also benefit from agritourism, being able to enjoy various opportunities for relaxation and education: getting to know the rural lifestyle and cultural values of local communities (Barbieri C., Mshenga P.M., 2008); information on food production and safety (Sharpley R., Telfer D.J., 2002); knowledge about environmental protection, agriculture and organic food, etc. (Bello F.G. *et al*, 2017).

CONCLUSIONS

Agritourism is frequently mentioned in the available literature as a strategy for sustainable diversification. The development of sustainable agritourism is due to the action of specific factors, which must be taken into account at both the micro

and macro level. These factors that affect the sustainability of agritourism work in three directions: ecological, economic and social. Based on the specialized literature, it can be concluded that not only the factors direct related to the farm are important for sustainability (good skills and competences, environmentally friendly farming practices and methods adopted by farmers, the preservation of natural resources, good infrastructure and accessibility, family involvement, quality products and services, education and training, etc.), but also some external factors. The success of agritourism also depends on local community support and other actors in tourism: the government, through promoted policies, specific legislation and financing programs; tour operators, who can establish partnerships with agritourism guesthouses; other farmers, by establishing mutually beneficial collaborative relationships.

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CRITICAL FACTORS FOR THE SUCCESS OF THE AGRICULTURAL COOPERATIVES

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Abstract
Agricultural cooperatives face numerous challenges and changes, their existence being influenced by their ability to adapt to resource scarcity, market instability and the need for continuous development. Based on the review of the specialized literature, the present paper aims to highlight the main driving forces behind the performance of cooperatives in agriculture. The findings indicate that the success of the agricultural cooperative are dependent not only on the economic environment, but also on the social context in which the cooperative operates. Two main categories of success factors were identified: external factors, such as government policy, the marketing system, external assistance, the legal framework; and internal factors, related to managerial skills, governance and the motivation for establishing the cooperative. The degrees of importance of these critical succes factors are determined by the level of development of the cooperative system.

Key words: cooperative, agriculture, success factors, development

All over the world, the establishment of cooperatives in the agricultural sector has been caused by the specific needs of small farmers and by the strategies to reduce rural poverty, improving the social and economic development of local communities (Gundani S.R., *et al*, 2018). The various benefits generated by cooperatives (access to markets, increased bargaining power, etc.) have convinced agricultural producers that they can play a significant role in ensuring the survival and sustainability of the farm (Giagnocavo C. *et al*, 2018). But only a part of them proved to be viable and sustainable, many cooperatives having survival difficulties from the early stages (Cook M.L., Burress M.J., 2009). To be sustainable, the cooperative must have long-term economic success and be able to compete with the private sector or with other cooperatives (Rankin M.K., Russell I.W., 2012). In countries where the cooperative sector has not reached maturity, such as developing countries, cooperatives face numerous obstacles (inadequate internal governance, underdeveloped market environment, lack of a favorable legal framework or adequate regulations, etc.) endangering their existence and functioning (Shirima V., 2022).

MATERIAL AND METHOD

The present paper explores the international literature in order to be identified the key success factors of agricultural cooperatives, emphasizing the importance of the way in which the internal and external factors act on their performance. The application of the specialized literature review method allowed the evaluation of the international experience on the topic in question, various studies conducted in different geographical areas and for different types of agricultural cooperatives being analyzed. The relevant driving forces for the competitiveness of cooperatives have been grouped into main categories according to their type and mode of action. The approach is based on the hypothesis that due to their combined interventions these factors have the potential to promote the viability of agricultural cooperatives.

RESULTS AND DISCUSSIONS

The success or failure of agricultural cooperatives depends on a number of critical factors, their action being largely influenced by the level of development of the cooperative organization (Grashuis J., 2019). These factors can be financial as well as organizational and operational (Sexton R., Iskow J., 1988). According to de Veen-Dirks P. and Wijn M. (2002), the critical success factors are those that ensure the competitive performance and the achievement of the organization's objectives.

Different scholars have conducted studies in various areas of the globe to assess the elements that have the potential to contribute to the successful development of farmer cooperatives,

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identifying a wide range of factors that include: technical and external financial assistance (Garnevska E. *et al*, 2011), training on members and leaders (Fabre C. *et al*, 2020), members' involvement and commitment (Trechter D.D. *et al*, 2002; Osterberg P., Nilsson J., 2009), the cooperative's business volume (Banaszak I., 2008; Rousslièr D., Joly I., 2011) and structure (Corcoran H., Wilson D., 2010), the size and heterogeneity of the group of associates (Valentinov V.L., 2004; Cook M.L., 2018; Banaszak I, 2008), collaboration with other businesses and institutions (Alfoqahaa S., 2018), the type and quality of the product which is the object of the cooperative's activity (Markelova H. *et al*, 2009; Alfoqahaa S., 2018), organizational leadership (Emmanul O., Nhlanhla N., 2014; Alfoqahaa S., 2018), legal framework in which the cooperative operates (Garnevska E. *et al*, 2011), managerial skills (Fabre C. *et al*, 2020), transparency and trust in the relations between members and leaders (Banaszak I, 2008; Emmanul O., Nhlanhla N., 2014), marketing strategies (Trechter D.D. *et al*, 2002; Giagnocavo C. *et al*, 2018), the selection process of members and the acceptance of business with non-members, etc. (Banaszak I., 2008).

Shirima V. (2022) considered that the key factors that would determine the success of a cooperative can be classified into three categories: commitment, strategy and governance (*table 1*).

Table 1

Determinants of agricultural cooperatives' success (Shirima V., 2022)

Commitment	Members control their co-operative Members use their skills to for co-operatives benefits Members are responsible for promoting their cooperative
Governance	Leadership and government support Develop measures throughout all levels in order to get feedback Create good governance structure Transparency
Strategy	Self-evaluation/assessment Ability to live the vision of the co-operative Ability to be a strategy focused organisation Objective development

Within each main category there are sub-factors that are either internal or operate from outside the cooperative (*figure 1*). The cooperative's performance depends on its ability to keep endogenous factors under control and to adapt to changes in the external environment (Grashuis J., 2018).

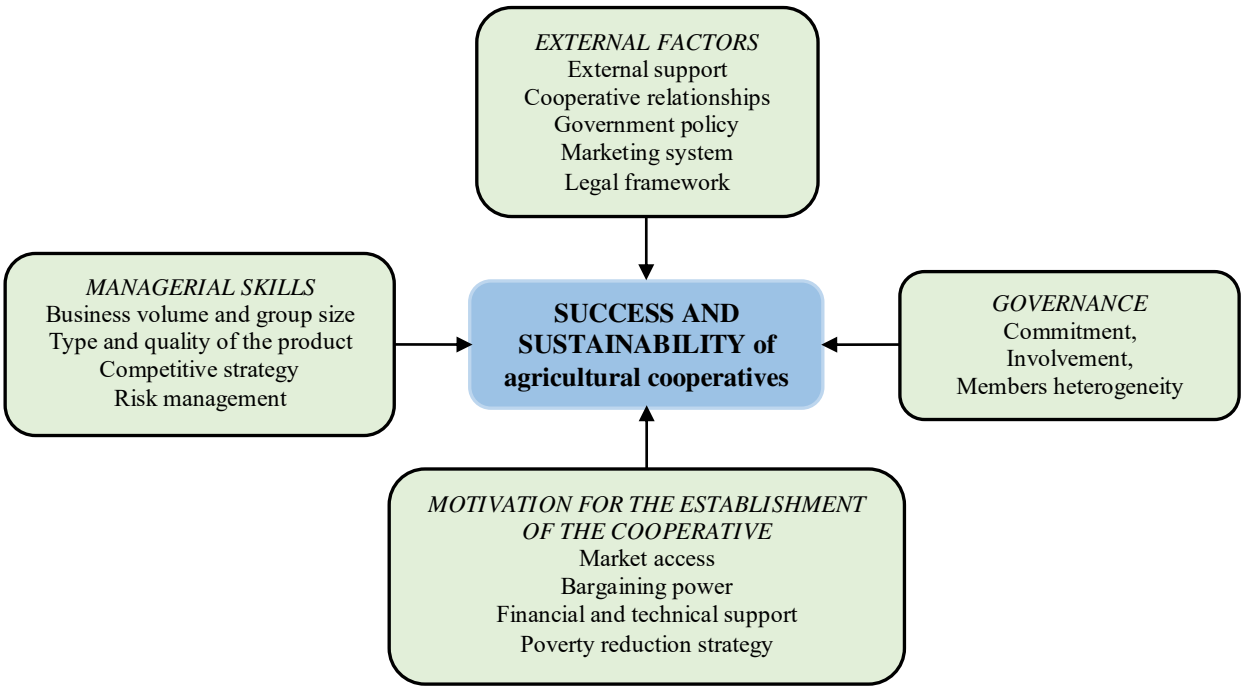

Figure 1 **The main internal and external factors affecting agricultural cooperatives' success**

*Internal factors***.** Governance, managerial skills and motivation for establishing and maintaining a cooperative are the main endogenous factors that affect its success or failure.

Cooperative governance**.** Cooperatives are commercial enterprises owned and controlled by their members and have their own governance structure, being different from corporate firms or those owned by private investors. Cooperative governance refers to the decision-making process and the ability to implement them. Decisions must represent the interests of cooperating members

group, counteracting the tendency to divide these interests (Chibanda M. *et al,* 2009). The main difficulty in managing the cooperative organization consists in harmonizing the requirements of the agricultural market with the members' interests. Cooperative boards must ensure, on the one hand, that the organization acts in accordance with the interests of its members, and, on the other hand, that it acts to improve the cooperative's performance through the adopted strategies and decisions (Cornforth C., 2004). The focus on short-term benefits and the undemocratic way of governing the cooperative generates members' distrust in the management team and discourages their investment in the cooperative. The intensity of the members' involvement and commitment in the cooperative's governance is closely related to its success (Osterberg P., Nilsson J., 2009).

• *Members' involvement* in cooperative governance is what sets the cooperative apart from other business organizations. This refers to various activities: attending meetings, working on committees, involvement in recruiting new members, etc. Farmers' dissatisfaction with the management of their organization is expressed by a decrease in loyalty to the cooperative (Emmanul O., Nhlanhla N., 2014). Active involvement in the decision-making process stimulates the cooperative members to be more devoted to the implementation actions compared to the case of imposed decisions (Osterberg P., Nilsson J., 2009).

• *Members' commitment* lies in their preference for what the cooperative offers they belong to and not by alternative organizations. Survival of the cooperative depends on their decisions to increase or decrease the volume of business with it, even going as far as withdrawing from the cooperative (Trechter D.D. *et al*, 2002). Several factors contribute to the stimulation of members' commitment, such as: benefits received from the cooperative (Osterberg P., Nilsson J., 2009), participation to cooperative governance, management's ability to translate members' needs into decisions (Fulton M., Giannakas K., 2001).

• *Members' heterogeneity* may affect the decision-making process, an excessive diversity of members' interests making it difficult for management to decide for the benefit of all (Cook M.L., Burress M.J., 2009; Valentinov V.L., 2004). This could lead to dissatisfaction and passivity among those members who feel that their needs are being neglected (Osterberg P., Nilsson J., 2009), fact that determines the decrease in the intensity of cooperation relations (Seabright P., 1997).

The cooperative management includes both the employed management staff and the board of directors and plays an important role in promoting operating policies and setting the direction of the cooperative (Fulton M., 2001), as well as in motivating members to act towards a common goal (Banaszak I., Beckmann V., 2006) In order for the cooperative to be successful, it is necessary for people in leadership roles to have business qualifications and expertise and to possess technical-economic and interpersonal skills (such as, e.g.: communication, organization, allocation of resources, etc.) (Nyoro J., Ngugi I., 2007).

The management process involves encouraging members to make the most effective decisions for (Alfoqahaa S., 2018): improving cooperation operations and alleviating external tensions or within the cooperative; obtaining consensus within the group of members; ensuring the respect of the group's decisions and their implementation.

The adoption of inappropriate decisions and policies for the members of the cooperative due to faulty management, could have negative consequences, even reaching organizational failure (Fulton M., 2001). The performance of cooperatives is affected by the lack of responsibility and transparency, uninspired financial transactions, inadequate management of resources, etc., the result being the reduction of the members' commitment and the weakening of their trust in the cooperative (Emmanul O., Nhlanhla N., 2014). A competent management must be able to ensure the transfer of information between the members and the cooperative, to mitigate the conflicts between the interests of the members and the requirements of the agricultural market and to stimulate their involvement in the cooperative's activities (Trechter D.D. *et al*, 2002). Having the necessary skills to choose the most suitable strategies regarding business volume, type of product, level of product quality and competition on the agricultural market, the management will ensure the loyalty of its members and contribute to the viability of the cooperative (Garnevska E. *et al*, 2011).

• *Business volume and group size.* To remain economically viable, cooperatives must manage large volumes of goods, thus reducing costs and achieving economies of scale. The level of the transaction cost per product unit can also be reduced by increasing the frequency of the transaction, which could be achieved by increasing the number of members (Banaszak I., 2008). A small number of members prevents cooperatives from collecting sufficient quantities of products to meet buyers' demands at adequate costs. These small quantities do not allow cooperatives to influence the market by controlling supply, leading to modest profits for farmers (Sexton R., Iskow J.,

1988). Cooperatives with a larger number of members have a higher level of social capital and more relations with the external environment achieving a better economic performance (Grashuis J., 2019). On the other hand, these cooperatives are more exposed to the increase in conflicts and the decrease of group cohesion, showing difficulties in collective actions (Valentinov V.L., 2004).

• *The type and quality of the product* that represents the cooperative object of activity has a strong impact on the business success. Selecting the type of product and the level of quality required in the market represents an essential managerial skill (Alfoqahaa S., 2018). High-value products are usually more perishable and offer higher returns, but involve more equipment and more technological and marketing know-how. On the other hand, cooperatives involved in the production of primary products (lower value) have the advantage of buying inputs in bulk and being able to store them for a longer period (Markelova H., *et al*, 2009).

• *The competitive strategies* of the agricultural cooperatives refer to their ability to orient themselves towards the market and to improve their profitability. Based on market information about competition and target customers, cooperatives can adapt to political, technological and economic changes that influence the demand for their products (Kyriakopoulos *et al*, 2004). By vertical or horizontal integration, cooperatives have more chances of success, because they achieve a reduction in transaction costs and an improvement in profitability (Giagnocavo C. *et al*, 2018), strengthening their market position vis-à-vis customers and suppliers (Trechter D.D. *et al*, 2002). At the same time, the success and sustainability of cooperatives are supported by their reputation and commercial relations established with other companies, as well as by alliances with other cooperatives (Dyer J., Singh H., 1998).

• *Risk management.* Cooperative organizations must resort to certain strategies to avoid or mitigate losses related to the risks associated with agricultural production: price volatility, drought, diseases and pests, floods, etc. (Shirima V., 2022). Depending on the costs and the effort of implementing the strategy, cooperatives can choose one or more options: attracting more members, more diverse and more geographically dispersed; diversification of the product line, in order to avoid that the income is ensured by a single gross product; participation in joint ventures and strategic alliances (Zeuli K.A., 1999).

The motivation and purpose of establishing the cooperative influences farmers' loyalty and commitment to the cooperative.

• *Market access.* Farmers show different motivations for acquiring cooperative membership: external financial support, easy access to inputs and overcoming marketing difficulties due to discriminatory treatment by intermediaries or market oligopoly or monopoly (Onumah G. *et al*, 2007). Due to the association in cooperatives, small agricultural producers gain easier access to market information, credits and technical advice, and, based on economies of scale, they manage to cope with fluctuating markets, excessive competition and high transaction costs (Clegg J., 2006).

• *The bargaining power* of farmers increases within the cooperative, both with input suppliers and with buyers of agricultural products sold through the cooperative. Thus, they obtain a competitive advantage and increased opportunities for market participation (Onumah G. *et al,* 2007), cooperative membership becoming very attractive due to economies of scale that ensure cooperatives better prices (Alfoqahaa S., 2018).

• *Poverty reduction strategy.* The organization of agricultural cooperatives does not only pursue economic but also social goals. They encourage local participation and inclusion, acting as self-help organizations (Christy R., 1987), addressing the problem of disadvantaged people in a liberalized market economy (Birchall J., 2004). In developing countries, the formation of cooperatives is a government strategy for poverty reduction and rural development, which can give small farmers the chance to increase their competitiveness and to have access to supply chains (Solomon P., 2023).

External factors. The prosperity and longevity of agricultural cooperatives is linked to their ability to face changes in government policy and consumer needs and preferences, as well as challenges of competition or those determined by economic fluctuations (Giagnocavo C. *et al*, 2018). External factors affect the competitiveness of cooperatives to a greater or lesser extent, depending on the level of development of the cooperative system of which they are a part (Grashuis J., 2018).

• *External assistance* has, in most cases, a positive effect on the sustainability and success of agricultural cooperatives, but it can also have a negative role. Agricultural cooperatives in developing countries are more exposed to the action of various external factors, needing government support, especially in the initial phase, to obtain various economic advantages (e.g.

facilitating access to markets) (Shirima V. (2022). However, the support of cooperatives by the state (political and legislative), as well as their external financing, could create a certain dependence and a certain control over the cooperative management, influencing the commitment of the members and the competitiveness of the organization (Rankin M., Russell I., 2005) In addition, external support could attract as members some opportunistic individuals who only aim to gain access to government subsidies and other facilities provided by the state, without any interest in the success of the cooperative activity. (Chibanda M. *et al*, 2009).

• *Cooperative relationships*. The successful development of the agricultural cooperative depends on the degree of cooperation not only between its members but also with various social partners (financial supporters, other cooperatives or institutions) (Ibourk A., El Aynaoui K., 2023).

• *Governmental policies.* Prioritizing consumer needs, food security and economic growth, governments may promote some policies that could be harmful to agricultural cooperatives. Lack of adequate information could make governments apply some inappropriate price policies (ceilings, high import and export taxes, control of marketing margins, etc.). This would lead to the cancellation of the benefit of competition, being rewarded inefficient operations (Timmer C, 1989), a fact that would negatively affect agricultural producers (Dorward A., *et al*, 2008).

• *Legal framework.* For the success of their development, farmers' cooperatives need an appropriate regulatory framework that punishes corruption and non-compliance with contracts (Nyoro J., Ngugi I., 2007). Otherwise, cooperatives will be vulnerable to manipulation, opportunistic behavior and fraudulent business, generating a high level of mistrust among those involved (Fafchamps M., 1996).

• *The marketing system and infrastructure* influence the functioning of agricultural cooperatives, having a high impact on farmers' commitment and, therefore, on the performance of cooperatives (Corcoran H., Wilson D., 2010). The market environment must be conducive to the involvement and competitiveness of all participants. Cooperatives have a hard time adapting to a non-transparent agricultural market, characterized by financial instability, price and income volatility due to reduced government involvement, increased competition, etc. (Sexton R., 1986. In case of market failure, agricultural cooperatives are more likely to succeed because of reduced competition (Hansmann H., 1999). However, the extent of market failure can also be an obstacle to cooperative success (Dorward, *et al*, 2008).

CONCLUSIONS

The critical success factors are those that ensure the competitive performance and the achievement of the organization's objectives. For agricultural cooperatives, achieving business success is a multifaceted process, which includes financial, organizational and operational aspects. Agricultural cooperative's performance and sustainability are linked to managerial skills, governance, motivation for establishing a cooperative (as endogenous determinans) and various exogenous factors, such as: external support, cooperative relationships, government policy, marketing system and legal framework. These determinants are interconnected and, if they act in a favorable manner, they can be the support for agricultural cooperatives' long-term success. The degrees of importance of these critical succes factors are determined by the cooperatives' age and the level of development of the cooperative system.

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LEARNING FOREIGN LANGUAGE FOR SPECIFIC PURPOSES IN TERMS OF PROFESSIONAL COMPETENCY DEVELOPMENT: PROPOSAL FOR A FRENCH TRAINING PROGRAMME FOR STUDENTS IN LIFE SCIENCES

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Abstract

Our paper is the result of twenty years of reflection and of teaching French to students in life sciences. This career path has given rise to several key concepts, namely specialized French as a teaching trend in didactics and, in training engineering, the construction of course progression, the objectives pursued and the profiling of exercises to ensure the development of learners' professional skills. The first part of our paper is of a didactic nature: it looks at the ideas that have marked the field of teaching French as a foreign language to professional audiences or those in the process of becoming professional, and also makes reference, where appropriate, to what has happened in the teaching of English. The aim of this part is not to draw up an exhaustive picture of the different methodologies, but rather to highlight the overall movement in this field of study. The second part is more practical and comes under the heading of training engineering, by proposing a specialized language teaching pathway, our point of view being, following Florence Mourlhon-Dallies' approach (*Enseigner une langue à des fins professionnelles*, 2008), that there is no one methodology that is better than another, but that it is all a question of project, audience and priority.

Key words: LSP (Language for Specific Purposes), Professional Competency Development, Proposed French Training Programme, Students in Life Sciences.

With its significant educational potential, the subject "foreign language for specific purposes" in higher education institutions contributes both to the personal development of learners and to the systematic renewal of professional knowledge, training, and development of students' communication skills. A strategy aimed at improving the content and methods of teaching language for specific purposes (LSP) involves the development of a holistic approach to problem solving based on theoretical study and experimental verification of teaching strategies (Matukhin D., Gorkaltseva E, 2015). The aim of foreign language teaching is to ensure students of non-linguistic faculties with the ability to use foreign languages in professional communication. "Therefore, being of practical usage, the study of foreign languages for special purposes aims at solving the communicative problems in students' future professional activity" (Belyaeva I.G. *et al*, 2019).

In the field of French didactics, it was around 1960 that 'scientific' reflection on the teaching of languages to adults in the process of professionalisation or in employment really began. The process of disciplinarisation of this area of language teaching was subsequently marked by a range of approaches, with labels that were often confused in practice (Holzer G., 2004).

However, it is important to identify the original contours and make conceptual demarcations, in order to show that this multiplicity of names is due to the fact that, depending on the nature of the demands and the dominant methodologies, the emphasis has been placed in turn on different training content and objectives (mastery of lexicon and grammar, reading and communication skills, professional skills, adaptation to the labour market (Mourlhon-Dallies F., 2008a).

MATERIAL AND METHOD

Our paper is the result of twenty years of reflection and of teaching French to students in life sciences. This career path has given rise to several key concepts, namely specialized French as a teaching trend in didactics and, in training engineering, the construction of course progression, the objectives pursued and the profiling of exercises to ensure the development of learners' professional skills. The first part of our paper is of a didactic nature and is based on the

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analysis of the main ideas that have marked the field of teaching French as a foreign language to professional audiences or those in the process of becoming professional, and makes reference, where appropriate, to what has happened in the teaching of English. The aim of this part is not to draw up an exhaustive picture of the different methodologies, but rather to highlight the overall movement in this field of study. The second part is more practical and comes under the heading of training engineering, by proposing a specialized language teaching programme, our point of view being, following Florence Mourlhon-Dallies' approach (*Enseigner une langue à des fins professionnelles*, 2008), that there is no one methodology that is better than another, but that it is all a question of project, audience and priority.

RESULTS AND DISCUSSIONS

1. *Main designations in use…*

Since the middle of the 20th century, approaches to teaching modern languages to adults in the process of professionalization or in employment have multiplied (hence the significant number of names created) and diversified (the multiplicity of trends reflecting distinct methodological approaches). By summarizing the main trends and their characteristics, we retain the highlights of the teaching of French for practical and professional purposes:

- 60s-70s

French as a specialized language (including scientific and technical)
Public: Scientific public
Methodology: Structuro-Global Audio-Visual (SGAV); 3-level teaching model: L1: basics of everyday language; L2: common scientific core VGOS (Vocabulaire Général d'Orientation Scientifique); L3: further training by discipline, based on a lexical inventory (VGOM - Vocabulaire Général d'Orientation Médicale, VIEA - Vocabulaire d'Initiation aux Etudes Agronomiques, etc.)
Functional French
Public: French government scholarship holders
Methodology: functional and communicative approach; considering the diversity of the audience and their needs; determination of content according to objectives; identification of communication situations and speech acts.

- 70s

Instrumental French
Public: (Latin America) Students; Researchers;
Methodology: French language as a tool for accessing written scientific and technical documentation.

- 80s

Functional French
Public: Professionals; Students; Researchers
Methodology: emergence of pragmatic linguistics; communicative approach (defining content according to communication situations); focus on the learner; emphasis on the use of authentic documents

- Since 1990

French for Specific Purposes
Specialized French
Public: Professionals; Students; Researchers
Methodology: communicative approach; learner-centred; linguistic feedback; discourse analysis; action-oriented approach task-based, project-based pedagogy); evaluation of communicative competence.
Professional French
Methodology: focused on professional practice.

2. *Specialized French/ French for Specific Purposes*

The multiplicity of names and the characteristics briefly presented show that, depending on the nature of the requests and the dominant methodologies, the emphasis has been placed in turn on different training contents and objectives (mastery of vocabulary, grammar, ability to read, to communicate, specialization and professional skills, adaptation to the labour market) (Mourlhon-Dallies, 2008). It is therefore necessary to go into more detail on the two dominations that particularly interest us for our study, namely specialized French, and French for specific purposes, and to identify their particular and common characteristics (*apud* Mangiante J.-M., Parpette, C., 2004; Carras *et al*, 2007; Mourlhon-Dallies, F., 2008a).

Specialized French is characterised by: a supply-side approach that anticipates, as it were, the future and potential needs of learners; a global approach to a discipline or professional branch; attempts to reflect the diversity of the field covered; broad audience; a set of resources and teaching approaches centred on (specialist) areas from which teachers draw to develop their lessons; the content of the programme, the supporting documents and the type of assessment are determined by the institution and the teacher, within the limits of the specialist area concerned; spread over time (medium- or long-term training).

French for specific purposes' characteristics are: training on demand; works on a case-by-case basis; well-defined segment; precise audience; tailor-made training engineering; intensive course (short-term training).

Both methodologies have in common: the new content not yet mastered by the teacher (the teacher's job is, in our opinion, an *ars combinatoria*).

From the above descriptions we can draw some halfway conclusions:

- ✓ The development from the middle of the twentieth century to the first decades of the twenty-first is that of teaching which has gradually moved away from strictly linguistic concerns in an attempt to link linguistics to its exteriors (socio-cultural, economic, cognitive, professional).
- ✓ The movement in didactics is parallel to that in discourse analysis and other language sciences: that of a certain interdisciplinarity coupled with 'praxeological' concerns (Mourlhon-Dallies, 2008a).
- ✓ We should not think that the approaches that preceded professional French are now outdated, nor should we believe that each new designation in our table cancels out the previous one.
- ✓ Depending on the teaching context, each approach has its own legitimacy and responds to its own concerns, in an extremely diverse field of teaching.
- ✓ It therefore appears that a certain know-how exists in terms of designing resources and training programs adapted to audiences in the process of professionalization; these resources, the result of an approach which aims to introduce students to professional discourse, to acquire specialized terminology and to know how to adapt to the requirements of their daily practice, also concern the acquisition of transversal language skills common to specialized disciplines (Velescu, Mihalache, 2023).

3. *French for Specific/Special Purposes (FSP) and English for Specific/Special Purposes (ESP)*

Although it is customary to equate the FSP and the ESP, it is nevertheless revealing to consider the notion of public and the way it is understood and categorized (we are here taking up the clarification of Mourlhon-Dallies F., 2008a). Thus, the ESP makes a clear distinction between academic audiences (English for Academic Purposes, EAP) and professional audiences (English for Occupational Purposes, EOP). The distinction between academic and professional is not without impact on the very notion of objective: for the latter, it is possible to determine the needs in terms of communication, skills, tasks, while for the former, students with still nascent trajectories, the objectives are broader (Mourlhon-Dallies F., 2008a) and the teacher of this type of learner quite often does the work of clearing the way and must make demarcations himself.

Specialized French can be seen as an institutionalisation of demand for French for Specific Purposes: it is because requests for training have been made for specific professional audiences that the training provision for these audiences has developed and diversified. (Carras C. *et al,* 2007).

Thus, we can see the similarity between academic audiences (in EAP = English for Academic Purposes) and those in specialized French.

Going through the ESP has the advantage of drawing on a reality of higher education, namely the degree of professionalisation of the learner population; in the early years of their course, students are 'professional apprentices', thanks to the specialist subjects; with the practical placements, they take their first steps in the field and find themselves in an in-between situation (Mourlhon-Dallies F., 2008b).

4. *Task-based teaching and specific groups of learners*

The chapter 2 of the Common European Framework of Reference for Languages (CEFR) introduces the action-oriented approach by postulating that the language user is a social actor who accomplishes tasks in given circumstances within a particular domain (personal, public, educational, professional). The task is therefore defined as any action aim that the author represents as having to achieve a given result in relation to a problem to be solved, an obligation to be fulfilled, a goal that has been set. Not all tasks are purely linguistic. They often form part of a scenario/project that enables them to be linked and articulated. The French action-oriented approach emphasises concrete projects, often carried out in groups and with a strong focus on production.

"The action-oriented approach [...] makes perfect sense with a professional audience. [...] For this type of learners, the tasks, which are directly linked to the objectives and therefore to the needs, are very real and are at the heart of the training" (Carras C. *et al*, 2007).

In specialized language teaching, the task focuses on the production of oral and/or written discourse in line with current professional discourse. Several model texts or recordings are provided for this purpose; learners are encouraged to work with many authentic documents and to consult resources on the Internet, as is done, for example, in *Rond-Point* method; this method for teaching 'general' French can be used for specialized French in many respects, particularly in unit 8 of book 1.

5. *Proposed French training pathways for the professionalisation of learners in life sciences*

5.1. General French methods for teaching specialized French

The preceding considerations on the approaches manifested in the teaching of professional languages and on the place of the task in recent methodologies allow us to say that given our context of teaching French as a foreign language, it is appropriate to take into account the fairly wide range of training objectives for our student public in the proposal of the present training course aimed at the development of professional skills in specialized French.

The Forword of "Nouveau Rond-Point 1" method underlines the idea of resuming the strong points of the first "Rond-Point", which introduced the action-based approach to French as a Foreign Language, with the didactic unit based on carrying out a task. The NRP 1 has undergone a thorough reworking of the units and involves the learner working in greater depth on lexis and grammar. Interaction and negotiation remain key concepts if students are to acquire the skills set out in the CEFR effectively. Unit 8 of Livre de l'élève 1: « À chacun son métier » states as final task: "We are going to select candidates for three jobs and choose one job for ourselves". The unit's characteristics are:

- textual typology: classified ads, biographical data (website), playing cards, tests, job offers, professional profiles.

- communication and skills: talking about your life; evaluating your skills and competences; expressing and comparing your opinions; situating a fact in the past.

- grammatical skills: the compound past tense; the past participle; the place of adverbs; temporal expressions: during, there is, already ...

-lexical skills: professions; qualities; to know and to know well.

- (inter)cultural skills: Meilleurs mains de France; crafts.

The exercise 1, *Pour être pompier...* asks learner to match professions and the qualities they require with pictures of people. Thanks to this activity, students will considerably extend their lexicon of professions, on the one hand, and discover many adjectives describing qualities, on the other.

With the exercise 2, *Votre métier*, every student must explain to the others the choice (present or future) of a profession. This oral production activity will enable learners to acquire the vocabulary of professions and qualities worked on in the previous activity. They will also have to think about their own choice of profession and their own qualities. Approach: To make the link with activity 1 and refresh the vocabulary, the teacher asks students to write down - individually and for themselves - three of their essential qualities. Then she/he asks them to write down the profession they could practise. In turn they say why they dream of doing it by reading out the three qualities they wrote down and explaining whether or not, on reflection, these qualities correspond to their choice of profession. The rest of the class can react afterwards. Going further: The teacher asks his students to choose someone they know or someone in public life, to recall the person's profession and to explain orally whether, in their opinion, he or she has the qualities required for the job.

The exercise 3, *Avantages et inconvénients* ask learners to explain the representation, positive or negative, that people have of various professions.

In the Guide pédagogique (Teaching guide), the authors propose three steps, as it follows:

"A. Ask your students to think individually about the qualities and faults they see in the professions listed in this activity and to fill in the table on this page accordingly.

B. Then ask them to group together to see if they share the same representation of the different professions.

C. If your students are not yet practising a profession, ask them whether or not they still have their dream after this exchange of opinions and why. This opinion can be expressed either orally or in a short text. This is the equivalent of the production in activity 2 (I am/want to be... because I have such and such a quality): I am/want to be... because this profession...

Going further: To reuse the new vocabulary seen in activities 1 and 3, you can play *Qui suis-je*?"

5.2. The contribution of multimedia to the specialized language competency development

The teachers of languages for specific purposes can find a wide range of documentation on the Internet that is often reliable (if they check the sources carefully) and always up to date. On the other hand, multimedia is probably most productive for the learner. Therefore, multimedia offers the possibility of differentiated teaching and greater learner autonomy. Used for language teaching purposes, the multimedia tool, makes active, interactive, differentiated teaching possible.

We successfully use with our students in life sciences faculties the ONISEP educational kit and the onisep.fr website (Office National d'Information Sur les Enseignements et les Professions)
(https://www.onisep.fr/metier/decouvrir-le-monde-

professionnel/agriculture) and we usually start by the discovery Quiz « Que savez-vous de l'agriculture ? » (The challenges facing agriculture today are to feed a growing population, meet quality standards and protect the environment. But do you know who the professionals involved are? Do you know the characteristics of agriculture in France? Test your knowledge of this key sector of the economy).

We continue with the educational worksheet « Portraits de professionnels. Qui est-ce? Un jeu pour reconstituer des portraits de professionnels »:

- aims: put together portraits of professionals to find out more about farming.

- content: find out about different jobs and learn more about them.

Students can work alone or in groups and then compare their answers. The exercises on the worksheet can be extended through Qui est-ce? (Who's who?), a game to reconstruct portraits of professionals.

The aim is first to identify the job and then to guess which job these sentences correspond to and thus reconstruct the portrait of each of these three professionals. The teacher can draw up a table to give them a more general idea of the activities, working conditions, qualities needed, advantages and constraints and, finally, the training required to practise the job.

The second activity aims to put together portraits of professionals using several sources of information. The learners must acquire data, organise and process it, make choices, coherent, problematic and argumentative statements in order to fill out two worksheets: Métiers de la recherche (Research careers) and Métiers de la production animale (Careers in animal production).

Content: discover careers and learn more about them.

Students can work alone or in groups and then compare their answers.

Materials and resources: Testimonials from professionals to get the activity started.

At this point in the training course, it would be interesting to discuss two documents with the learners: the Europass Curriculum vitae and the Cover letter. We can start with three exercises from Nouveau Rond-Point 1: « Petites annonces » (Matching a jobseeker profile to a suitable job offer), « Leur vie professionnelle » and « Le CV de Sophie ».

In the second stage, the students create their own CV and Cover letter using the Europass platform (https://europass.europa.eu/fr).

5.3. Assessment

5.3.1. Analysis of the existing situation in assessment

For language for specific purposes university-based training, assessment is an integral part of the training. Internal summative assessment is the sanction for this type of training. As a result, learners focus their efforts on passing an exam rather than acquiring skills.

More generally, it should be pointed out that the evaluation of these courses in an institutional environment does not always go hand in hand with the action-based approach used in the courses. However, if learners are placed in professional situations, it is important to include this type of activity in the assessment, whereas the examinations offered are often limited to a very traditional assessment, in the form of language skills.

5.3.2. Assessment of dual competence (proposal)

Teaching a specialized language raises the question of dual competence: linguistic competence on the one hand, and professional competence on the other (scientific knowledge and cultural competence). Dual assessment would be one solution, but this may be difficult to put in place, including for material and economic reasons. Assessment could be based on real-life situations, such as work placements (for example, the teaching units created by the authors of the manual « Communiquer en FOS » using authentic documents collected and the experience of scholarship students from the Agence Universitaire de la Francophonie). If practical application is out of the question, simulation may be an interesting means of assessment.

We use for the assessment of our students in life sciences faculties the video questionnaire: « Fiche métier », from the onisep.fr website; in this questionnaire, each student chooses a profession from the video file and fills in the questionnaire.

Another assessment activity is that one we call « Affiche du métier »: "You work in a company in the sector and, at a fair dedicated to agricultural careers and aimed at young people, you are invited to present your profession in the form of a poster, with the following content: places where you work; representative activities; qualities required; advantages and disadvantages of the profession. Draw up the poster and present it to your colleagues."

Resulting from a functional language teaching approach, « Le français de l'entreprise » by Michel Danilo and Béatrice Tauzin is part of the series of works which mark a renewed interest in the specialized field. The Forword signed by Jacques Cartier bears witness to this methodology: 'Its well-structured presentation, its division into different sections, each of which is presented as a

genuine technical dossier, and its pedagogical approach, which takes as its starting point the 'really' authentic reality, make this a solid work that is particularly well adapted to professional situations in the French-speaking world' (Danilo, M., Tauzin, B., 1990).

The Unit 4 - Découvrir l'entreprise (Discovering the company), with sub-chapters titled : Définir l'entreprise (Defining the company) ; Caractériser les entreprises (Characterising companies); Présenter l'organisation de l'entreprise (Presenting the organisation of a company); Analyser l'organisation (Analysing the organisation); Présenter les différentes formes juridiques des entreprises (Presenting the different legal forms of companies) allow us to give students the team project of the presentation of a company in their training field, with the following contents: Name; Logo; Slogan; Characteristics; Products/Services; Justification of choice of the company; Webography.

Then, we work on the Unit 5 – Entreprendre (Entrepreneurship), with sub-chapters: Créer, oui ou non? (To create, yes or no?), Avoir le bon profil (Having the right profile), Avoir une idée (Having an idea), Se mettre à son compte (Setting up your own business), Implanter une entreprise (Setting up a business), and the students must create their own business project (Mon projet d'entreprise) for the assessment (starting from exercise 1 page 48).

CONCLUSIONS

The training course that we have proposed has the advantage of using resources drawn from different approaches of teaching specialized languages and it is precisely this aspect that makes the work of the teacher who has before him an audience of students in the process of professionalization; consequently, a documentary like "We feed the world: le marché de la faim" (director Erwin Wagenhofer), which is interested in the modes of production and their consequences on global balances, showing rural people and industrialists, or films such as « Jean de Florette » (1986), based on the work of Marcel Pagnol (the reference to literature is not to be excluded in the teaching of specialized languages), the comedy « Je vous trouve très beau » (2005) with the Romanian Medeea Marinescu or the drama « Au nom de la terre » (2019), a great critical and public success, to name just a few. All resources are useful, if the language teacher combines them in a coherent approach that takes into account the audience, its objectives and its needs.

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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON FOOD CONSUMPTION BEHAVIOR IN E-COMMERCE

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Abstract

Artificial intelligence (AI) has rapidly emerged as a transformative force across multiple sectors, with digital marketing being a prominent beneficiary. As AI technologies continue to advance, their potential to reshape the digital marketing landscape is becoming increasingly apparent, leading to profound implications for businesses and their digital communication strategies. AI in Consumer Behavior Analysis: AI algorithms can analyze vast amounts of data from various sources to understand consumer behavior patterns. This allows marketers to create more targeted and personalized campaigns, ensuring that the right message reaches the right audience at the right time. AI-powered tools can automate repetitive tasks such as email marketing, social media posting, and even customer service through catboats. This not only saves time but also ensures consistency and efficiency in marketing efforts. By using predictive analytics, AI can forecast future trends and consumer behaviors, allowing businesses to adjust their strategies proactively. This can lead to more effective marketing campaigns and better allocation of resources. AI can generate and optimize content for various platforms, ensuring that it is engaging and relevant to the target audience. Tools like natural language processing and machine learning can help create high-quality content that resonates with consumers.

Key words: Artificial intelligence, AI, Digital marketing, E-commerce, Food industry

This paper is structured in three parts. Thus, in the first part, the review of the specialized literature relevant to the research carried out is presented, focusing on the use of AI in the field of commerce. In the second section, the methodology used to conduct the research is detailed, stating the purpose and objectives. The third part reflects the research results, which show the main purposes of AI mobile applications in e-commerce.

Artificial intelligence personalizes and improves the shopping experience for users, while for merchants, it is a means of increasing sales and improving customer relations. It has become an essential component of how many consumers interact with digital platforms. Artificial intelligence has emerged as a technology that can differentiate between two competing firms in e-commerce environments (Bawack R.E., 2022), a decisive factor for the success of a company using e-commerce in front of the competition.

By using AI (artificial intelligence), a company can improve customer experience, optimize business processes and make more informed decisions, which can provide a competitive advantage over other firms in the same field.

MATERIAL AND METHOD

Artificial intelligence enables the collection, analysis and interpretation of a vast amount of data in real time, thus facilitating informed decision-making. As an entrepreneur or manager, using AI systems can help anticipate demand for products or services, assess risks and opportunities, and identify emerging trends in the market segment.

In Romania, the e-commerce market made its presence felt starting in 2000 and began to really develop with Romania's entry into the European Union, when infrastructure investments began through access to European funds.

RESULTS AND DISCUSSIONS

In the period 2015-2023, Romania's population registered a slight decrease, from 19.8 million to 19.0 million inhabitants. In contrast, the number of internet users has increased significantly, from 11 million in 2015 to 14 million in 2023. This increase in internet users is also reflected in the internet usage rate, which has increased from 56% in 2015 to 82% in 2023.

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These data indicate a substantial increase in the accessibility and use of the internet among the population. The application of AI in the food industry has been growing for years due to various reasons such as food sorting, classification and prediction of the parameters, quality control, and food safety. (Mavani, *et al*, 2022).

The total value of electronic commerce (e-tail) increased from €1.4 billion in 2015 to €6.5 billion in 2023. This growth reflects the rapid expansion of the e-commerce market in Romania. The average value of online purchases per day increased from €3.8 million in 2015 to €17.8 million in 2023, indicating a higher frequency and value of online transactions. Also, the average number of transactions per day increased from 8.2 million in 2015 to 11.5 million in 2023 (Micu A. *et al*, 2020).

Table 1

Electronic commerce issues

Electronic commerce issues	2015	2016	2017	2018	2019	2020	2021	2022	2023
Romania's population (millions of people)	19.8	19.7	19.6	19.5	19.4	19.3	19.2	19.1	19.0
Internet users (millions of people)	11	11.2	11.2	11.7	12.0	12.5	13.0	13.5	14.0
Internet penetration rate (%)	56	58	58	70	72	75	78	80	82
Smartphone penetration	31.6	38.8	46	52.5	58	63	68	72	75
Orders placed online from mobile devices (%)	25-30	35-40	45	54	60	65	70	75	78
The value of online shopping (e-tail) (billion €)	1.4	1.8	2.8	3.5	4.2	5.0	5.8	6.3	6.5
Average value of online shopping / day (million €)	3.8	4.9	7.6	9.8	11.5	13.7	15.9	17.3	17.8
Average number of transactions / days	8.2	8.4	8.7	9	9.5	10	10.5	11	11.5
Online payment by card (million €)	514	745	980	1300	1600	1900	2200	2500	2800

Source: Data processed by authors based on reports available on www.gpec.ro and www.statista.com

The presence of artificial intelligence has intensified competition in the field of e-commerce, prompting companies to adopt this technology to stay at the top of customer preferences. A deep understanding of artificial intelligence offers a significant advantage to the e-commerce industry, as it enables a more detailed knowledge of consumer behavior. Through a clear analysis of buying behavior, companies can develop optimal strategies that align their goals with customer needs and preferences.

Eating behavior is influenced by various neural pathways and psychological factors. In the field of AI and consumer behavior, it is essential that companies find a balance between harnessing the capabilities of AI and ensuring transparency and ethical use of data. Building trust with consumers through clear communication about the benefits and limitations of AI is critical to driving acceptance and adoption.

Based on a comprehensive study of the scientific literature on the impact of artificial intelligence in food trade, the authors conducted a quantitative research to demonstrate the nature of the link between this impact and consumer perceptions of artificial intelligence (Purcărea T., 2020).

There are numerous benefits that derive from the use of artificial intelligence in e-commerce (*figure 1*). These include:

Improving the customer experience: Artificial intelligence can personalize the shopping experience for each individual customer. By analyzing browsing behavior and purchase history, AI can recommend relevant products and personalized offers, leading to increased customer satisfaction and loyalty.

Predictive market analysis: AI can analyze sales data and market trends to predict future demand. This helps companies manage their inventory more efficiently, plan marketing campaigns and make informed decisions about new product launches.

Facilitation of decision-making: By using machine learning algorithms, AI can provide valuable insights and detailed analysis that help managers make faster and more accurate decisions. For example, AI can identify growth opportunities or flag potential risks.

Streamlining the sales process: AI can automate many of the repetitive tasks in the sales process, such as managing orders, updating inventory and processing payments. This allows sales teams to focus on more strategic activities and improve operational efficiency.

Automation and optimization of the data transcription process: AI can automate the data collection and analysis process, thereby reducing human error and saving time. For example, speech recognition and natural language processing technologies can quickly and accurately transform phone conversations or text messages into structured data.

Therefore, for a leading agriculture in Romania, the integration of AI in agricultural operations represents a transformative leap in the exploitation of the latest technologies that can provide invaluable support to farmers, in addition to innovative crop protection solutions and advanced hybrids. Technology facilitates decision-making processes that exceed human capabilities in terms of speed, accuracy, analysis and multitasking (Cheong Y.S., 2021).

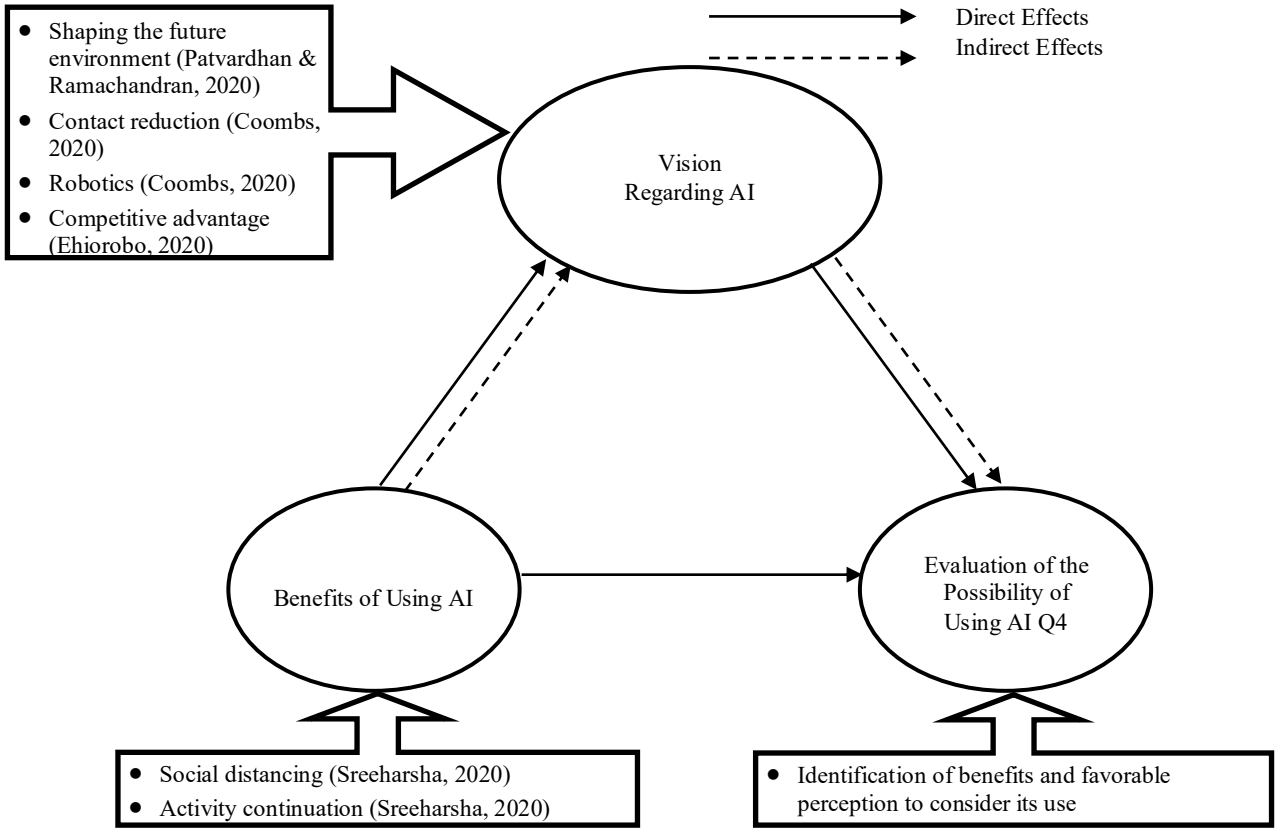

Figure 1 **Conceptual model and hypotheses to be tested with SmartPLS 3**

Artificial intelligence has become a predictive tool in the optimization of online stores, transforming the buying experience of users and improving the efficiency of merchant operations. From personalizing the shopping experience to managing online payments and transaction security, AI is deeply influencing every aspect of e-commerce.

Based on the results obtained from the administered questionnaire, the majority of respondents are male (52%), while 47% of participants are female. The age distribution analysis shows that 28% of respondents are aged between 25 and 34 years, representing the largest age category. The next age group, 35-44 years old, includes 21% of participants. Respondents aged between 45 and 54 years constitute 18% of the total, while those aged between 55 and 64 years represent 10% of the group. The age group over 65 years has a percentage of 5%.

This demographic distribution provides insight into the diversity of the studied group and allows for a detailed analysis of trends and preferences among different age and gender categories.

The analysis of respondents' monthly incomes shows that those with incomes between 2500 and 5000 lei represent the largest share, at 34%. Next are respondents with monthly incomes between 5000 and 7000 lei, which constitute 29% of the total.

This income distribution provides a valuable perspective on the economic situation of the participants and can contribute to a deeper understanding of their behavior and preferences.

Regarding the question in the survey about the frequency of purchasing food products online,

the answers were distributed as follows: 50% of respondents indicated that they occasionally purchase food products online, 18% of respondents make these purchases weekly, 13% never buy food products online, 11% purchase monthly and 8% of respondents make these purchases daily. These results suggest a predominantly occasional behavior in the purchase of food products online among respondents.

Additionally, there is a significant diversification in purchase frequency, reflecting various consumption habits in the digital environment.

From the survey, we identified the main reasons why consumers choose to purchase food products online:

- **Convenience**: 48.4% of respondents mentioned convenience as the main reason for preferring online shopping. This method allows them to avoid crowds and shop from the comfort of their own home.
- **Time savings:** A major factor for 62.1% of participants is time savings. Online shopping is quick and efficient, eliminating the need for frequent trips to the supermarket.
- **Wide variety of products:** 37.9% of respondents appreciate the greater diversity of products available online compared to physical stores. This gives them the option to choose from a wide range of products.
- **Better prices:** 27.4% of participants highlighted better prices as a determining factor in their decision to buy online. Promotions and discounts are more frequent in the online environment.
- **Personalized recommendations:** 23.2% of respondents indicated that personalized recommendations, based on purchase history and individual preferences, are a significant reason for choosing online shopping.

From the survey administered, we obtained the following results: 39.4% of respondents are not familiar with the use of artificial intelligence (AI) in e-commerce, while 60.6% of respondents are familiar with this concept.

These results highlight a clear need for additional education and information in the field of AI for e-commerce. On one hand, the majorities of respondents (60.6%) recognizes and understand the potential of AI in this sector, suggesting that AI-based technologies have already started to make their presence felt in e-commerce. On the other hand, a significant percentage (39.4%) is not yet familiar with these technologies, indicating a potential barrier to the widespread adoption of AI in e-commerce.

From the survey, we observed the following results regarding the influence of AI:

- **Moderately:** 32% of participants believe that artificial intelligence moderately improves their online experience. They appreciate that AI brings benefits in navigating and using digital platforms.
- **Significantly:** 26% of respondents think that AI significantly influences their online experience, making it more efficient and enjoyable.
- **Very significantly:** 18% of participants appreciate that AI greatly improves their online experience, highlighting the clear advantages of using AI-based technologies.
- **Slightly:** 14% of respondents consider that AI only slightly improves their online experience, being less convinced of its benefits.
- **Not at all:** 10% of participants do not feel any improvement in their online experience due to AI, suggesting either insufficient interaction with AI technologies or that they do not find them useful.

These data underscore the diversity of perceptions regarding the impact of artificial intelligence on users' online experience. They reflect both the enthusiasm and reservations about adopting and using AI in everyday life.

Following the survey of 100 respondents, it was found that 78.8% of respondents answered affirmatively, indicating that they had observed personalized food product recommendations on the e-commerce platforms they used. This significant majority suggests that personalization technologies are widely implemented and recognized by users. On the other hand, 21.2% of respondents answered negatively, indicating that either they had not encountered these recommendations, or they were not sufficiently noticeable to be observed.

According to the survey data, 36.5% of respondents consider the recommendations useful, 31.3% find them neutral, 17.7% appreciate them as very useful and 8.3% consider them useless. These results highlight the diverse perceptions of users regarding personalized recommendations offered on e-commerce platforms. The majority of respondents (36.5%) find these recommendations useful, indicating a recognition of the added value that personalization can bring to the purchasing process. Meanwhile, a significant percentage of users (31.3%) have a neutral opinion, suggesting that while they are not disappointed with the recommendations, they also do not consider them essential to their shopping experience.

On the other hand, 17.7% of respondents consider the recommendations very useful, highlighting a segment of users who benefit

significantly from these technologies. However, there is also a minority of 8.3% who do not find these recommendations useful, suggesting that there is room for improvement in terms of the relevance and precision of these recommendations.

According to the data obtained from question 11: "To what extent do personalized recommendations influence your purchasing decisions?" conducted using the Likert scale; option 3, having a neutral value, was the most chosen by respondents, with 36% of them selecting this option. In the scale, 1 represents "not at all" and 5 "very much".

These results indicate that, while personalized recommendations have an influence on purchasing decisions, this influence is moderate for the majority of respondents. Option 3, chosen by 36% of participants, suggests that recommendations are perceived as useful and relevant, but not decisive in the purchasing process. These findings underscore the importance of improving personalization algorithms to offer more precise and tailored recommendations to consumers' individual needs. Improving these aspects could increase the positive influence of recommendations on purchasing behavior. (*Ziakis, C., 2023*).

According to the data obtained from question 12 related to concerns about the privacy of personal data when using e-commerce platforms that use artificial intelligence, 50.5% of respondents are not at all concerned about the privacy of their personal data when using these. In contrast, 49.5% of respondents are very concerned about this aspect.

These results reflect an almost equal division in users' perceptions of the security and privacy of personal data on e-commerce platforms that use AI. The half that is not concerned suggests significant confidence in the data protection measures implemented by these platforms. On the other hand, almost half of respondents express considerable concern, highlighting the need to improve transparency and education regarding data privacy and security policies.

In conclusion, these results underscore the importance of continuing efforts to protect users' personal data and effectively communicate implemented security measures. Increasing transparency and educating users about privacy policies could help reduce concerns and strengthen trust in e-commerce platforms that use AI.

According to the data obtained from question 13 of the survey, 72.7% of respondents answered affirmatively, indicating that they had observed personalized recommendations based on their purchase history. At the same time, 15.2% of respondents are not sure and 12.1% answered negatively, suggesting that they had not observed such recommendations.

These results indicate a high prevalence of implementation and recognition of personalization technologies based on purchase history in e-commerce platforms. The majority of respondents who answered affirmatively suggest that these personalized recommendations are a significant aspect of their shopping experience. On the other hand, the relatively small percentage of respondents who are unsure or who had not observed these recommendations indicates that there is still room for improvement in the visibility and relevance of these technologies.

According to the survey data, out of a total of 100 respondents, 61.2% are influenced by reviews from other consumers. Promotions and discounts have a similar impact, influencing 61.2% of respondents. Personalized recommendations influence 36.7% of participants, while new launches and products have an influence percentage of 31.6%.

These results highlight that consumer reviews and promotions are the most important factors influencing consumers' purchasing decisions when it comes to online food products. Personalized recommendations and new products, although important, have a lesser impact compared to the first two aspects mentioned.

In conclusion, e-commerce platforms should place special emphasis on user reviews and offering attractive promotions to maximize their influence on consumer purchasing behavior. At the same time, improving personalized recommendation systems and promoting new launches can contribute to a more complete and satisfying shopping experience.

The data collected from the last question of the survey, applied to 100 respondents, highlights their perceptions of using artificial intelligence in e-commerce. Participants had to choose numerical responses, from "strongly agree" to "strongly disagree", to express their agreement with various statements.

For the statement "AI-based personalized recommendations influence my purchasing decisions", 33% of respondents selected "agree", while only 4% selected "strongly disagree". These results suggest that personalized recommendations have a significant impact on the purchasing decisions of an important part of users, though there is also a segment that does not consider these recommendations relevant.

Regarding the statement "Chatbots and virtual assistants improve my online shopping experience," 29% of respondents answered

"neutral," indicating a neutral perception of these technologies. Additionally, 9% of respondents selected "strongly disagree." However, 34% of respondents agreed with this statement, highlighting relatively strong support for the role of chatbots and virtual assistants in improving the shopping experience.

The last statement, "I am concerned about the privacy of my personal data used by AI," showed that most respondents (27%) selected "strongly agree," demonstrating considerable concern for the privacy of personal data. In contrast, 10% of respondents selected "strongly disagree," indicating a lack of concern in this regard.

These results suggest that, although there is significant support for the use of artificial intelligence in e-commerce, privacy concerns are predominant. To enhance trust and acceptance of AI in e-commerce, it is essential to address these concerns by ensuring appropriate transparency and protection of users' personal data.

CONCLUSIONS

In conclusion, artificial intelligence (AI) provides a crucial competitive advantage in e-commerce, personalizing and enhancing the shopping experience for users and contributing to increased sales and optimized merchant-client relationships. Companies that adopt AI manage to optimize their operations and make more informed decisions, significantly differentiating themselves from the competition.

Applications and platforms such as Truda, DataFeedWatch, Channable, Feedonomics, Productsup, Shopify, BigCommerce, PrestaShop, Magento and WooCommerce offer advanced solutions for managing and optimizing product data, improving operational efficiency and marketing campaign performance.

The study highlights that AI personalizes the shopping experience and facilitates decision-making, allowing entrepreneurs to anticipate demand, assess risks and identify emerging trends. The questionnaire reveals that most consumers prefer online shopping due to convenience, time savings, diversity of available products, better prices and personalized recommendations. These consumer behaviors are influenced by demographic and economic factors.

Transparency and ethics in the use of AI algorithms are crucial for building consumer trust. Companies must clearly communicate the benefits and limitations of AI, ensuring responsible data use and strengthening trust in digital platforms.

The survey data shows the diversity of perceptions related to AI in e-commerce. The majority of respondents are familiar with AI use, and perceptions of its influence vary: 32% consider that AI moderately improves the online experience, 18% believe that AI has a very significant impact, while 10% do not observe any improvement. Additionally, most of the 100 respondents have noticed personalized recommendations and an insignificant number are concerned about personal data privacy.

Consumer reviews and promotions are the main factors influencing purchasing decisions, mentioned by more than half of the respondents. These conclusions underscore the need to optimize AI technologies and educate consumers to maximize benefits and ensure responsible data use.

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A DIACHRONIC VIEW ON MEAT ADVERTISING – THE CASE OF SISSI PRODUCTS FROM CAROLI FOODS GROUP

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Abstract

Advertising plays a significant role in raising consumers' awareness regarding the emergence and existence of products on the market. Meat advertising may set various reception trends nowadays due to a constant emphasis on adopting sustainable farming and consuming practices. The present study focuses on a diachronic analysis of the commercials for Sissi products from Caroli Foods Group covering the time span between 2016 and 2024. Special attention has been given to the semiotic and rhetoric elements and their fluctuations over time due to the shortening span allotted for commercials as well as to the intended effect on the prospective consumers. The conclusion is that despite the changes in the amount of information delivered by the commercials, there is a constant unwavering focus on the quality of the products which boast a very strict nutritional standard and cater for the needs of the most sophisticated consumers who may favour a certain cultural and social input.

Key words: meat advertising, meat commercials, diachronic analysis, semiotic elements, rhetoric devices

Advertising is a key component of marketing since it is the means by which knowledge of a product, its qualities and benefits, reaches the potential consumers. The rate of responding to advertising depends on the skills of the advertisers to use all the linguistic and artistic elements that may converge to the same aim – that of persuading. Diachronically, the language used in advertising is reflective of the social and cultural trends at a certain point in time as well as the audience's capacity to favourably and accurately process the linguistic input: "It is important to note that the language of advertising is a source that reflects the lexical means available in the national language, shows the scale of the social meaning of the language, and determines the ways of its development. […] Undoubtedly, the clarity and comprehensibility of the elements of simple, fluent, coherent language, which exist within the language of advertising, testify to the importance of its place in social relations." (Shirinboyevna M. D., 2020)

The present study focuses on a diachronic analysis of the commercials for Sissi products from Caroli Foods Group covering the time span between 2016 and 2024 and streamed on YouTube since one can get a better grasp of the number of views online as well as the number of likes accumulated which may be telling regarding the enthusiastic reception of the commercial by the consumers. Special attention has been given to the semiotic elements and rhetoric devices and their fluctuations over time due to the shortening span allotted for commercials in general, as well as to the intended effect on the prospective consumers.

The emergence of meat products on the market is always accompanied by an element of surprise. In the case of Sissi products from Caroli Foods Group the name itself – 'Sissi' – surprises, being familiar to only a certain category of consumers. The fame of Empress Elisabeth of Austria may have been augmented due to the various film adaptations. Her image on various products is either the one captured by various artists of her time or one that resembles her and sends the viewers on a path of recollecting all memories they might have of the qualities of this historical figure. The commercials analysed tend to adapt the features of the female character playing in the spots either to the screening from 1955 – the commercials before 2021 – or to the more recent series from 2021 – the one from 2024. This portrayal may be reflective of the complex personality of the Empress herself, who seems to transcend history and mark the present thanks to her being "the ideal conflation of these two seemingly contradictory ideals: of nobility/ quality and of natural and modern femininity." [Hametz, M. E., Schlipphacke A., 2018]

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MATERIAL AND METHOD

A number of eleven commercials (TV commercials included) streamed on YouTube have been analysed paying close attention to the semiotic elements and rhetoric devices used. The texts of the commercials have been translated into English in order to offer a better insight into the progression of the message across the years. The key words have been highlighted so that the readers may be aware of the intention behind the message.

The commercial from 2016 *Sissi, sunca din ce in ce mai fina /Sissi* [1]*, an even finer ham* launched on October 13, 2016, having more than 130,000 views and 60 likes immerses the audience in a story that preserves some historical truths from the life of the real Sissi princess:

> *"There once was **a princess** who **cared** so much **about her figure** that she refused to honor what she called a heavy supper that steals the night's sleep and the beauty of dawn.*
>
> *'She hasn't come again.'*
>
> *The Prince gave orders for the preparation of **the finest product**. From the carefully chosen pork, only **the most tender ham** was selected, and every last bit of fat was trimmed away to make **a very tender ham**.*
>
> *'**A fine girl** like her deserves my **appreciation**...'*
>
> *At Caroli Foods **out of appreciation** for women, we strive to produce **an ever finer ham**. Sissi, 1.5% fat ham."*

The commercial is accompanied by the following message: "Inspired by the story of Princess Sissi, we at Caroli Foods strive to produce **a ham that gets finer and finer**. From carefully selected meat, every last speck of fat has been removed for Sissi ham, resulting in **a very fine ham** with 1.5% fat. Thus, the new products in the Sissi portfolio are suitable for **the modern woman who is concerned about an active lifestyle, but figure-conscious at the same time**. **Out of appreciation** for women. Sissi, **ham that's getting finer and finer**! With 1.5% fat." The story is set in an aristocratic dining salon with people replicating the code of dress and manners typical of higher classes.

In the same year 2016, close to Christmas time – December 19 – the company launches another commercial: *Povestea printesei Sissi – arata-ti aprecierea din ce in ce mai des/ The story of Princess Sissi - show your appreciation more and more often* [2] which preserves the same story pattern. With more than 25,000 views and 140 likes, the story of Sissi told in one minute and 21 seconds focuses on some key issues related to the real Austrian princess, highlighting her role and impact. This time the commercial starts with a book opening while the voice is telling the story of the Princess and a chorus is singing in the background, transporting the viewers into the atmosphere of cathedral music, usually heard on Christmas days:

> *"Behind every **successful woman** is a man who always **supports and appreciates** her. Princess Sissi...*
>
> *Some considered her a rebel, others an innovator, but her husband considered her a princess like the empire had never had before. Probably **the most beloved and appreciated** princess.*
>
> *The first princess to have a gymnasium in the palace. The first princess to go on a diet. A princess who helped the empire evolve.*
>
> *Today, inspired by the story of Princess Sissi, we at Caroli Foods strive to produce **an ever finer ham with 1.5% fat**. From carefully chosen pork, only the ham has been selected. Every last speck of fat has been removed for **a very fine ham**.*
>
> *Sissi **encourages** you to **show your appreciation** because we truly believe that **women who feel appreciated can change the world!***
>
> ***Show your appreciation** as often as possible!*
>
> ***Behind every success there are more gestures of appreciation.***

One year later, December 2017, *Sissi – Gestul tau de apreciere / Sissi - Your gesture of appreciation / TV commercial* [3]*,* with almost 89,000 views and more than 30 likes, wraps the advertising message in the form of a longer song that revolves around the idea of appreciation – which is already established as their slogan – and highlights the vision and the mission of the producers and their commitment to the customers:

> *"I haven't told you enough how much I **love** you.*
> *How I **appreciate**.*
> *What is **fine**, we **value**.*
> *What's **sublime**, we **love**.*
> *When you **feel** and **believe**, you **appreciate**.*
> *What is **dear** to you is **dear** to me, too.*
> *You **lure** me, I **lure** you.*
> *It's real, I'm not dreaming, I **appreciate**.*
> *Sissi – ham with 1% fat."*

One year later, *Sissi – Gest de apreciere la pranz/ Sissi - Lunch appreciation gesture / TV commercial* [4] with almost 17,000 views and 60 likes was launched exactly on Christmas day, December 25, 2017. It reminds people of those who have supported them and helped them in time of need and encourages them to show their appreciation. The setting is a combination of home and work premises. The loving husband and daughter bring Mum lunch and a flower resembling the diamond edelweiss hairpins Sissi used to wear. The message is a slight reversal of the cliché role of women: the woman is the busy one making a career and the father fulfills the domestic chore of cooking for her.

The commercials from July 2018: *Salată cu Sissi șuncă de curcan și ananas/ Sissi Turkey ham and pineapple salad* [5] (1 minute and 34 seconds, 587 views) and *Bruschete cu Sissi șuncă de pui și pastă de măsline/ Bruschetta with Sissi chicken ham and olive paste* [6] (1 minute and 25 seconds, 574 views) offer the audience recipes instead of pure commercials, indirectly advertising for the product and incorporating the information in a useful context.

The commercial from December 20, 2019: *Sissi specialitati crud-uscate afumate/ Sissi raw-dried smoked specialties* [7] (368,074 views, 27 likes) was already reduced to 20 seconds. On the same musical background from 2017 and preserving only some key scenes from the old one with the fashion designer, the voice announces that: *"**Out of appreciation** for you we have created the new raw-dried specialties: ham, tenderloin and pastrami, carefully smoked with hardwood."* In the same year and month, a commercial reduced to six seconds only: *Sissi specialitati crud-uscate afumate/ Sissi raw-dried smoked specialties* [8] (with more than 5,000 views and 13 likes) presents only the three new products and encourages the prospective consumers to *"Indulge yourself with the new Sissi raw-dried and smoked specialties: ham, tenderloin and pastrami."* The song playing in the background has been significantly reduced to: *"What is fine, we value. What's sublime (fading song)".*

The time span between 2019 to 2023, coinciding with the time of the pandemic was interrupted by a commercial in the spring of 2021 promoting a kind of bonus for the loyal consumers: *Cu Sissi, TU ești prințesa!/ With Sissi, YOU are the princess* [9] (more than 1,100 views, 4 likes) with the voice announcing: *"Sissi rewards you with a picture in your own image or daily with a personalized present."*

The media commercial from January 2023 announces that: "Sissi brand receives the title of Supplier of the Royal House of Romania!":

> *"The **noble taste** of Sissi products has always been given by their **fine texture**, **low fat content** and the **quality** of the ingredients, attributes appreciated which have brought us the title of Supplier of the Royal Household of Romania. **Delight** in the new fine ham without E [additives]!"*

It is followed by the commercial from October 31, 2023: *Sissi fără E-uri/ Sissi without E-additives* [10] (over 1,022 views, 6 likes) which preserves the same theme and song in the background. The long fashion designer clip is reduced to 20 seconds. The message changed: *"When mornings start like this and the lunch break is short, you **can always count on** Sissi. Try the new specialties from the range **without E-additives**: Sirloin, bacon and neck fillet. Sissi, **out of appreciation** for you!"*

The last commercial launched on August 29, 2024 – *Sissi: Gusturile fine cresc odată cu tine Sissi: Fine tastes grow together with you* [11], with almost 539, 000 views and 2 likes brings a completely new perspective: the family depicted is a totally new one while the setting sheds a new light on another habit of Princess Sissi: taking care of her beautiful hair. The song in the background is in English making thus the message accessible only to those who understand this language: *"In this place we call home/ That we built stone by stone […] And the smiles up ahead/ They will be alright."* The commercial is attempting a kind of passing on the fine aristocratic habits related not only to a neat preservation of one's look, but also to the fine tastes in eating: *"**Fine meats** from carefully selected raw materials using only very **tender meat**. Sissi, **fine tastes** grow with you."* The little girl figure present in the commercial has switched from a previous member of the family that contributed to her mother's joy by creating something beautiful for her (the hairpin) to a partaker in a kind of initiation in the art of keeping oneself beautiful and that of learning fine manners and acquiring fine tastes from an early age.

RESULTS AND DISCUSSIONS

The commercials analysed revolve around some key elements. From the diachronic perspective, there are some aspects that have undergone a surprising change. While the setting in the commercials from the year 2016 aims to replicate an aristocratic background and tell the story of Princess Sissi retaining core aspects from the habits of the historical character, the commercials from 2017 to 2023 set the scene in a more familiar context, that of our present time, in which the focus is on the female character – a fashion designer with a slender figure who is caught in the hectic preparation of her fashion show, while the husband prepares her a snack with Sissi products and the daughter herself, following in the steps of her mother, creates flowers resembling the famous diamond edelweiss hairpins of Sissi. The commercials aim to preserve the aristocratic tastes and the desire to eat healthy food in order to stay in good shape.

The symbols related to the domestic context – from royal salons with princes and princess to more modern dwelling places exuding a similar air of aristocracy – reveal the intentions of the advertisers to direct the preferences of the audience towards embracing a sort of social sophistication.

The diachronic fluctuations are obvious when it comes to the female character. From the princess's white gown to the casual clothes worn while working, the stage black clothes for a fashion show, and finally to a red dressing gown and a red evening dress in the final commercial are telling of the intentions of the producers.

From the semiotic point of view, all the elements present in the commercials tell a story beyond the one that is being verbalized. The colours themselves need decoding from the point of view of their role in advertising. The switch from the white gown from the initial commercials, which can be easily connected with the typical dresses Sissi appeared donning in most paintings and which conveys a message of purity, safety and creativity, to the simple black one in the fashion show sending a message of strength, authority and stability, and finally to the bright red gowns in the most recent commercial, which is associated with passion and excitement, may be an indicator of the readiness to align with subtly evolving social trends. The consistency is revealed by the fact that these are also the colours on the packaging of the products from the Sissi brand. From a marketing perspective, black is usually used by brands that offer luxury products, white invites to a consideration of the essence of the products while red is closely related to passion and is said to stimulate appetite.

The language suffers a sort of limitation due to the shortened time span allotted to commercials. However, the rhetorical devices, especially the rhyming words in the song that acts as an echo slogan relying on the force of rhyming in Romanian (*Nu ți-am spus îndeajuns cât te iubesc/ Cât apreciez./ Ce e fin,* ***prețuim****./ Ce-i* ***sublim, iubim****./ Când simți și* ***crezi, apreciezi****./ Ce ți-e drag, mi-e drag./ Mă atragi, te atrag./ E real,* ***nu visez, apreciez****.*) acts as an activator of cognition and emotionality, possessing in its simplicity the force of being memorable precisely due to the short, resounding emotional states it conveys. The slogan "consists of a word, syntagm, or sentence that completes the main ad text, repeating the main motive and rationale" and acts as an "echo phrase" (Shirinboyevna M. D., 2020). "Apreciaza" / "appreciate" emerges like a constant impetus for a society who does not know how to do that or who does not do it very often. The word acquires an educational value as it positively incites the consumers to embrace an attitude of appreciation and of manifesting it practically by offering what is best to the loved ones, being confident and convinced that people can achieve more when they are encouraged. The words that consistently appear in the commercials belong to the same semantic field: *fine, finest, sublime* referring both to the product as well as to the people that consume it. Similarly, the verbs revolve around the same semantic sphere of positive feelings: *appreciate, love, lure, value, care, support* turning the entire advertising discourse into a motivational one able to restore core values in the society while persuading people to consume the finest of products.

CONCLUSIONS

The meat commercials advertising Sissi products focus primarily on presenting a product of the finest quality, appealing mainly to women, especially to those who may have a model in the Empress Sissi and favour a slender figure while being socially active. In line with the philosophy promoted is the information regarding the nutritional value of the products: lean meat, 1.50% fat content, and no E-additives, which anchors the message into a continuing social trend of keeping fit and tuned to the changing consumption trends. The reduced time span brings the products into limelight while sacrificing the narratives that add life and mystery to their promotion.

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[2]https://www.youtube.com/watch?v=IOOJe42tjFQ
[3]https://www.youtube.com/watch?v=Odw80TkOKH4
[4]https://www.youtube.com/watch?v=IfMyxuBT054
[5]https://www.youtube.com/watch?v=MizxoDY6k90
[6]https://www.youtube.com/watch?v=3GATP9YIRko
[7]https://www.youtube.com/watch?v=F1t9jc6uKso
[8]https://www.youtube.com/watch?v=4Ivk0ZgYwhg
[9]https://www.youtube.com/watch?v=QV7GmeOGxzY
[10]https://www.youtube.com/watch?v=v7jb26-I3Ms
[11]https://www.youtube.com/watch?v=2B5xgQrzEzI

THE ATTACK AND METHODS OF PREVENTION AND COMBAT OF THE SPECIES *DIABROTICA VIRGIFERA VIRGIFERA* LE CONTE IN THE CONDITIONS OF CENTRAL MOLDOVA

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Abstract

The species *Diabrotica virgifera virgifera* Le Conte (western corn rootworm) is part of the order Coleoptera, family Chrysomelidae. Originally from North America, it entered in Europe in 1992, and in Romania in 1996. Both adults and larvae of this species are harmful, with the adults attacking the aerial parts of the plant (leaves, panicle, silk, pollen and milk stage berries) and the larvae causing root damage (Moeser and Hibbard, 2005). To recognize plants attacked by larvae, a preventive assessment can be made regarding the characteristic symptomatology of the stem, namely "swan neck" (Krysan and Miller, 1986). In the conditions of Central Moldova, in the year 2024, the average number of larvae per plant ranged from 1 to 7, and the frequency of swan neck symptom ranged from 0% to 44.7%. The average attack frequency produced by adults on leaf was 59%, and on silk 89%. The average number of adults per plant recorded values between 3.8 and 7.1 before the chemical treatment was applied to the vegetation, which was reduced to 0.2 adults per plant after the application of the treatment. The efficacy of insecticides was between 96.6% and 97.2%.

Key words: attack, larvae, adults, *Diabrotica*, chemical treatment

Diabrotica virgifera virgifera Le Conte is part of the order Coleoptera, family Chrysomelidae.

Originally from North America, it entered Europe in 1992, and in Romania in 1996. The multiplication and mass spread of this pest is due to the large areas cultivated with corn, as well as the use of monoculture (Baca et al., 1993).

Both adults and larvae of this species are harmful, with the adults attacking the aerial parts of the plant (leaves, panicle, silk, pollen and milk stage berries) and the larvae causing root damage (Moeser and Hibbard, 2005). To recognize plants attacked by larvae, a preventive assessment can be made regarding the characteristic symptomatology of the stem, namely "swan neck" (Krysan and Miller, 1986).

The specialized literature specifies the fact that through the method of attack and the damage produced, the attack produced by larvae is of particular importance, and to a lesser extent the one produced by adults (Bărbulescu, 1997).

Production can be reduced by 10-13%, sometimes even up to 50% (Horgoș and Grozea, 2020).

As methods of prevention and control, Grozea (2007) recommends crop rotation, avoiding monoculture being the most important method, the chemical method through the treatment of the seed but also the soil to control the larvae, as well as treatments on the vegetation to control the adults. He also recommends mechanical methods, by using yellow traps with glue, but also pheromonal ones, with their help a significant number of adults are captured. And biological methods with the help of natural enemies but also by using biopreparations, can reduce the attack produced by the species *Diabrotica virgifera virgifera* Le Conte.

Regarding the chemical control of adults, Levine (1991) and Meinke (1996) state that chemical treatments against adults are applied to reduce the population of adults, in order to reduce the number of eggs laid, so that the number of larvae in the following year to be diminished and not present a danger.

In the present work, are presented preliminary results regarding the attack and prevention and control methods of the species *Diabrotica virgifera virgifera* Le Conte in the conditions of Central Moldova, in the year 2024.

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MATERIAL AND METHOD

In the spring of 2024, in the experimental field of the plant protection laboratory of ARDS Secuieni, two maize experiences were placed, consisting of four variants, placed according to the randomized block method, in three repetitions, where was followed the influence of the applied chemical treatment on the soil, as well as on the vegetation, on the reduction of the attack produced by the species *Diabrotica virgifera virgifera* Le Conte.

The placement of the experiences was carried out on a typical cambic phaeosium type soil, with pH in water 6.29, nitrogen index 2.1, mobile P2O5 39 ppm, mobile K2O 161 ppm.

Sowing was done on 15.04.2024, the hybrid used was Turda Star. The emergence of the plants was recorded on 06.05.2024.

Three granular products with insecticidal action were tested, applied to the soil at the same time as sowing: Force G (tefluthrin 15 g/kg) – 15 kg/ha, Picador (cypermethrin 1.6 g/kg) – 12 kg/ha and Trika expert (lambda cyhalothrin 4 g/kg) – 15 kg/ha and three products with insecticidal action, applied to vegetation at the end of flowering: Decis (deltamethrin) – 0.075 l/ha, Inazuma (acetamiprid + lambda cyhalothrin) – 0.2 kg/ ha and Fastac (alphacypermethrin) – 0.6 l/ha.

To identify the larvae of *Diabrotica virgifera virgifera* in the soil, determinations were made consisting of the analysis of 10 maize plants in three repetitions and the counting of the larvae on the root.

To determine the attack of adults of *Diabrotica virgifera virgifera* on leaves and silk, observations were made on 25 plants, in three repetitions, and the frequency of attack was determined. The determination of the number of adults per plant was achieved by visual assessment of 25 plants in three repetitions.

The experimental data obtained were analyzed by appropriate statistical methods using the difference test (DL) (DL < 0.01 %– ***/OOO – highly significant positive/highly significant negative; DL < 1% —**/– ** / OO – distinctly significant positive/distinctly significant negative; DL < 5 %—*/ – */O – significant positive/significant negative).

The calculation of the efficacy of the insecticides was done with the help of Abbott's formula.

The agricultural year 2023/2024 is characterized as warm and dry.

According to the meteorological data recorded at the unit's own weather station, between October 1, 2023 and August 31, 2024, the agricultural year included a warm autumn (October and November), December and February were warm, while January was normal from temperature point of view. The increase in average temperatures was also maintained in the spring and summer months, except for May, which was normal in terms of temperatures. The monthly deviations in terms of temperatures were between -1.9℃ (January) and 7.7℃ (February) (table 1).

The period from April to August was extremely warm.

The amount of precipitation recorded in the interval October 1, 2023 - August 31, 2024 was 323.2 mm, which is -164.4 mm less than the multi-year amount for the same interval October - August, which is 487.6 mm. In terms of precipitation, the April - August period recorded monthly deviations from the multi-year monthly amount between -61.6 mm (July 2024) and -0.3 mm (June 2024) (table 1).

RESULTS AND DISCUSSIONS

In the year 2024, the larvae of the species *Diabrotica virgifera virgifera* were identified in the corn crops in Central Moldova starting from the first decade of June. The average number of them per plant varied from 1 to 7, the fewest larvae being registered in the variant where the granular insecticide Force G was applied to the soil in a dose of 15 kg/ha (figure 1).

Analyzing the swan neck symptom on the stem, it was found that its frequency recorded values between 0%, as was recorded in the variant where the granular insecticide Force G was applied to the soil in a dose of 15 kg/ha and 44.7% as it was recorded in the control variant, without soil treatment (figure 2).

The attack produced by the adults of the species *Diabrotica virgifera virgifera* Le Conte on leaves and silk was also noted, and it was found that they produced an attack on the leaf whose frequency was on average 59%, and on silk 89% (figure 3).

Table 1

The evolution of temperatures and rainfall in the agricultural year 2023 - 2024, A.R.D.S. Secuieni

Specification		X	XI	XII	I	II	III	IV	V	VI	VII	VIII	Total
Temperature °C	Dec, I	13,3	10,7	-0,8	-0,9	6,2	4,6	14,4	15,4	22,0	23,2	22,6	
	Dec, a II a	10,5	5,6	1,6	-3,2	4,7	4,7	13,6	13,5	20,7	27,6	25,4	
	Dec, a III a	15,3	1,6	3,0	-1,2	6,6	9,7	11,7	18,1	23,0	22,7	24,0	
	Monthly average	13,1	6,0	1,3	-1,8	5,8	6,4	13,2	15,8	21,9	24,5	24,0	11,8
	Multiannual average	9,2	3,6	-1,5	-3,7	-1,9	2,8	9,6	15,4	18,9	20,4	19,7	8,4
	Deviation	**3,9**	**2,4**	**2,8**	**-1,9**	**7,7**	**3,6**	**3,6**	**0,4**	**3,0**	**4,1**	**4,3**	**3,4**
Rainfall MM	Dec, I	1,2	5,2	2,2	11,8	0,2	2,6	3,0	6,8	8,2	12,8	12,8	
	Dec, a II a	7,4	43,6	2,2	0,8	7,4	28,8	11,6	5,0	73,4	0	0	
	Dec, a III a	0,2	2,8	1,2	3,8	1,8	9,2	18,8	24,2	2,8	6,2	5,2	
	Monthly total	8,8	51,6	5,6	16,4	9,4	40,6	33,4	36,0	84,4	19,0	18,0	323,2
	Multiannual average	36,9	27,7	25,4	19,6	19,2	26,3	44,9	64,3	84,7	80,6	58,0	487,6
	Deviation	**-28,1**	**23,9**	**-19,8**	**-3,2**	**-9,8**	**14,3**	**-11,5**	**-28,3**	**-0,3**	**-61,6**	**-40,0**	**-164,4**

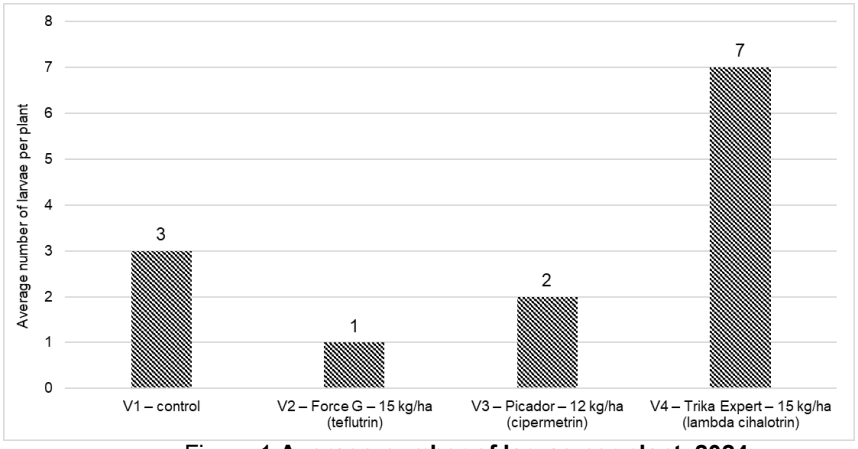

Figure 1 **Average number of larvae per plant, 2024**

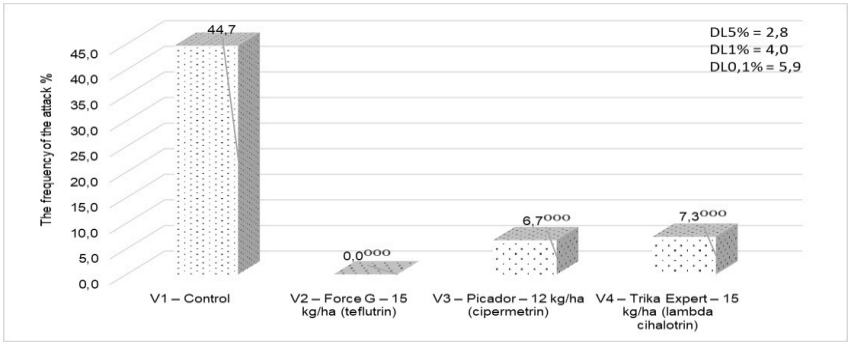

Figure 2 **Frequency of swan neck symptom, 2024**

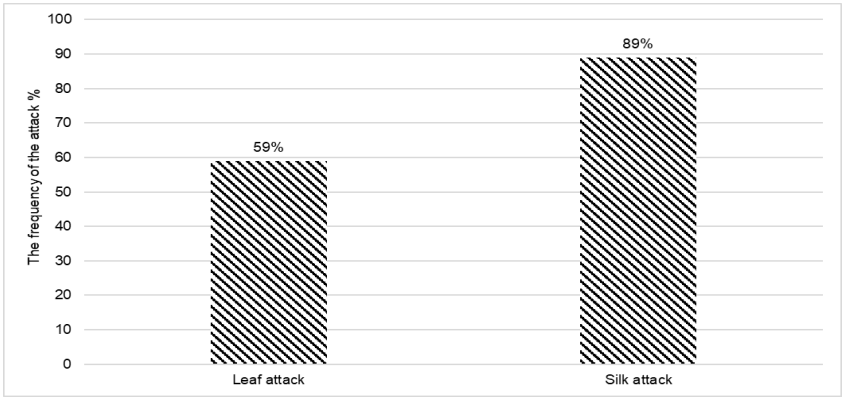

Figure 3 **Frequency of the attack produced by the species *Diabrotica virgifera virgifera* Le Conte on leaf and silk**

The average number of adults per plant before the chemical treatment on the vegetation was between 3.8 and 7.1 specimens/plant. Observations made 72 hours after the chemical treatment on the vegetation showed that the average number of adults per plant was reduced to 0.2 specimens (figure 4).

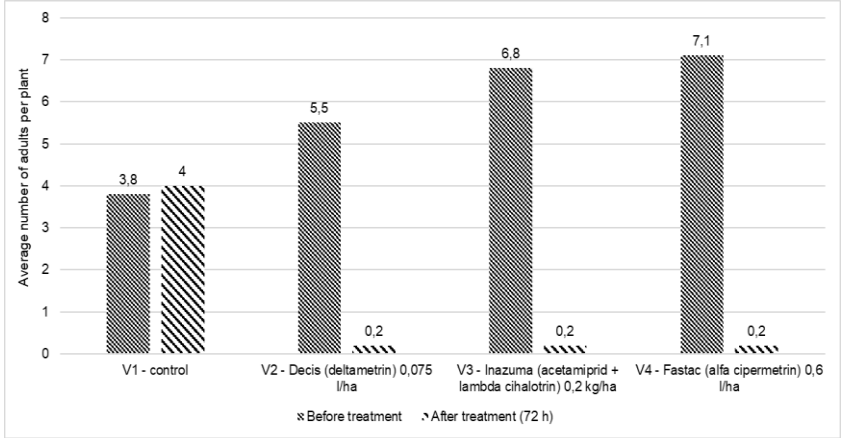

Figure 4 **Average number of adults per plant before and after application of the treatment on the vegetation, 2024**

The applied insecticides registered close efficacies to each other, the best results being obtained in the variant where the Fastac insecticide was applied in a dose of 0.6 l/ha, the efficacy being 97.2%, followed by the Inazuma insecticide (0.2 kg/ha), with a very close efficacy (97.1%) and the insecticide Decis (0.075 l/ha) with an efficacy of 96.6% (figure 5).

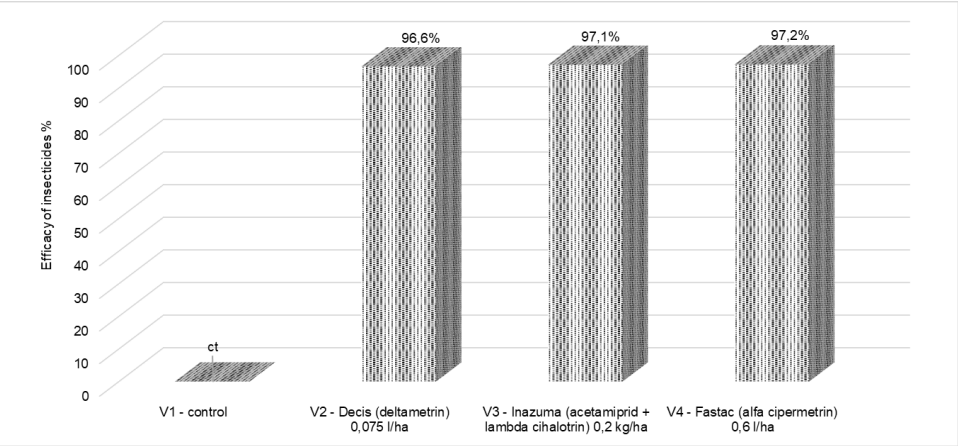

Figure 5 **The efficacy of applied insecticides (E %), 2024**

CONCLUSIONS

In 2024, the species *Diabrotica virgifera virgifera* produced attack in both the larval and adult stages.

The average number of larvae per plant was between 1 and 7, the lowest number of larvae being recorded in the variant where Force G insecticide was applied to the soil in a dose of 15 kg/ha.

The frequency of the swan neck symptom recorded values between 0% (Force G at a dose of 15 kg/ha) and 44.7% (the control variant).

The frequency of adult attack on leaf was 59% and on silk was 89%.

The average number of adults per plant was reduced to 0.2 specimens after applying the chemical treatment on the vegetation.

Regarding the insecticides applied to the soil, in 2024, the best results were obtained in the variant where the Force G granulated insecticide was applied in a dose of 15 kg/ha.

Regarding the insecticides applied on the vegetation, the best results were recorded by Fastac insecticide (0.6 l/ha), followed by Inazuma insecticide (0.2 kg/ha).

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CHALLENGES IN SUNFLOWER CULTURE

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Abstract

Among the most important soil pests that attack sunflowers are the sow beetle (*Agrotis segetum*), the wireworm (*Agriotes* sp.) and the corn borer (*Tanymecus dilaticollis*) and in recent years they represent a big problem in the south-east of Romania. Other pests that cause great damage to the sunflower crop are the seeding crow (*Corvus frugilegus*), the collared pigeon (*Columba palumbus*) and house sparrow (*Passer domesticus*). Besides these pests, field rabbit (*Lepus europaeus*) represent another problem that causes significant damage to the sunflower crop. Among the pathogens that attack sunflower culture in Romania, the most important are *Plasmopara halstedii*, which causes downy mildew, *Sclerotinia sclerotiorum*, which causes white mold and *Phomopsis helianthi*, which causes phomopsis stem canker of sunflower. In last years, we observed in sunflower culture in Romania, sunflower white rust (*Albugo tragopogonis*) but without important economic losses. Atmospheric and pedological drought cause significant damage to the sunflower culture even with irrigation systems because of the high temperatures recorded in the flowering phenophase which makes the pollen unreliable. Another problem in sunflower culture is represented by the high degree of infestation with weeds such as broomrape (*Orobanche cumana*), *Chenopodium album*, *Ambrosia artemisiifoli, Xanthium strumarium, Cirsium arvense, Atriplex littoralis, Setaria viridisi* and *Sorghum halepense*.

Key words: *sunflower, soil pests,weeds, disease*

A sunflower (*Helianthus annuus*) is an annual plant and represent main oleaginous plant in Romania (Csep N., 2018). The sunflower was cultivated in Romania, in year 2022 on 1093 thousand hectares with a production of 2107 thousand tons and in year 2023 on 1089 thousand hectares with a production of 2028 thousand tons (INSSE, 2024). In year 2023, among the states of the European Union, Romania took the first place in terms of the area cultivated with sunflowers and the second place in terms of production (INSSE, 2024).

The main soil pests that cause production losses in sunflower culture are corn borer (*Tanymecus dilaticollis*), cutworm *(Agrotis sp.)* and wireworm *(Agriotes sp.)* (Badiu A.F. *et al*, 2019**;** Georgescu E. *et al* 2019, 2020**;** Trașcă F. *et al* 2019)**.**

Tanymecus dilaticollis and *Agriotes sp.* attacks sunflowers in the first phases of vegetation and can be controlled with insecticides with active substance 600 gr/liter imidacloprid and can be used only with authorization from Ministry Of Agriculture And Rural Development – Romania and applied only on surfaces heavily infested with these pests (ANFDF, 2024).

In last years, in Romania, was reported a big attack of birds like *Corvus frugilegus, Columba livia livia, Columba palumbus* and *Passer domesticus* in emergence phenophase of sunflower and ripening stage (G4media 2023; Ferma 2023, 2024; Sanatatea plantelor 2022; Agrointel, 2023).

The field rabit (*Lepus europaeus*) is another pest that causes damage to the sunflower crop (Ziua de vest, 2021).

Pathogens *Plasmopara halstedii, Sclerotinia sclerotiorum, Phomopsis helianthi, Alternaria helianthi, Albugo tragopogonis* causes loses of seed yield of sunflower culture (Anton F.G., 2021; Chiriac A.R. *et al*, 2023;

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Oprea D. *et al*, 2022**;** Petrova M., 2023; Radu I. et al, 2019; Risnoveanu L. et al, 2019).

Among the most limiting abiotic factors that affect the sunflower culture are represented by drought and heat (Anton F.G. *et al*, 2023; Clapco S. *et al,* 2018; Sauca , Port A. *et al*, 2023; Prodan (Poalelungi) T. *et al,* 2021; Sauca F., Anton F.G., 2019; Sauca F., *et al,* 2018).

MATERIAL AND METHOD

In year 2023 was observed behavior of 5 sunflower hybrids created at NARDI Fundulea, in 12 localities from Romania (*figure 1*). In Fundulea, these sunflower hybrids were cultivated on non-irrigated field.

Figure 1 County from Romania were was tested 5 sunflower hybrids in 12 localities, in year 2023

Oil sunflower hybrid FD15E27 is a semi-late hybrid and is cultivated in system Express Sun and is resistant at sulfonylurea herbicide with active substance tribenuron methyl.

Oil sunflower hybrids HS8445CLP, HS8840CLP and HS9233CLP are semi-late hybrids and are cultivated in system Clearfield Plus and are resistant at imidazolinone herbicides with active substance imazamox.

Oil sunflower hybrid HS1122CON is a semi-late hybrid and is cultivated in conventional system and is suitable for organic farming system. These five oil sunflower hybrids was sowing at beginning of April, in year 2023 in 12 localities in different environmental conditions to observe interaction between genotype and environment (GxE).

RESULTS AND DISCUSSIONS

The lowest seed yield was registered in Fundulea, because in growth stage of plant emergence (BBCH 10-12) and in seed filind and beginning of ripening (BBCH 78-85) was an a big attach of birds (*Corvus frugilegus, Columba palumbus* and *Passer domesticus)* and field rabbits, *Lepus europaeus (figure 2)*.

High infestation with weeds and sunflower broomrape (*Orobanche cumana Wallr)* affected production of sunflower (Anton F.G., Rîşnoveanu L., 2020; Anton F.G. *et al,* 2018, 2023; Clapco S., 2021; Clapco S., Duca M., 2020; Clapco S. *et al*, 2020; Cvejić S.*et al*, 2020; Duca M., Bivol I., 2023; Rîşnoveanu L. *et al*, 2016; Seiler G.J., 2019; Shevchenko S. *et al*, 2024 a,b).

For scaring birds, in Fundulea, in year 2023, we use mechanical cannon with gas explosion that make noise and scarecrows but it was unsuccessful.


Figure 2 Aspects of the sunflower field where there are large gaps caused by birds in year 2023, in Fundulea

Average monthly temperature registered in Fundulea, in year 2023 was higher than average monthly on 60 years (*figure 3*). Average annual temperature was 14.1ºC in year 2023 and average multiannual temperature of 60 years was 10.9ºC.

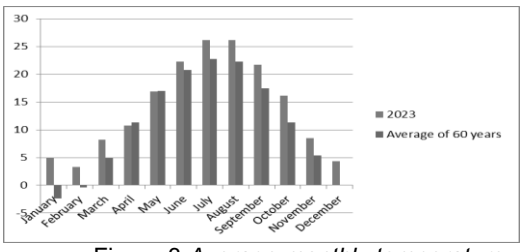

Figure 3 *Average monthly temperature registered in Fundulea, in year 2023*

Total amount rainfalls registered year 2023 in Fundulea of 423.4 mm, was lower than average of 60 years of 584.3mm (*figure 4*). Total amount rainfalls registered during vegetation of sunflower from months April to September was 204.4 mm and average of 60 years was 351.8 mm.

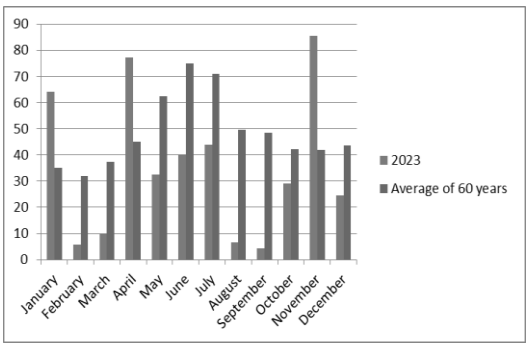

Figure 4 *Average monthly rainfalls registered in Fundulea, in year 2023*

The highest average seed yield from year 2023, was registered in locality Tecuci (county Galati) with 3832 Kg/ha and the lowest was registered in locality Fundulea (county Calarasi) with 1137 kg/ha (*table 1 and figure 5*).

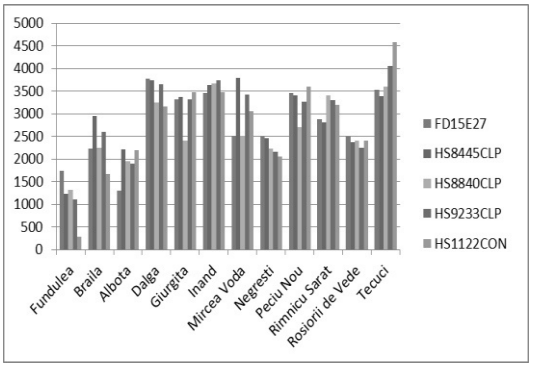

Figure 5 *Average seed yield (kg\ha) of five sunflower hybrids recorded in 12 localities, in Romania in year 2023*

Table 1

Average seed yield (kg\ha) registered in year 2023, in 12 localities

Locality	Average seed yield kg\ha	Difference
Fundulea	1137	-1665
Braila	2339	-463
Albota	1909	-893
Dalga	3511	+709
Giurgita	3177	+375
Inand	3591	+789
Mircea Voda	3060	+258
Negresti	2282	-520
Peciu Nou	3288	+486
Rimnicu Sarat	3119	+317
Rosiorii de Vede	2387	-415
Tecuci	3832	+1030
Average	2802	0

Average monthly rainfalls of 6.6 mm registered in month august in Fundulea, in year 2023, in phenological stage of seed filing, led to lower seed yield. High temperature registered in Fundulea, in year 2023, in phenological stage of flowering with a maximum of 39,3ºC in date of 25.07.2023, 39,6ºC in date of 26.07.2023 and 39,6ºC in date of 4.08.2023, led to low pollen viability.

Average highest seed yield registered in year 2023 was 2946 kg/ha by sunflower hybrids HS8445CLP in system Clearfield Plus (*table 2*).

Table 2

Average seed yield (kg\ha) of five sunflower hybrids, registered in year 2023 in 12 localities

Sunflower genotype	Average seed Yield Kg\ha	Difference
FD15E27	2766	-36
HS8445CLP	2946	+144
HS8840CLP	2638	-164
HS9233CLP	2898	+96
HS1122CO	2762	-40
Average	2802	0

Oil sunflower hybrid HS1122CON registered the lowest seed yield in Fundulea to the high infestation with weeds like *Chenopodium album*, *Ambrosia artemisiifoli, Xanthium strumarium, Cirsium arvense, Atriplex littoralis, Setaria viridisi* and *Sorghum halepense.* These weeds can be controlled with an integrated system of herbicides applied preemergence and postemergence. Clearfield, Clearfield Plus and Express Sun systems have better control against annual and perennial monocotyledonous and dicotyledonous weeds. In all systems of sunflower culture, but in special for conventional system we can use preemergence herbicides with active substance pendimetalin, aclonifen, S-metolaclor and selective graminicidal herbicides with active substance quizalofop-p-etil, quizalofop-p-tefuril, cletodim.

Soil pests *Tanymecus dilaticollis, Agrotis sp*. and *Agriotes sp.* has insignificant attack in year 2023, in Fundulea due to the protection offered by the seed treatment with systemic insecticide with active substance cyantraniliprol and imidacloprid (use only with authorization from Ministry Of Agriculture And Rural Development). An alternative to chemical treatments for *Tanymecus dilaticollis* is neem oil (Georgescu E. *et al*, 2024).

Pathogens *Plasmopara halstedii, Sclerotinia sclerotiorum, Phomopsis helianthi, Alternaria helianthi, Albugo tragopogonis* has insignificant attack in year 2023, in Fundulea due to the protection offered by the seed treatment with fungicides with active substance oxathiapiprolin and with treatment in vegetation with systemic fungicides with active substance boscalid, piraclostrobin, azoxistrobin, difenoconazol.

In Braila in year 2023, oil sunflower hybrid HS1122CON registered the lowest seed yield

(1670 kg/ha) due to high infestation with parasite *Orobanche cumana.* In fields with broomrape is better to cultivated sunflower hybrids Clearfield in system Clearfield Plus witch controlled this parasite.

All five sunflower hybrids registered different heights in all localities were they were tested (*figure 6*). Maximum height was registered by sunflower hybrid HS9233CLP with 215 cm, in locality Giurgita, in county Dolj and minimum height was registered by sunflower hybrid HS1122CON with 100cm, in locality Mircea Voda, in county Braila.

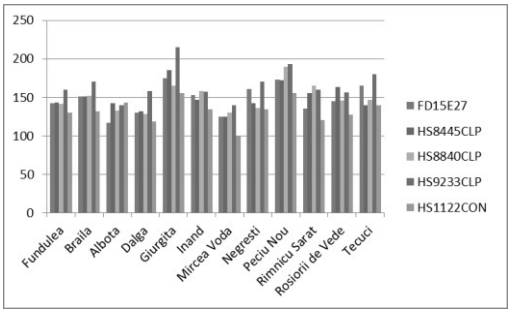

Figure 6 *Average height (cm) of five sunflower hybrids recorded in 12 localities, in Romania in year 2023*

Hectolitre weight (kg 100L -1) of al 5 sunflower hybrids was between 30.4 kg 100L -1 at sunflower hybrid HS1122CON, in locality Fundulea and 46.3 kg 100L -1 at sunflower hybrid HS8445CLP, in locality Braila (*figure 7*).

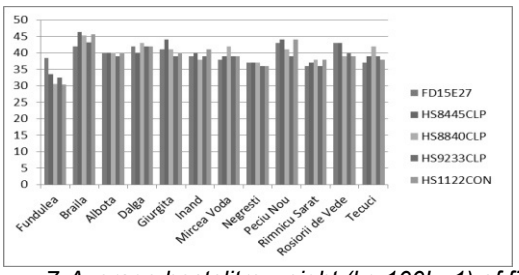

Figure 7 *Average hectolitre weight (kg 100L -1) of five sunflower hybrids recorded in 12 localities, in Romania in year 2023*

TSW (one thousand seed weight in grams) of all five sunflower hybrids was between 25.57g at sunflower hybrid HS1122CON in Braila location and 84g at sunflower hybrid HS9233CLP in Peciu Nou, in county Timis (*figure 8*).

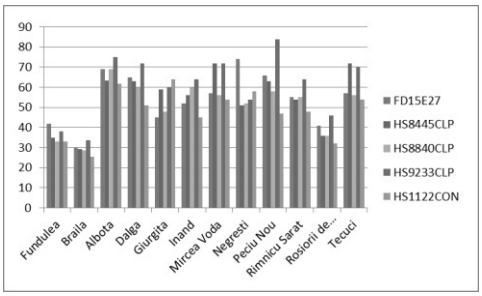

Figure 8 *Average TSW (g) of five sunflower hybrids recorded in 12 localities, in Romania in year 2023*

CONCLUSIONS

To manage difficulties from sunflower culture is necessary to use integrated plant protection measures.

For controlling populations of pests such *Tanymecus dilaticollis, Agrotis sp*. and *Agriotes sp* is recommended to use seed pre sowing treatment with insecticides and treatment in vegetation with systemic and contact insecticides.

For controlling soil borne pathogens *Plasmopara halstedii*, *Sclerotinia sclerotiorum, Phomopsis helianthi, Alternaria helianthi* and *Albugo tragopogonis* is recommended to use seed pre sowing treatment with system fungicides and treatment in vegetation with systemic and contact fungicides.

To avoid drought and heat is recommended to sowing earlier sunflower between middle and end of March and to use irrigation systems were is possible, before flowering and in stage of seed filling.

For controlling infestation with weeds such as *Amaranthus retroflexus, Atriplex littoralis, Chenopodium spp. Cirsium arvense, Solanum nigrum and Xanthium spp.* is recommended to sowing sunflower hybrids with resistance at sulfonylurea herbicides in Express Sun system.

For controlling infestation with weeds such as *Xanthium strumarium, Ambrosia artemisiifolia, Setaria viridis, Cirsium arvense, Convolvulus arvensis* and parasitic plant *Orobanche cumana* Wallr, is recommended to sowing sunflower hybrids with resistance at imidazolinone herbicides in Clearfield Plus system.

For conventional sunflower hybrids, to manage weeds infestation is recommended to use an preemergent herbicide and a graminicidal herbicide in vegetation.

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CONSIDERATIONS REGARDING THE TEXTURAL HETEROGENEITY OF SOILS ON THE STRAIGHT SLOPE OF THE VALEA URSULUI STREAM RECLAIMED BY ANTI-EROSION WORKS, IAȘI COUNTY

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Abstract

The present study investigates the textural heterogeneity of soils on the rehabilitated agricultural terraces of the Valea Ursului stream slope, part of the Ezareni farm in Miroslava commune, Iași County, Romania.

The study area, located within the geomorphological framework of the Iași Ridge, is characterized by a complex slope system influenced by the contact between the Central Moldavian Plateau and the Jijia-Bahlui Plain. Dominant soil types include cambic chernozem, calcaric chernozem, colluvial chernozem, clinogleic chernozem, and eroded or anthropogenically altered soils (eroded and exposed anthrosols).

Soil samples were collected from five representative profiles, each analyzed up to a depth of 100–150 cm, encompassing all pedogenetic horizons. Laboratory analyses revealed that slope terracing and anti-erosion interventions altered soil texture, particularly in the arable layer and underlying horizons. These textural changes have critical implications for soil physical properties, including tillage resistance, porosity, water and air permeability, and water retention capacity.

The findings highlight the importance of monitoring textural dynamics in reclaimed agricultural terraces to ensure sustainable land management. This study provides valuable insights for optimizing soil conservation strategies in similar erosion-prone landscapes, contributing to the long-term stability and productivity of agro-ecosystems in northeastern Romania.

Key words: soil texture dynamics, chernozem degradation, slope complex, terracing effects

The mineral constituents of the solid part of the soil represented by sand, silt, and clay form the soil texture or granulometry (Onwuegbunam D. O. et al., 2025).

The proportion of sand, silt, and clay determines the type of soil texture. Determination of particle size fractions according to the Atterberg scale (1912): - sand: 2 - 0.02 mm Ø; - silt: 0.02 - 0.002 mm Ø; - clay: < 0,002 mm Ø. In contemporary pedology, the soil is considered a natural or diverse body modified by man, formed on the land surface, it is a unique natural resource, used as a means of production, a good that was not created or produced by man and is limited in extent, unmultiplicable and irreplaceable (Jităreanu G. et al., 2020). The main criterion by which the limits of separation between particle size fractions are established is to include in the same category particles having practically the same properties.

An elementary particle is defined as a solid, silicate mineral particle that cannot be divided into smaller particles by simple physical or chemical treatments (Canarache A., 1990; Filipov F., 2005).

Texture is the main physical property of soil, with a particularly important role in determining most of the other physical properties as well as many chemical properties. Texture is a practically unchangeable soil characteristic, therefore agricultural and amelioration technologies must take into account this particularity of each soil type.

Soils are also considered three-dimensional natural bodies of relatively loose material, located on the surface of the Earth's crust and composed of mineral, organic components, and living organisms, interacting, with physical, chemical biological, and morphologically different from those of the parent materials from which it was formed and evolved over time through specific pedogenetic and pedogeologic (reliefogenetic) processes under the action of climate and living organisms in different relief conditions, having their own organization and being capable of continuous exchange of substances and energy with the environment, of self-development and of providing the necessary conditions for the growth of terrestrial plants, their main property being

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fertility (Florea N. , 1994; 2004; Amponsah J. et al., 2025).

On agricultural soils, compaction is a process of soil degradation and in the field of construction is a necessary work carried out by specific technological procedures. Compaction can have natural or anthropogenic causes (Canarache A., 1990).

The indicators of the state of soil compaction are represented by the morphological type of structure, the uniformity of root distribution, apparent density and total porosity in correlation with soil texture, aeration porosity, degree of compaction, packing density, etc..

In order to assess the state of soil compaction on the slope developed by soil erosion control works, we analyzed the state of compaction of the soil evolved under the influence of forest vegetation and soil on the arable land on the Ezăreni plateau. The comparative study of the soil compaction of soils on the landscaped slope and those representative of the Ezăreni plateau allowed to highlight the effect of the slope shaping works on soil compaction on the agro-terraces and the grassed strips.

MATERIAL AND METHOD

Location of research

Geomorphologically, the Ezăreni farm lies within the Iași Coast (Strunga-Voinești-Mogoșești-Ciurea-Tomești), bordered by the Central Moldovan Plateau to the west and south, and the Moldavian Plain/Jijia-Bahlui Plain to the east.

The farm's land occupies the interfluve defined by the Valea Ursului (Ezăreni) stream to the north, the Cornești stream to the west, the Boaghia stream to the south, and the Podiș plateau to the west. Elevation ranges from 58 m at the Valea Ursului-Cornești confluence to 132 m on La Podiș hill.

Dominant soils include Cambic chernozemic, calcareous chernozemic, clogged Cambic chernozemic, clinogleic chernozemic, and, on slopes, weakly to moderately eroded Cambic chernozemic or decopatic chernozemic, and eroded/decopatic anthrosols.

Soil profiles (Fig. 1) were located on the right slope of the Valea Ursului stream, a left tributary of the Ezăreni stream, which feeds into the Nicolina stream. The elevation ranges from 67.1 m at the slope's base in the northeast to 97.1 m at its crest in the center, a relief amplitude of 30 m.

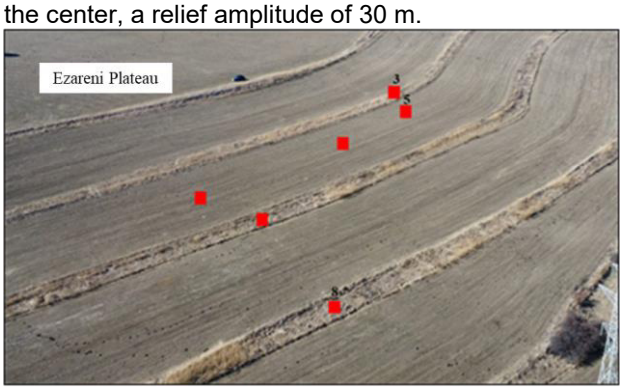

Figure 1. Location of soil profiles

Particle size analysis methodology

Particle size analysis involved pretreatment based on sample composition:

- Carbonates > 2%, organic matter < 5%: 1N hydrochloric acid treatment, followed by dispersion with 4% tetrasodium pyrophosphate.
- Carbonates < 2%, organic matter > 5%: Organic matter oxidation with 30% hydrogen peroxide, followed by dispersion with 4% tetrasodium pyrophosphate.
- Carbonates < 2%, organic matter < 5%: Dispersion with 4% tetrasodium pyrophosphate.
- Carbonates > 2%, organic matter > 5%: 1N hydrochloric acid treatment (carbonate removal), organic matter oxidation with 30% hydrogen peroxide, and dispersion with 4% tetrasodium pyrophosphate.

Particle size fractions were determined using:

-Pipette method: fractions ≤ 0.02 mm;

- Wet and dry sieving: fractions and sub-fractions between 2-0.02 mm.

Results are expressed as percentages of pretreated material, totaling 100%. Textural classification followed both the international system (ICPA Methodology, 1987) and the American system.

RESULTS AND DISCUSSIONS

Profiles P3, P5, and P8 represent soils uncovered by agropropedimentary improvement works, including eroded soils (P3, P8) and eroded-covered soils (P5) found on weathered and arable strips (Fig. 2).

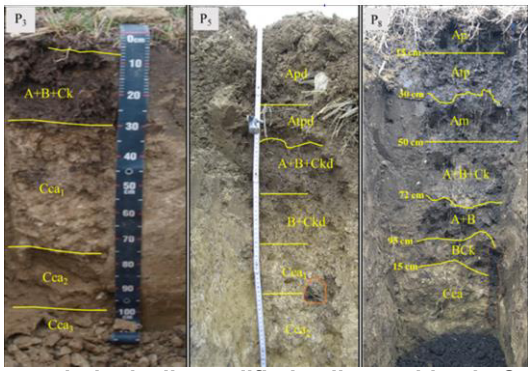

Figure 2. Anthropogenic macromorphologically modified soils resulting in Calcareous Decopperic Soil, (P3), Molic Erodic Soil (P5) and Cernocambic Aric Soil (P8)

The calcareous decopic anthrosol, P3, shows a clay maximum in the Cca1 horizon located at a depth of 30-75 cm, followed by a decrease in depth from 41.5% to 27.1%, going from medium clayey loam to medium loam texture (fig. 3). At depths of more than 100 cm, the lithological fine sand content increases.

In the anthrosol, the presence of the moderately and strongly subsided layer at shallow depth is remarkable.

The susceptibility to compaction of the anthrosols is emphasized by the shallow presence of the moderately and strongly compacted layer (Atp) formed shortly after the slope redevelopment.

The compaction of the arable substrate was favored by the low permeability for water and air, as well as by the temporary manifestation of stagnant excess moisture. The lithological discontinuities within the eroded anthrosols amplify the temporary occurrence of excess moisture and shorten the duration of the optimum period for agricultural work.

The infiltration of water is also slowed down due to the reduced drainage porosity of the shallow carbonate-accumulating C horizon, as a result of precipitation and deposition of calcium carbonate, which clogs some of the existing pores.

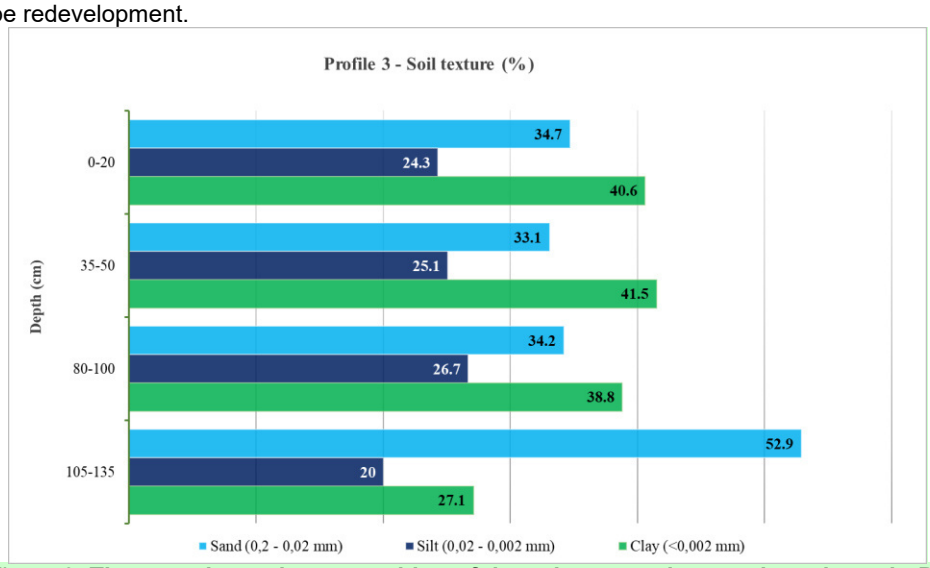

Figure 3. **The granulometric composition of the calcareous decopertic anthrosol - P3**

The Molic eroded erodic anthrosol (P_5), located where leveling and stripping occurred during terracing, exhibits the highest clay content (>45%) in its upper soil horizon among the studied profiles, classifying it as a clay loam. This clay dominance, illustrated in Fig. 4, makes P_5 highly resistant to plowing.

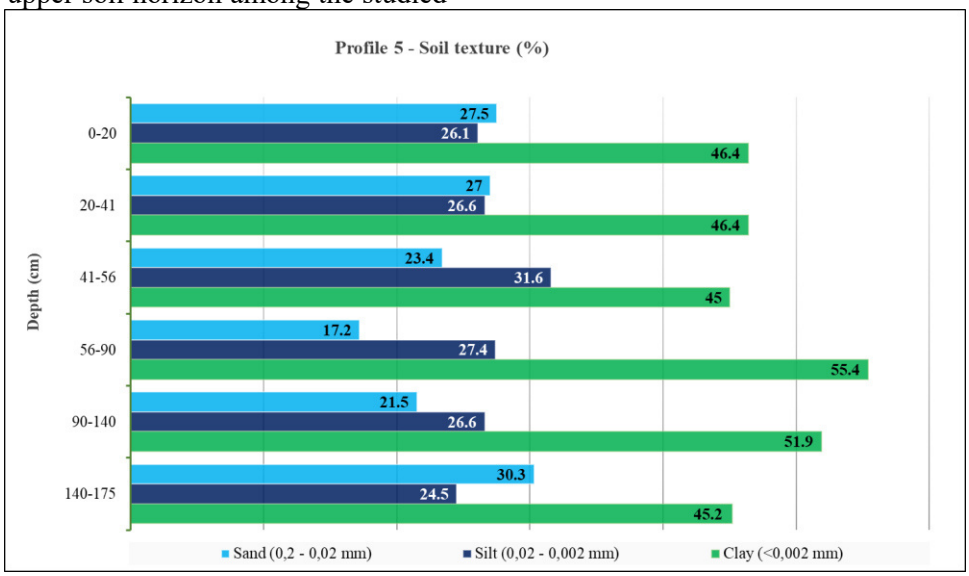

Figure 4. Particle size fractions of the mollic erodic anthrosol – P5

The cernocambic clay loam (P8) exhibits a peak clay content of 36.9% in the Atp horizon (15-25 cm depth), decreasing to a medium loam texture by the BCk transition horizon (80-100 cm). Below 120 cm, fine sand content reaches a maximum of 54.2% while clay content drops to a minimum of 20.6% (Figure 5).

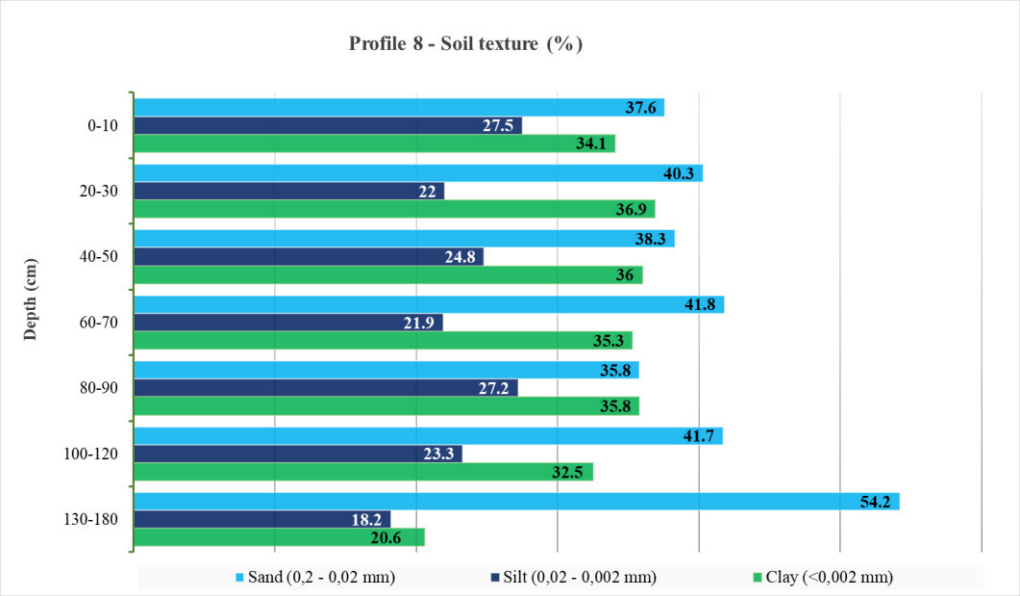

Figure 5. The content of fine sand, silt and clay P8

CONCLUSIONS

As a result of very intensive local improvement activities, highly anthropogenically modified soils have resulted, represented by erodic-decopertic, calcareous, erodic-molic and aric, cernocambic soils.

The erodic anthrosols occur only locally as a result of stripping and levelling of small mounds of old stabilized landslides.

The values of the ratio of non-leachable particle size fractions silt/sand allowed the lithologic discontinuities of the deluvial deposits from which the soils on the landscaped slope were formed to be highlighted.

The susceptibility to compaction of the eroded soils is evidenced by the presence at shallow depth of the moderately and strongly compacted layer (Atp) formed shortly after the slope redevelopment.

The presence of the hardpan layer, observed in the field at the depth of 25-35 cm, is confirmed by the low values of total, useful and draining porosities.

The lithologic discontinuities within the eroded anthrosols amplify the temporary manifestation of excess moisture and shorten the duration of the optimal period for agricultural tillage.

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CASE STUDY ON THE ELABORATION OF FERTILIZATION MANAGEMENT ON A FARM IN PRUT VALLEY – IASI COUNTY

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Abstract

Agrochemical mapping aims to monitor soil fertility to determine fertilizer requirements and includes field research, laboratory determination and mapping of the distribution and range of pH and essential nutrients by conventional signs and colors. Soil fertility is its fundamental and specific ability or capacity to provide plants with the necessary and balanced amounts of nutrients, permanently and simultaneously, in the context of the other vegetation factors (water, light, temperature, other physical and biological factors). Basically, fertility results from the complex and dynamic interaction of soil constituents (primary and secondary minerals, clay minerals, humus, salts, etc.) with some physical properties (texture, structure, aerobic regime) and other soil-specific processes (humification - mineralization, adsorption - desorption - ion exchange, solubilization and nutrient cycling between ecosystem components). The composite agrochemical sample consists of a number of subsamples, as follows: 25 for uniformly fertilized soils, 30 for weakly and moderately eroded soils and 40 for strongly eroded soils, non-uniformly fertilized, depleted and organic soils, soils from orchards, greenhouses and solariums. Geomorphologically, the territory of Probota village belongs to the Moldavian Plain. This geomorphologic unit is a broad-veined hilly plain consisting of more or less fragmented hilly interfluves. The Moldavian Plain is of sculptural origin, formed in the presence of a slightly erosive sandy-clay substratum, unlike the oolitic sandstones and limestones of the neighboring regions. The land is situated in the Prut valley, bounded on the long side by drainage canals, and another partly divides the plot in two. The altitude is between 39 and 41 m.

Key words: fertility, agrochemical mapping, soil, nutrients

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Nutrients derived from fertilizers owe their usefulness both to their quantitative participation in biomass production and to their specific roles related to their involvement in essential plant metabolic processes (Adebayo et al., 2025). Their classification considers not only their percentage representation in the dry plant mass (dry matter = dry matter) but also their multiple and decisive roles in crop formation (Table 1).

Table 1

Classification of nutrients-fertilizers (Lăcătușu R., 2006 after Bergman, 1992)

Group of nutrients			The essential nutrient
Basic organogenic constituents with physiological-metabolic role			C, O, H
Constitutive and metabolic mineral nutrients, essential agrochemical-fertilizer	Macronutrients	primery	N, P, K
		secondary	S, Ca, Mg
	Micronutrients	primery	Fe, Mn, Cu, Zn, B, Mo, Cl
		secondary	Al, Co, Na, Ni, Si, V

Macronutrients have essentially plastic, constitutive roles, with nitrogen being involved in the quantitative increase in plant production, and phosphorus and potassium with nutrient balance effects in relation to nitrogen and with a decisive role in crop quality (Canarache A., 1990).

Micronutrients have primarily enzymatic roles, with essential metabolic implications (boron also has plastic roles) and their application is linked to specific agrochemical conditions, determining their chemistry or depending on the application of macroelements and reaction modifications to which these elements show interactions (Florea N., 1994).

To obtain the effect and efficiency of fertilization, the knowledge of the specific and particular roles of each element is considered, supporting the efficiency of their interactions and, obviously, the nutritional properties of soils and agricultural crops (Jităreanu G. et al., 2020)

RESEARCH LOCATION

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The agricultural field is located in the Prut valley, delimited on the long side by drainage canals. The altitude is between 39 and 41 m. We studied the physical block 460 - Canal 7, 37 ha in area, which was cultivated with winter wheat from which four agrochemical composite samples were collected. This field is exploited by S.C. AGRICOLA 96 S.A. Țigănași, Iasi county.

The Prut plain is a well-defined relief subunit with geomorphologic features that distinguish it from the rest of the territory. It was constituted in the Holocene due to intense alluviation and is characterized by thick accumulations of about 20 m, having the following composition:

– at the base over the Basarabian clays and marls are gravel;

– follows sandy silt;

– clayey alluvium with lenses of sands occur at the top (Filipov F., 2005).

Fine sands lie on top of the clayey alluvium in the gravelly areas.

The meso- and microrelief forms are represented by microdepressions, inter-microdepressions, wider depressional areas, and grains of different heights (Figure 1).

Figure 1 **Drainage canal near the studied plot**

In general, the land is horizontal with a gentle slope from north to south. The overall drainage is moderate to imperfect in the areas of the grind, poor in the area of the plain proper and very poor in the micro-depressions (Bhuyan et al., 2025).

Despite the fact that the plain has been heavily modified by banking works, drainage canals, irrigation canals and stream bed straightening, these phenomena are still occurring and are making agricultural operations more difficult. Due to the banking of the Prut River, this sector is not flood-prone.

MATERIAL AND METHOD

The agrochemical mapping was carried out in a system prescribed by the methodologies elaborated and perfected by the National Research and Development Institute for Pedology, Agrochemistry and Environmental Protection - ICPA Bucharest, which are generally accepted in Romania.

In agrochemical mapping, several stages are distinguished, including preparatory, field, laboratory and actual mapping.

A. Preparatory stage

This stage initially includes establishing the objectives of the work, especially if there are some aspects that require further study in relation to the framework methodology. The choice of the topographic scale is also decided, which is necessary as a basis for soil sampling and the realization of the following stages.

B. Field stage

In order to collect agrochemical samples, it is necessary to establish a material base and set certain sampling criteria, depending on the nature of the land use, the degree of soil uniformity and fertilization.

The topo-pedological base is used for the constitution of the plots for the collection of agrochemical composite samples. Their size depends on pedological complexity, use and fertilization background.

Sampling is carried out with agrochemical probes. The probe itself consists of a metal rod with a 30-40 cm long channel in which the sample is collected when the probe is inserted into the soil. In our case, the WINTEX 1000 sampling mechanism is attached to the HONDA ATV (Figure. 2).

Sampling depth is 0-20 cm, the area of land corresponding to a composite soil sample is mapped with broken lines and is called a sampling plot. These plots with similar characteristics form the fertilization plots, which are mapped with a solid line.

Figure 2 **Soil agrochemical sampling set-up**

C. Laboratory stage

After conditioning the samples by drying, removal of organic residues and fine grinding to determine the humus content, the samples enter the current analytical flow. Aqueous pH, P and K soluble in AL are determined. The exchangeable bases (CEC) and the hydrolytic acidity (Hg) are determined to assess the nitrogen supply, both necessary to calculate the degree of base saturation, which is used together with the humus content value to calculate the nitrogen index (NI).

If necessary, soluble forms of magnesium and trace elements can also be determined.The samples were analyzed in the laboratories of the Research Institute for Agriculture and Environment of the Iasi University of Life Sciences according to the working instructions, standards and methods of work previously mentioned.

Mapping stage

According to the analytical data, climate and soil conditions, the specific nutrient consumption, depending on the crop, the expected yield and the agrochemical properties of the soil, the following analytical data interpretation is done following the instructions given for this purpose. Interpretation values are given in this paper for each physical block, relating to pH, content in mobile forms of P and K, soluble in AL, NI, as well as content in salts (where applicable), magnesium, microelements.

The elaboration of agrochemical maps and the agrochemical report are the main objectives of this work stage.

Depending on the amount of plant-assimilable nutrients contained in the analyzed plot, the crop plant and the expected yield, the fertilization plan was drawn up.

Soil reaction is an indicator that determines the ratio between the concentration of hydrogen and hydroxide ions. The scale adopted, from 0 to 14, tells us what kind of substrate we are dealing with. This is particularly important because of the need to prepare the soil to grow specific plants.

The pH values are noted to one decimal place at the top of each sampling plot or in the mapping table and the scale of interpretation is given in Table 2.

Table 2

Characterization ranges of soil reaction in aqueous suspension

pH	Soil reaction status
< 5	Strongly acid
5.1 – 5.8	Medium Acid
5.9 – 6.8	Slightly acid
6.9 – 7.2	Neutral
7.3 – 8.4	Slightly alkaline
> 8.5	Medium, strongly alkaline

The limiting factors for plant growth on acid soils are the acid-forming ions: H^{+}, Al^{3+} şi $Al(OH)^{2+}$. Acidity generates aluminum to such an extent that at pH < 5.0 exchangeable aluminum predominates among the exchangeable cations. More than 80% of the exchangeable acidity consists of aluminum ions.

To assess the nitrogen potentially accessible to plants, consisting of exchangeable and soluble ammonium, nitrate and nitrite, the nitrogen index (NI) is used in agrochemical mapping, calculated according to the equation:

$$NI = H \times BS / 100$$

where: H - humus content (%)

BS – base saturation (%).

NI helps to differentiate organic fertilizer rates, which are inversely proportional to the NI value, with rates decreasing as the NI value increases.

Representation of the nitrogen status of the soil (Table 3) is made according to the scale below according to the value of IN.

Table 3

Interpretation values (ICPA Bucureşti, 1981**)**

Nitrogen index	Supply level
< 2.0	Low
2.1 – 4.0	Moderate
4.1 – 6.0	High
> 6.1	Very high

The characterization of the phosphorus supply situation is done according to Table 4.

Table 4

Soil phosphorus status (ICPA București, 1981)

P_{AL} (ppm)	Supply level
< 8	Very low
9 - 18	Low
19 - 36	Moderate
37 - 72	Good
> 72	Very good

Available potassium is also determined in ammonium acetate-lactate extract at pH 3,75, determined by the Egner-Riehm-Domingo method using the atomic absorption apparatus, flame technique - CONTR AA 700 (STAS 7184/18-80).

The description of the phosphorus supply status is given in Table 5.

Table 5

Soil potassium status (ICPA București, 1981)

K_{AL} (ppm)	Supply level
< 66	Low
67 - 132	Moderate
133 - 200	Good
> 200	Very good

RESULTS AND DISCUSSIONS

Agrochemical characterization of the 460 land parcel - Canal 7.

The responsiveness and nutrient supply status of soils is presented in Table 6.

Table 6

Nutrient content of BF 460

	pH		Mobile P, ppm		Mobile K, ppm		Humus %	NI
	Minimum	Maximum	Minimum	Maximum	Minimum	Maxim		
Values	6.9	7.6	15	26	308	331	4.7	4.5
Status	Neutral	Slightly alkaline	Low	Moderate	Very good	Very good		
Average	7.1		19		315			
Status	Neutral		Moderate		Very good		Good	Good

The pH values are reported to one decimal place at the top of each sampling plot. pH values range from 6.9-7.6, resulting in neutral to slightly alkaline soils (Table 7).

Table 7

Allocation of sampling plots according to soil reaction (pH)

Interpretation	Sample number
Strongly acid	
Moderate acid	
Slightly acid	
Neutral	419; 420; 421.
Slightly alkaline	418.
Moderate, strongly alkaline	

The mobile phosphorus (P) content is expressed in ppm (parts per million) and is written in integer numbers in the middle of each harvest plot.

In general, the mobile phosphorus content ranges from 15-26 ppm P_2O_5, so soils are low to moderately supplied with mobile phosphorus, as shown in Table 8.

Table 8

Level of supply of available phosphorus

Supply level	Sample number
Very low	
Low	418;419;421.
Moderate	420.
Good	
Very good	

The values expressed in ppm K are inscribed in the outline of each sample plot, with integers immediately below the value indicating the mobile phosphorus content.

In total, within this plot, the mobile potassium content has values between 308-331 ppm K, indicating that the soils have a very good mobile potassium status (Table 9).

Table 9

Level of supply of mobile potassium

Supply level	Sample number
Low	
Moderate	
Good	
Very good	418; 419; 420; 421

The fertilization plan designed for the main agricultural crops within the physical block is shown in Table 10.

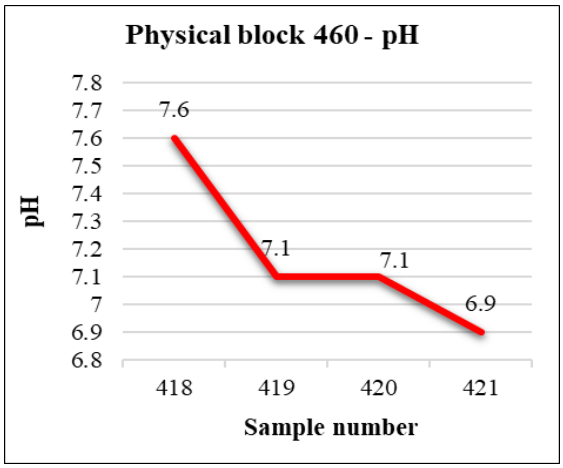
Table 10

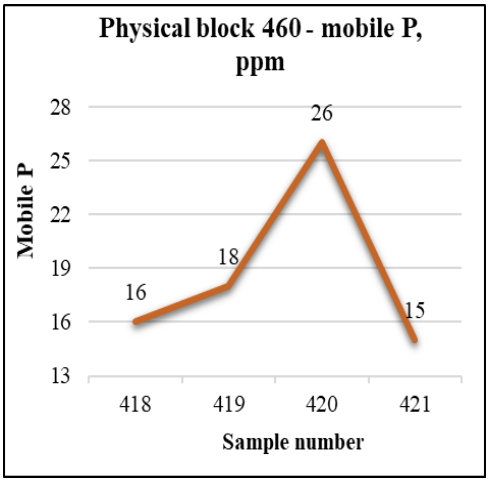
Fertilization plan for physical block 460

Crop	Estimated production (kg/ha)	**Nutrient values** (December, 2019)					
		Nl			**P**	**K**	**S**
		3.3			63	243	
		Annual amount of fertilizer with soil application, kg/ha active substance (a.s.)					
		N a.s.	**N (autumn)**	**N (spring)**	**P_2O_5**	**K_2O**	**S**
Wheat	5000	117	47	70	42	28	
	6500	138	58	80	66	54	
	7000	144	64	80	73	62	
Winter barley	4000	78	28	50	18	-	
	5000	94	34	60	40	-	
	6000	107	37	70	59	-	

As these nutrients are deficient it is recommended that they are applied foliar during vegetation. At the time of application, all requirements and restrictions of the manufacturer of the selected products should be respected.

The variations in soil reaction and nutrient content within the physical block for each agrochemical soil sample are shown in Figure 3.





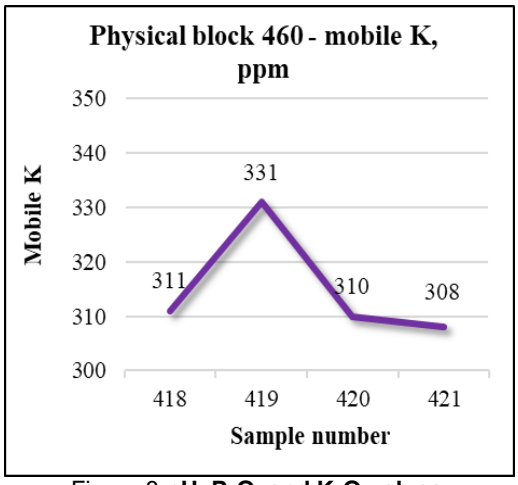


Figure 3 **pH, P_2O_5 and K_2O values**

The maps include the topographic features, the limits of the agrochemical composite sample plots. Maps shall be drawn for each agrochemical indicator measured: pH, N, P, K supply status, etc. In each analytical unit, the order numbers of the samples and the analytical results obtained shall be recorded (Figure 4).

Fertilization plots remain valid until a new cycle of agrochemical mapping.

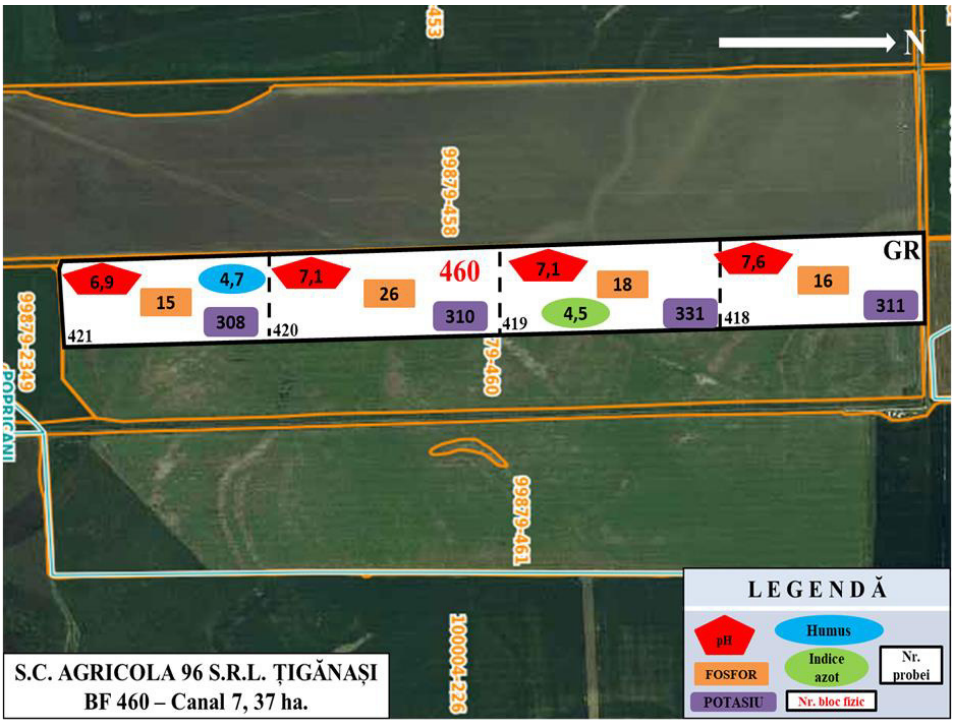


Figure 4 **Agrochemical sampling plots and analysis results**

CONCLUSIONS

The fertilization plan is a useful tool for calculating fertilizer doses and choosing the right time to purchase the required quantity and quality of mineral or organic fertilizers.

On the basis of the data obtained from this plan, we can also:

– developing the crops plan;

– to manage fertilizers properly, economically and environmentally;

– to determine the dosages of organic and mineral fertilizers;

– decide the type of fertilizer;

– determine the timing of fertilizer application;

– establish the supply and/or availability of fertilizer.

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THE EFFECT OF TILLAGE SYSTEMS ON SOIL COMPACTION OF ARABLE SOILS COMPARED TO FOREST LAND ON THE EZĂRENI PLATEAU, IAȘI COUNTY

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Abstract

Ezăreni Farm is located in Miroslava commune, Iasi County, within a geomorphological area defined by the Iași Ridge, situated between the Central Moldavian Plateau to the west and south, and the Moldavian Plain, specifically the Jijia–Bahlui Plain, to the east.

The soil characteristics reflect the influence of land use and vegetation, with forested areas showing deeper humus and calcium carbonate accumulation horizons compared to arable lands. During winter, wind erosion and increased subsoil compaction reduce the depth of these horizons.

The soils have a predominantly fine texture, with the highest clay content in the AB transition horizon, where humus distribution gradually decreases. Cambic chernozem on the edge of the Ezăreni plateau, developed under forest vegetation, is very loose in the 0–20 cm layer, with bulk density values between 0.97 and 1.09 g/cm³. Increasing compaction and changes in soil texture between 32–160 cm depth confirm the aeolian origin of the upper soil layer. In contrast, the cambic chernozem under arable use is loose in the ploughed layer, moderately compacted in the subsoil, and strongly compacted at 80–100 cm depth. The moderate compaction in the middle part of the soil profile is due to clay illuviation and the prevailing aerohydric regime, which contribute to denser packing of soil aggregates.

Key words: bulk density, compaction, soil texture, wind erosion.

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In agricultural soils, compaction is considered a form of degradation, whereas in construction, it is a necessary operation performed through specific technological methods. Compaction may have either natural or anthropogenic causes (*Canarache et al., 1990*).

Soil compactness, also referred to as overall cohesion or compacity, is a complex property resulting from the soil's textural characteristics and degree of packing. It is expressed by the resistance the soil offers to the penetration of a tool or other foreign object and to the fragmentation of its mass during mechanical operations (Florea N., 1994).

Indicators of soil compactness include the morphological type of structure, the uniformity of root distribution, bulk density, total porosity in relation to soil texture, aeration porosity, degree of compaction, packing density, and others.

To evaluate the compaction state of soils on a slope improved with erosion control works, we analyzed the compaction status of soils developed under forest vegetation and those on arable land on the Ezăreni plateau. A comparative study of the compactness of soils on the managed slope and those representative of the Ezăreni plateau revealed the impact of slope-shaping works on soil compactness in agroterrace platforms and grassed strips (*Jităreanu et al., 2020*).

Total porosity represents the entirety of capillary pores with diameters <10 μm (10^{-6}) for clay-textured soils and <30 μm (10^{-6}) for sandy-textured soils, through which water usually circulates (capillary porosity), and non-capillary pores, with diameters >1 mm, through which air usually circulates (non-capillary or aeration porosity) in the soil mass. Total porosity values generally range between 40% and 60%. The more compacted a soil is, the lower its total porosity values, often around 42–45%. In loose, arable layers, values range between 48–50%. These values increase significantly with higher organic matter content. High total porosity values indicate a strong water retention capacity, high permeability, and good aeration, although sometimes associated with lower bearing capacity (*Jităreanu et al., 2020*).

Soil compactness affects both total porosity and the ratio between micropores, mesopores, and macropores. As a result of soil compaction processes, total porosity and aeration porosity decrease, while the proportion of micropores—where water is held in a form inaccessible to plants—increases. The lower

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threshold of aeration porosity that does not restrict plant growth is considered to be 10% v/v (*Canarache et al., 1990*).

MATERIAL AND METHOD

Location of research

To highlight the effect of soil tillage on the degree of compaction, two soil profiles were studied on the Ezăreni plateau—one located on forest land and the other on arable land (Fig. 1).

The land where the profiles were placed has a slope of less than 5%, meaning it is approximately flat, with a low risk of erosion (possibly wind erosion on arable land or water erosion in the marginal area of the plateau).

According to indicator no. 201 from the M.E.S.P., the soil surface appears normal, with no signs of salt crusting or cracking.

Soil tillage operations can be carried out without restrictions; however, it is recommended that the soil is not left exposed for extended periods to prevent wind from displacing surface particles, transporting and depositing them on adjacent areas—especially on forested land.

On the Ezăreni Plateau (La Podiș Hill), two soil profiles were made under similar relief conditions but with different land uses (Fig. 1).

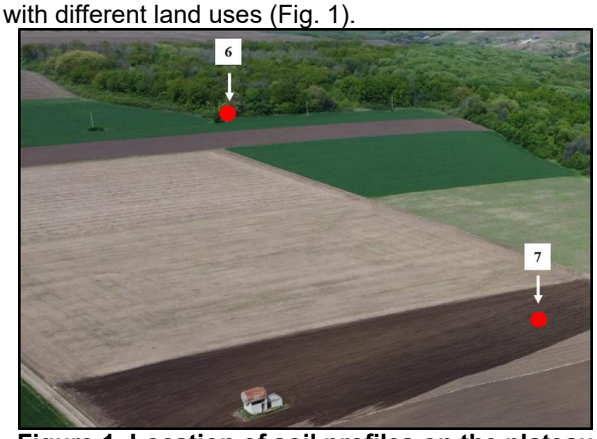

Figure 1. Location of soil profiles on the plateau of the Ezăreni farm

The soil profiles were excavated using a spade, shovel, and axe to remove the lignified roots of forest vegetation. The profiles measured approximately 65–80 cm in width, 180–200 cm in length, with a depth of 160 cm for the profile located under forest vegetation and 175 cm for the one in arable land.

In the forest profile, ten soil horizons and sub-horizons were identified and described in the field, while seven were identified in the arable land profile. From each profile, undisturbed soil samples were collected using 100 cm³ stainless steel cylinders, from depths of 0–100 (110) cm at 10 cm intervals, using the Eijkelkamp soil sampling set.

Sampling was performed immediately after the profiles were opened, to avoid data distortion caused by soil shrinkage, particularly in soils with medium to fine textures. The sampling technique involved preparing a horizontal flat surface 30–45 cm wide, which was gently trimmed to avoid pore blockage. The cylinders were then placed with the sharp edge downward and inserted into the soil by pressing with the cylinder holder and hammer.

Cylinders had to be inserted perfectly vertically, and filled with soil slightly above the upper edge (by 3–4 mm). The excess soil was removed with a knife, cut flush to the cylinder edge for bulk density determination, or trimmed more carefully with chipping motions for other measurements, ensuring the soil surface was level with the cylinder rim. Once capped, the cylinders were placed in special transport boxes.

Three replicates were taken for each depth. The 100 cm³ soil samples were transported to the laboratory, weighed, and placed in trays with water to determine capillary capacity, total water holding capacity, and bulk density. The cylinders were then oven-dried at 105°C for 48 hours or until reaching a constant weight, removed to a desiccator, and weighed again.

Based on these data, bulk density values were determined, which were later used to assess soil compaction and hydro-physical indices. The relationship between bulk density and key soil characteristics is strongly interdependent, especially regarding soil texture and organic matter content. Similar bulk density values can be favorable in sandy soils but entirely unfavorable in clay soils (Amponsah et al., .2025)

Bulk density (BD) was determined using the metal cylinder method with known volume (100 cm³) at the soil's actual moisture content, and is expressed in g/cm³. Knowing the weight of the oven-dried soil (M) in grams and its total volume (Vt) in cm³, including both the solid part (Vs) and the pore space (Vp), the bulk density can be calculated using the formula:

$$BD = M / Vt = M / (Vp + Vs), g/cm^3$$

Most cultivated plants prefer bulk density values between 1.0–1.4 g/cm³ (*Onwuegbunam, D.O. et al., 2025*). Soils are considered too loose when bulk density is below 1.0 g/cm³ and too compacted when above 1.4 g/cm³. Values between 1.0–1.2 g/cm³ are optimal for potato, beet, carrot, parsley, and radish, while 1.2–1.3 g/cm³ are preferred by cereals, corn, and sunflower (*Rusu T. et al., 2009*).

High bulk density values indicate reduced water retention capacity, permeability, and aeration, and increased mechanical resistance to tillage and root penetration. Conversely, low bulk densities can reduce load-bearing capacity, making traffic and agricultural operations more difficult.

It is important to note that soil compaction was influenced by both bulk density values and soil texture class. The indices and formulas used in these determinations followed the methodologies established by *Canarache A. et al. (1990) and Dumitru Elisabeta et al. (2009).*

RESULTS AND DISCUSSIONS

The bulk density of soil represents the ratio between the mass of oven-dried soil and its total volume, thus being a property of the soil as a whole, including both the solid particles and the pore spaces between them (*Canarache A., 1990*). It

is one of the key indicators for assessing the compaction state of soils.

The evaluation of soil compactness based on the bulk density values recorded along the soil profile is conducted in correlation with the textural class of each pedogenetic horizon.

The cambic chernozem located on the marginal part of the Ezăreni plateau, which developed under the influence of forest vegetation, is very loose in the 0–20 cm depth interval, with bulk density values ranging from 0.97 to 1.09 g/cm³ (Fig. 2).

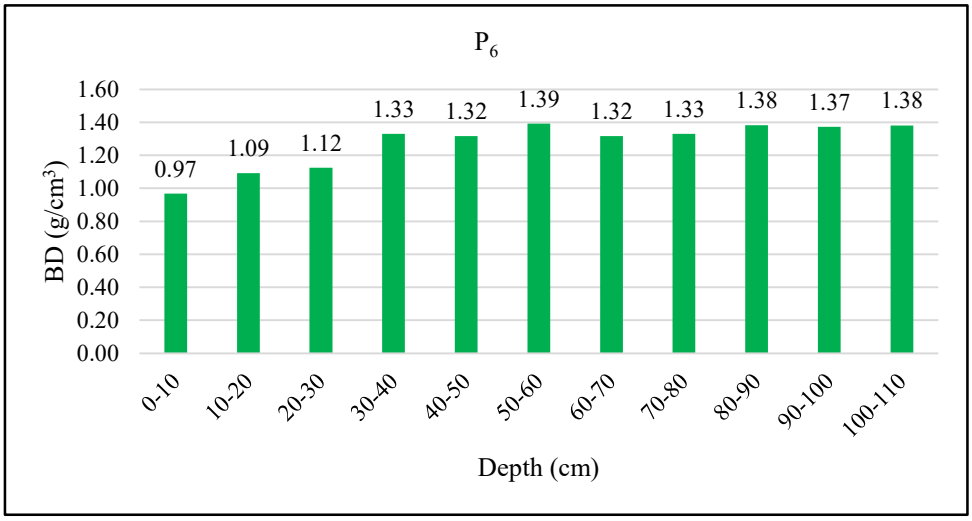

Figure 2. Bulk density values of cambic chernozem (profile 6)

These low bulk density values are due to the high frequency of herbaceous plant roots, including semi-shade species and those that develop early in spring before the leafing of trees and shrubs. In the 20–30 cm depth interval, the average bulk density value is 1.12 g/cm³, indicating a loose soil structure. It is worth noting that starting from 32 cm and down to the base of the profile at 160 cm depth, the soil texture becomes medium clay loam.

The gradual increase in bulk density values within the 0–32 cm depth and the change in textural class between 32–160 cm confirm the aeolian origin of the upper part of the soil profile, as also observed during the morphological description in the field.

In the middle and lower parts of the profile, the soil falls within the uncompacted to slightly compacted category. Notably, the variation range of bulk density values between 32 and 110 cm depth is narrow, ranging from 1.32 to 1.39 g/cm³.

Porosity was determined using undisturbed soil samples collected with metal cylinders of known volume, taken from each soil profile at one-meter depth, in 10 cm increments.

The moderately wind-deposited cambic chernozem from the marginal part of the Ezăreni plateau, developed under forest vegetation, is loose to very loose in the 0–30 cm depth interval, with total porosity values ranging from 56.77% to 62.08% (Fig. 3).

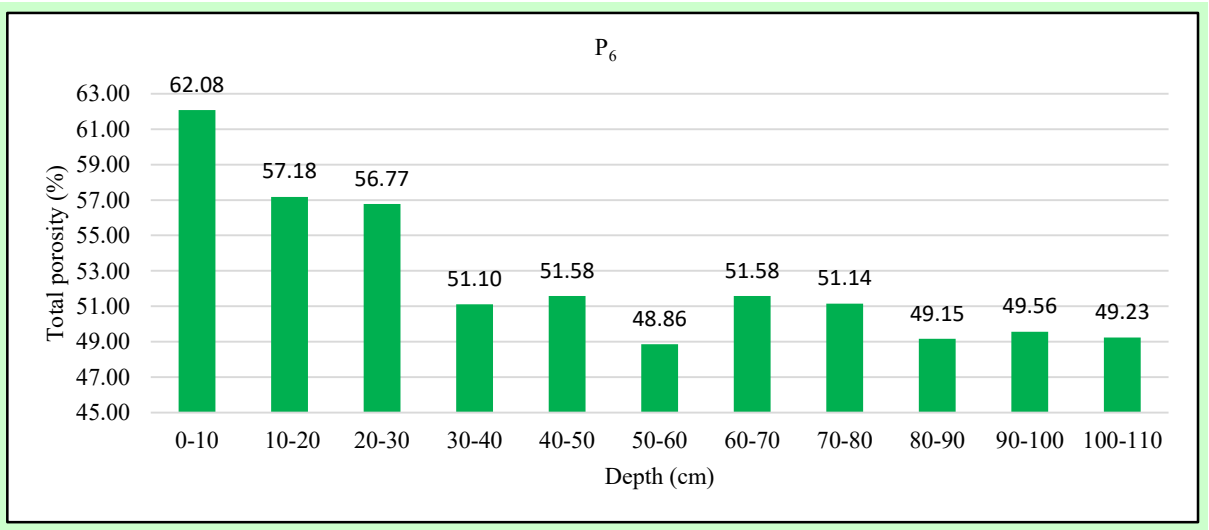

Figure 3. **Cambic chernozem total porosity values (profile 6)**

This is attributed to the higher content of decomposing organic matter and the activity of herbaceous plant roots, which promote good soil structure (*Filipov F., 2005*). The high porosity values are similar to those found in organo-mineral soils of greenhouses or meadows in wetland areas.

Below 30 cm depth, the soil shows relatively uniform total porosity values between 48.8% and 51.58%, corresponding to the slightly compacted category. This narrow range of total porosity values is due to the absence of anthropogenic influence on pedogenetic processes and the soil's physical-chemical properties. The soil has evolved strictly under natural vegetation conditions specific to the area, and under the influence of local pedoclimatic factors. The moderately wind-deposited cambic chernozem shows inactive porosity values between 9.84% and 19.11% v/v (Fig. 4).

The highest inactive porosity values, observed between 50–60 cm depth, are due to the fine texture and moderate compactness of the soil.

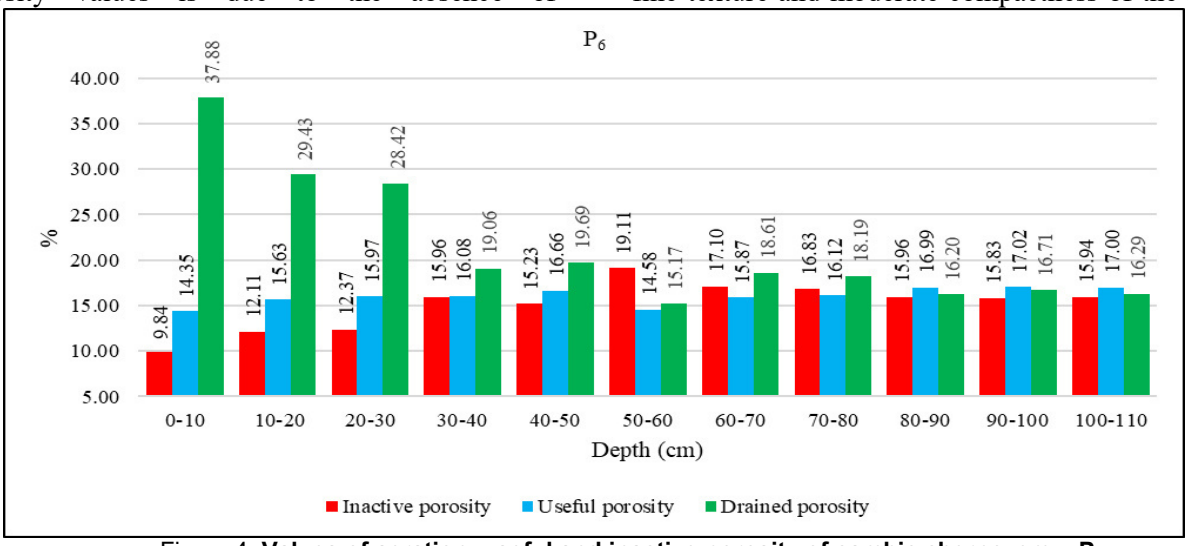

Figure 4. **Values of aeration, useful and inactive porosity of cambic chernozem – P_6**

The proportion of micropores increases within the 0–50 cm depth range and varies within narrow limits between 60–100 cm depth.

The useful porosity, represented by mesopores that retain plant-available water, ranges between 14.35% and 17.02% v/v.

High values of drainage porosity, ranging from 28.42% to 37.88% v/v in the 0–30 cm depth interval, are due to the pronounced looseness of the soil, the high organic matter content, and the presence of undecomposed organic residues.

The slight decrease in drainage porosity between 40–110 cm depth is associated with a moderate increase in soil compaction, as also indicated by bulk density values.

The cambic chernozem in the arable land of the Ezăreni plateau is loose in the topsoil, moderately compacted in the subsoil, and strongly compacted between 80–100 cm depth (Fig. 5).

The moderate soil compaction observed in the cambic B horizon is caused by natural pedogenetic processes such as clay illuviation (responsible for the formation of the cambic B horizon) and changes in the aerohydric regime resulting from frequent wetting–drying cycles, which promote denser packing of structural aggregates.

The presence of a hardpan is also indicated by moderately high bulk density values, reaching 1.58 g/cm³. Notably, there is a slight decrease in density at the 50–60 cm depth interval.

The compacted subsoil layer, identified both macroscopically and through measured bulk density values in undisturbed soil samples, highlights the necessity of deep loosening down to a depth of 50 cm.

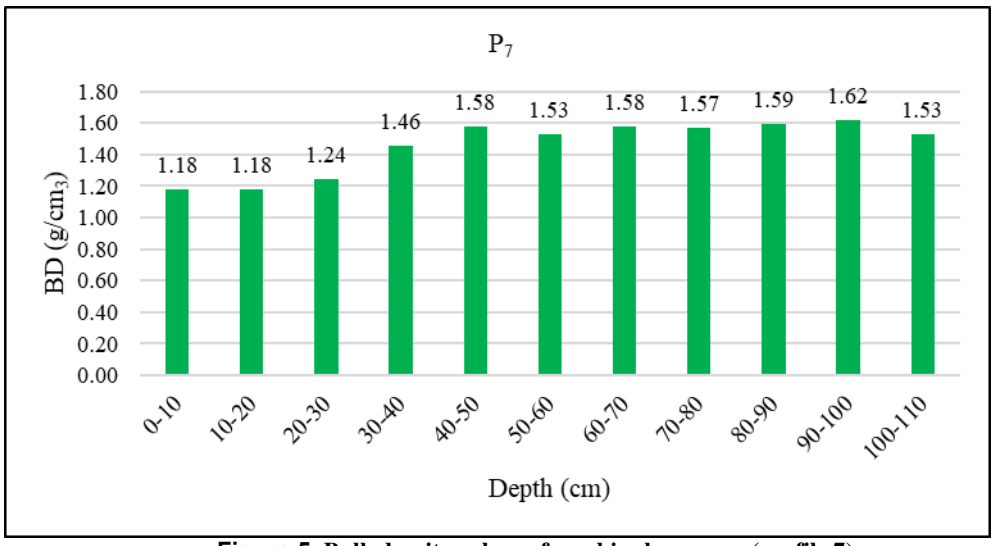

Figure 5. Bulk density values of cambic chernozem (profile 7)

The presence of the hardpan layer hinders water infiltration, root penetration, and intensifies the negative effects of prolonged droughts, which have become more frequent during the studied period.

The cambic chernozem on the arable land of the Ezăreni plateau is loose in the ploughed layer, moderately compacted in the subsoil, and strongly compacted at a depth of 80–100 cm (Fig. 6).

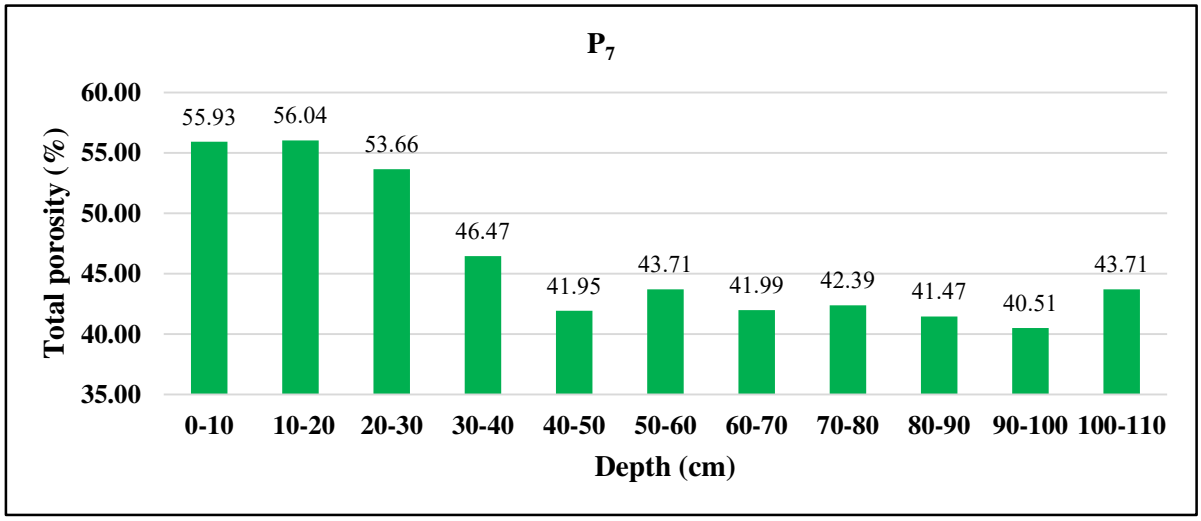

Figure 6. Cambic chernozem total porosity values (profile 7

The surface horizon (0–30 cm) is loose, with total porosity values ranging between 53.66% and 56.04%, which is due to plowing performed under normal soil moisture conditions. It is considered that the plowed layer is well-tilled and loosened when the total porosity falls within the range of 48–55%.

The underlying layer is moderately compacted, with total porosity (TP) values between 41.95% and 46.47%, and corresponds to the presence of a hardpan layer—a subhorizon strongly influenced by tillage, which is a direct result of anthropogenic activities specific to crop cultivation.

The lowest TP value is found at a depth of 80 cm, measuring 40.51%, where the soil is heavily compacted due to the lithological substrate.

In the plowed layer of the cambic chernozem from the arable land of the Ezăreni plateau, the values of drainable porosity range between 22.16% and 25.37% v/v. The share of mesopores, which retain the available water that can gradually be absorbed by plant roots, is approximately 15% v/v (Fig. 7).

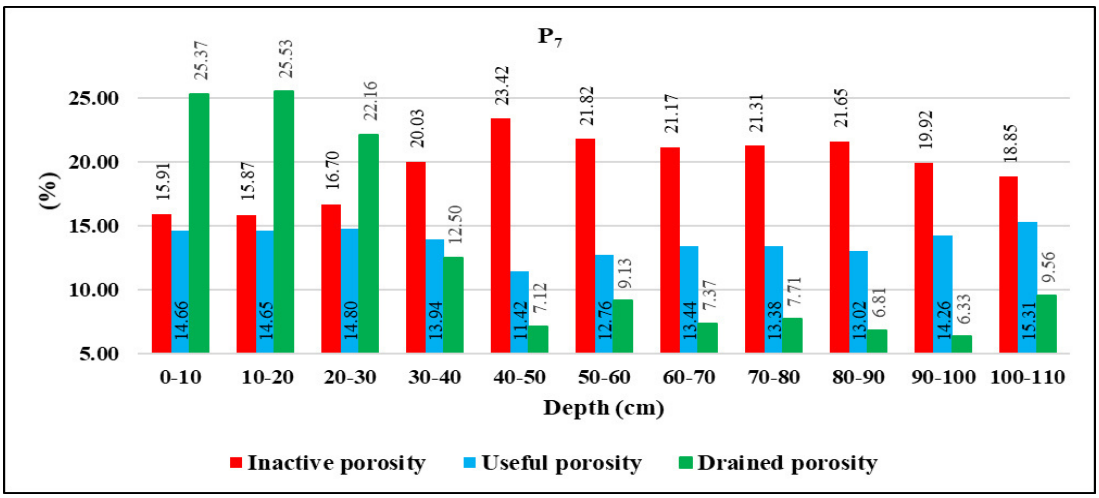

Figure 7. Values of aeration, useful and inactive porosity of cambic chernozem

The values of inactive porosity in the arable layer range between 15.87% and 16.7% v/v.

The compaction state of the subsoil layer can be expressed both through soil pedomorphological indicators, through laboratory analytical data of bulk density, and through the values of the ratio between the volume occupied by macropores, mesopores, and micropores.

In the depth interval of 30-40 cm, the value of the draining porosity was 12.5% v/v, which is 4.8% v/v higher than the lower part of the hardpan layer. This difference is due to plowing at different depths during the establishment of autumn and spring crops.
It is noteworthy that in the lower part of the compacted layer, the minimum value of draining porosity is recorded at 7.12% v/v. When the soil moisture is at field capacity, an aeration deficit of 3.88% v/v is recorded.

The variation range of the draining porosity value in the 50-100 cm depth interval is between 6.33% and 9.56% v/v. With a current water content at field capacity, soil aeration in these layers is weak and moderately deficient.

It is also important to mention that in the 100–110 cm depth interval, the soil compaction decreases, as evidenced by the slight increase in aeration porosity by 3.2% v/v.

The increase in draining porosity and, implicitly, in aeration porosity is due to changes in the soil's granulometric composition and lithological discontinuity, highlighted by the dust/sand ratio value.

The values of usable porosity range from 11.42% to 15.31% v/v. The lowest values, 11.42% and 12.76% v/v, are recorded in the 40–60 cm depth interval.

The range of inactive porosity values recorded in the soil profile is broader, falling between 15.87% and 23.42% v/v.

From the distribution of draining, usable, and inactive porosity values across the profile, it is evident that as soil compaction intensifies, the proportion of macropores decreases, while the volume occupied by micropores, which define inactive porosity, increases concurrently.

CONCLUSIONS

The land use on the La Podiș hill plateau has influenced the development of soils, with the thickness of the humus accumulation horizon and the depth at which calcium carbonate appears being greater in soils developed under forest vegetation compared to those on arable land.

The manifestation of the wind erosion process on the surface of the plowed layer during the winter season, along with the stronger compaction of the sub-arable soil layer, has led to a reduction in the depth at which the calcium carbonate accumulation horizon appears.

The texture of the soils on the Ezăreni plateau is fine, and the maximum clay content is found in the AB transition horizon, where a morphologically uniform decreasing distribution of humus is observed.

The Cambic Chernozem on the marginal part of the Ezăreni plateau, developed under the influence of forest vegetation, is very loose in the 0-20 cm depth range, with bulk density values between 0.97 – 1.09 g/cm³. The gradual increase in soil compaction and the modification of the soil texture class at the depth range of 32-160 cm confirms the aeolian origin of the upper soil layer.

The cambic chernozem on the arable land of the Ezăreni plateau is loose in the plowed layer, moderately compacted in the sub-arable layer, and strongly compacted in the 80-100 cm depth range.

The moderate compaction of the middle part of the cambic chernozem on the plateau is due to the process of clay illuviation and the

aerohydric regime, which has favored a denser packing of soil aggregates.

The average value of the draining porosity in the upper part of the hardpan layer, which is 4.8% higher than that recorded in the lower part, is due to the plowing carried out at different depths when establishing autumn and spring crops.

From the distribution of macropores, mesopores, and micropores along the Cambic Chernozem profile, it is observed that as soil compaction intensifies, the proportion of macropores decreases, and the volume occupied by micropores, which define inactive porosity, increases simultaneously.

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RESEARCH CONCERNING CONTROL OF THE LARGE CABBAGE WHITE (*PIERIS BRASSICAE*) LARVA IN THE OILSEED RAPE CROP FROM SOUTH-EAST ROMANIA

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Abstract

Large cabbage white (*Pieris brassicae*) was considered a secondary pest of the oilseed rape (OSR) crop during the autumn period in Romania and a primary pest of the cabbage crop. This study monitored the attack of the *P. brassicae* larva on both OSR untreated and treated seeds with cyantraniliprole active ingredient (625 g/l) at the experimental field from NARDI Fundulea, located in the southeast of Romania between 2019 and 2021. In the autumn of 2019, on 28 October, at OSR untreated plants, the attack degree was 12.49 %, while at the seed-treated variant, the attack degree was 4.30 %. On 6 November, the attack degree was 38.58 % in the untreated variant, while in the treated variant, it was 8.77 %. In the autumn of 2020, it registered higher attacks from this study. On 11 November, the attack degree was 53.07% in the untreated variant, while in the treated variant with cyantraniliprole a.i. the attack degree was 22.14%. In 2021, it didn't register the attack of this pest in the experimental field. A possible explanation is the delayed emergence of the OSR plants at the end of October. Regarding pest density, this study shows that in the autumn of 2019, on 6 November, the untreated variant registered 4.24 larvae/m^2 and 2.32 larvae/m^2 in the treated variant. In the autumn of 2020, on 2 October, the untreated variant registered 4.82 larvae/m^2 and 2.57 larvae/m^2 in the treated OSR variant. On 11 November, the pest density was higher than the economic damage threshold at both variants. This study reveals a higher attack of the large cabbage white at OSR crop in southeast Romania, compared with results from the previous studies. At the same time, it registered higher pest' attacks in November.

Key words: oilseed rape, pests, higher attack

Oilseed rape (OSR) is one of the most important crops in Romanian agriculture due to its multiple advantages, such as the attractive price for the farmers and good previous crop for cereals (Hăjmăjan H. *et al*, 2012; Popescu A., 2020; Micu M.M. *et al*, 2023). The area cultivated with OSR in Romania ranged from 352622 ha in 2019 to 641425 in 2023 (MADR data, 2024). OSR crops have many abiotic challenges for Romanian farmers, such as drought from the sowing period or frosts during the winter (Grosz D., Tabără V., 2012; Hess L. *et al*., 2015; Marinică, 2019; Pullens, J.W.M., *et al*., 2021). Pests represent one of the most limiting biotic stress factors for this crop in the geographical space of Romania (Popov C., Bărbulescu A., 2007; Râșnoveanu L., 2011a,b; Buburuz A.A. *et al*, 2013; Buzdugan L., Nastase D., 2013; Georgescu E. *et al*, 2015, 2020; Trotuș E. *et al*, 2001, 2011, 2019, 2020; Trașcă F. *et al*, 2019). Research made in our country concluded that higher pest pressure for OSR crops occurred in the autumn, after the plants' emergence and early vegetation stages, but in the spring too, when plants are in buds formation-flowering stage-early maturity stage (Popov C., Bărbulescu A., 2007; Trotuș E. *et al*, 2009; Râșnoveanu L., 2010; Buburuz A.A. *et al*, 2012; Buzdugan L., Nastase D., 2013; Ursache P.L. *et al*, 2017). In the last 20 years, in Central Moldavia, Romania, and the southern parts of this country, the flea beetles (*Phyllotreta* spp. and *Psylliodes chrysocephala*) represent more than 25 % of harmful insect species from OSR crops and one of the predominant species that attack in the autumn (Trotuș E. *et al,* 2009; Bucur A., Roșca I., 2011; Georgescu E. *et al*, 2015, Trașcă F. *et al*, 2019). In some years, with warm autumns, sawfly larvae (*Athalia rosae*) can produce higher damage at OSR plants (Râșnoveanu L., 2011b; Buburuz A.A. *et al*, 2012; Răileanu M.P., Tălmaciu M., 2013; Raicu A.D, Mitrea I., 2020; Trotuș *et al*, 2020, 2022). However, there were not many Romanian papers concerning the large cabbage white larva (*Pieris brassicae*) attack on the OSR crop in the autumn. Only a few studies have mentioned the presence of this pest in the OSR fields but with lower densities (Bucur A., Roșca I., 2011; Râșnoveanu L., 2011b; Trotuș *et al*., 2020, 2022). It was considered a primary pest for cabbage crop (Patriche G. *et al*, 2005; Mustață G., Mustață M., 2013; Iabloncik

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A.R. *et al*., 2022; Iosob G.A. *et al*, 2020, 2023). In recent years, our previous research has revealed that in the south-east of Romania, in autumn, there was a higher attack of the green peach aphid (*Myzus persicae*) and diamondback moth larva at OSR crops (Georgescu E. *et al*., 2020, 2023). The higher pest population of these pests was in late autumn, in November, and even in the first half of December, in the years with warm autumns. Climate change was a possible explanation for the higher attack of the pest species, which is considered secondary for OSR crops (Courson E. *et al*., 2015; Fricke U. *et al*., 2022). In Romania, in the last years, in many areas, the average air temperatures during the autumn season were higher than multiyear averages while rainfall decreased (Marinică I., Marinică A., 2019; Tudose T., Moldovan F., 2020). High temperatures and drought can increase the pest attack on main crops, including pests at OSR (Popov C. *et al*, 2006; Deutsch C.A. *et al*, 2018). In the Romanian literature, there wasn't information concerning high atrak of the the large cabbage white larva at OSR crops in warmer autumn conditions. In this paper, the authors present a study regarding the behavior of this pest in autumn in southeast Romania; at OSR untreated plants and OSR seeds treated with cyantraniliprole active ingredient.

MATERIAL AND METHOD

Experimental design

The field trial was carried out at the Agricultural Engineering Laboratory from the National Agricultural Research and Development Institute (NARDI) Fundulea, Călărași County, Romania (latitude: 44.46; longitude: 26.32; alt.: 68.00 m), in the autumn, three years, between 2019 and 2021.

Each year, the OSR crop was sown using the Wintersteiger Plotseed TC, A-4910 machine. The previous crop was barley. The distance between rows was 25 cm, the sowing depth was 3 cm, and the sowing density was 60 seeds/m^2. In this experience, it has planted a PT275 hybrid.

In 2019, OSR was sowed on 6 September, the beginning of plants' emergence was on 24 September, while full plant emergence was on 12 October. In 2020, OSR was sowed on 10 September, the beginning of plants' emergence was on 14 September, while full plant emergence was on 14 September. In 2021, OSR was sowed on 10 September; the beginning of plants' emergence was on 21 October, while full plant emergence was on 27 October. Because of the drought, OSR full emergence was registered at 35 days from the sowing.

This study has two variants: untreated plants (control variant) and seed treatment with the ***cyantraniliprole*** active ingredient, a diamide insecticide from the ryanoid class (Selby T.P. *et al*, 2013). Each variant has an area of 2500 m^2. *Table 1* presents the experimental variants and active ingredients.

Table 1

Experimental variants at OSR crop, during autumn, at NARDI Fundulea, 2021

Nr. crt.	Variant	Active ingredient	Dose
1	Untreated (control)	—	—
2	Lumiposa (seed trt.)	cyantraniliprole (625 g/l)	0.114 l/To seeds

Assessments in the field

Assessments concerning large cabbage white larva *(P. brassicae*) **attack degree (AD%)** at the OSR crop were made four times:

- when plants were in the 1-2 leaves stage (BBCH 11-12);
- when plants were in the 2-3 leaves stage (BBCH 12-13);
- when plants were in the 4-5 leaves stage (BBCH 14-15);
- when plants were in the 6-8 leaves stage (BBCH 16-18).

Each variant was established with 10 assessment points. At each point, it assessed 100 plants from 4 rows in the stair system (25 plants/row). The distance from the first assessment point and plot margins was 10 m. Plants were photographed with a Panasonic Tz-200 camera in Macro mode. The camera lens was placed 10 cm from the OSR plants. Photos of all OSR plants from the assessment points were downloaded and analyzed on a computer desk.

The pest attack degree, AD (%), was calculated after the formula presented below, where F(%) is attack incidence (number of the attacked plants from the total number of analyzed plants), and I(%) is large cabbage white larva attack intensity:

$$AD(\%)=[F(\%)*I(\%)]/100$$

The assessments concerning the large cabbage white **larvae counting** from the OSR field experiment were made simultaneously with those concerning the pest attack degree.

Meteorological data

It was provided by Meteo station of the NARDI Fundulea, placed at 2000 m from the experimental field. It has monitored daily air temperature and rainfalls during the autumn of 2019-2021 (September-November).

Statistical analysis

Data from the field assessments were **statistically analyzed** with the Student-Newman-Keuls test (Student, 1927; Neuman D., 1939; Keuls M., 1952) using ARM 2022 software (Gylling Data Management, 2022). The results of this field trial were presented as the mean values for flea beetles' attack intensity or attack degree, plant

density, the standard deviation from the average values (SD), and the coefficient of variation (CV).

Table2

Attack degree (%) of large cabbage white (*Pieris brassicae*) at OSR trial in the autumn of the year 2019

Nr. crt.	Variant (active ingredients)	Attack degree (AD %)							
		15 October		23 October		28 October		6 November	
1.	Check (untreated)	0	a	0	a	12.50	a	38.58	a
2.	cyantraniliprole (625 g/l) seed treatment	0	a	0	a	4.30	b	8.77	b
LSD (P=0.05)		0		0		2.896		6.121	
Standard deviation (SD)		0		0		1.287		2.721	
Variation coefficient (C.V.)		0		0		15.330		11.490	

Means followed by the same letter do not significantly differ (P=.05, Student-Newman-Keuls test)

Table 3

Population density (%) of large cabbage white (*Pieris brassicae*) at OSR trial in the autumn of the year 2019

Nr. crt.	Variant (active ingredients)	Number of larva/m^2							
		15 October		23 October		28 October		6 November	
1.	Check (untreated)	0	a	0	a	3.26	a	4.24	a
2.	cyantraniliprole (625 g/l) seed treatment	0	a	0	a	2.28	b	2.32	b
LSD (P=0.05)		0		0		1,449		0,687	
Standard deviation (SD)		0		0		0,644		0,305	
Variation coefficient (C.V.)		0		0		23,250		9,320	

Means followed by the same letter do not significantly differ (P=.05, Student-Newman-Keuls test)

Table 4

Attack degree (%) of large cabbage white (*Pieris brassicae*) at OSR trial in the autumn of the year 2020

Nr. crt.	Variant (active ingredients)	Attack degree (AD %)							
		24 September		2 October		12 October		11 November	
1.	Check (untreated)	6.54	a	45.71	a	48.32	a	53.07	a
2.	cyantraniliprole (625 g/l) seed treatment	2.36	a	7.16	b	9.24	b	22.14	b
LSD (P=0.05)		1.480		8.533		9.257		8.320	
Standard deviation (SD)		1.463		8.435		9.151		8.225	
Variation coefficient (C.V.)		32.890		31.910		31.800		21.870	

Means followed by the same letter do not significantly differ (P=.05, Student-Newman-Keuls test)

Table 5

Population density (%) of large cabbage white (*Pieris brassicae*) at OSR trial in the autumn of the year 2020

Nr. crt.	Variant (active ingredients)	Number of larva/m^2							
		24 September		2 October		12 October		11 November	
1.	Check (untreated)	0.78	a	4.82	a	4.03	a	3.53	a
2.	cyantraniliprole (625 g/l) seed treatment	0.51	b	2.57	b	2.31	b	2.81	b
LSD (P=0.05)		0.373		0.719		0.542		0.450	
Standard deviation (SD)		0.368		0.711		0.536		0.444	
Variation coefficient (C.V.)		57.090		19.250		16.920		14.020	

Means followed by the same letter do not significantly differ (P=.05, Student-Newman-Keuls test)

Table 6

Attack degree (%) of large cabbage white (*Pieris brassicae*) at OSR trial in the autumn of the year 2021

Nr. crt.	Variant (active ingredients)	Attack degree (AD %)							
		12 November		19 November		26 November		3 December	
1.	Check (untreated)	0	a	0	a	0	a	0	a
2.	cyantraniliprole (625 g/l) seed treatment	0	b	0	b	0	b	0	b
LSD (P=0.05)		0		0		0		0	
Standard deviation (SD)		0		0		0		0	
Variation coefficient (C.V.)		0		0		0		0	

Means followed by the same letter do not significantly differ (P=.05, Student-Newman-Keuls test)

Table 7

Population density (%) of large cabbage white (*Pieris brassicae*) at OSR trial in the autumn of the year 2021

Nr. crt.	Variant (active ingredients)	Number of larva/m^2							
		12 November		19 November		26 November		3 December	
1.	Check (untreated)	0	a	0	a	0	a	0	a
2.	cyantraniliprole (625 g/l) seed treatment	0	b	0	b	0	b	0	b
LSD (P=0.05)		0		0		0		0	
Standard deviation (SD)		0		0		0		0	
Variation coefficient (C.V.)		0		0		0		0	

Means followed by the same letter do not significantly differ (P=.05, Student-Newman-Keuls test)

RESULTS AND DISCUSSIONS

During the assessment period, weather conditions at the experimental site from NARDI Fundulea were favorable for pest development and attack. In 2019 and 2020, average temperatures registered in September, October, and November were higher than the 50-year average (*figure* 1). The highest deviation from the average was recorded in November (+4.9 °C) 2019, September (+3.3 °C), and October (+3.4 °C) 2020.

Figure 1. **Average temperatures registered at NARDI Fundulea in autumn between 2019 and 2021**

In 2021, the average temperature registered in September was slightly lower than the 50-year average (-0.2 °C), while in October, the same year, the average temperature was lower than the average (-1.1 °C). These were only two autumn moons with a negative deviation from the average temperature value from this study period (2019-2021). Meteorological data registered at NARDI Fundulea, the experimental site, reveal that, generally, rainfalls from autumn months were below the average from 2019 to 2021 (*figure 2*). A higher negative deviation from the average was registered in September 2019 and 2021. Only in two autumn months from the three-year study were rainfalls higher than the averages. However, in September 2020, more than 86 % of the rainfall from this month was registered only in one day (4 September). The draught from the autumn can delay the OSR emergence and intensify the attack of the pests (Olesen J.E., 2010; Buzdugan L., Nastase D., 2013; Fricke U. *et al*., 2022).

Data from *Table 2* show a large cabbage white larva attack degree of 12.50 %, while in the variant with treated seeds, the attack was low. On 6 November, it registered a higher pest attack on plants from the control variant (AD=38.58 %).

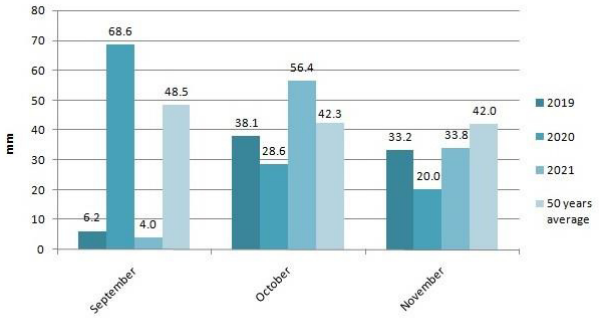

Figure 2. **Average rainfalls registered at NARDI Fundulea in autumn between 2019 and 2021**

At the same time, the pest attack degree at the treated seeds variant was 8.77 %. In both cases, there were significant statistical differences between the attack degree registered at the control variant and the attack registered at the variant with treated seeds ($p<0.05$). In 2019, on 28 October, pest density was 3.26 larva/m^2 in the control variant and 2.28 larva/m^2 in the treated variant, while, on 6 November, it registered 4.24 larva/m^2 in the control variant and 2.32 larva/m^2 in treated variant (*table* 3). In both cases, significant statistical differences were registered between the control and treated variants ($p<0.05$). In the autumn of 2020, it registered higher attacks of the large cabbage white larva from this study period. At the end of September, the attack degree was 6.54 % in the control variant, while in the treated variant, it was 2.36 %. At the beginning of October, the pest attack degree increased to 45.71 %, while at the treated seeds variant, the attack degree was 7.16 % (*table 4*). In the first half of November, the attack degree was higher than 53 % in the control variant, while in the treated variant, the attack degree was 22 %. All assessments from the autumn of 2020 have registered significant statistical differences between the two variants ($p<0.05$). Data from *Table 5* show high pest density at the control variant in the first half of

October and November. Also, the treated variant registered high pest density in October and the first half of November. Even though it has registered higher statistical differences between pest density at the control and treated variant, in October and November, in both cases, the pest population on OSR crop was higher than the economic damage threshold for this species (>2-3 larva/m^2). In the autumn of 2021, it didn't register an attack of the large cabbage white larva (*tables 6 and 7*). A possible explanation is the late emergence of the OSR plants because of the drought from September and less favorable conditions for the pests in the last half of November when plants were in the BBCH 14-16 stage. This is the first paper from the Romanian literature that shows a higher attack of the large cabbage white larva (*P. brassicae*) at an oilseed rape crop in the southeast of Romania. At the same time, the first paper from the Romanian literature reveals high pest attacks and population density at OSR plants in the first half of November in warm autumns.

CONCLUSIONS

In this study, the weather conditions from autumn were favorable for large cabbage white larva attacks at OSR plants. Generally, the average month temperature in September, October, and November (2019-2021) was higher than the 50-year average, while rainfall was below the average. In the autumns of 2019 and 2020, it registered high pest attacks at OSR plants in October and the first half of November. In 2021, it didn't register pest attacks on OSR crops from this study.

Seed treatment with the active ingredient *cyantraniliprole* effectively protects OSR plants in the first vegetation stages. However, in the warm autumn of November 2020, the larva attack was also higher in the treated variant. If larva density is higher than the economically damaging threshold, foliar treatment with an insecticide is needed to protect the plants against this pest.

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