ELEMENTS REGARDING THE PROTEOLYSIS AND LIPOLYSIS OF REFRIGERATED MEATS AND FAT FROM THE MANGALITSA BREED

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Abstract

In the case of the present research, we wanted to know and evaluate the proteolytic and lipolytic transformations and changes that intervene in the intimacy of the meat-raw material and fat, obtained from the Mangalitsa pig breed and preserved by refrigeration, for different periods of time.

The need to determine such sensory and physico-chemical transformations, appearing during the conservation period in some animal products, is of great interest in the spectrum of the evolution of some quantitative and qualitative parameters and their correlation with the state of freshness and the optimal storage time, in order to know as accurately as possible the term of validity and durability of a food product, as well as to ensure consumer protection.

In order to study the proteolytic and lipolytic changes in pork, which appeared during the refrigerated storage period, work was done on a number of 20 carcasses, the samples required for the analyzes being collected before the meat was refrigerated at 0-4°C and then at intervals of 2, 5, 7, 9 and 11 days of storage. The control sample and the experimental samples were taken from the muscles of the rump and the back fat.

According to the results obtained, regarding the lipolytic changes, their nature was hydrolytic and oxidative, these transformations being highlighted by determining the free acidity, in the first case, and by determining the peroxide index (PV), the iodine index (IV), of the content in malondialdehyde (MDA-TBARS), epihydrinic aldehyde and fatty acids, in the second case.

Carrying out such research has a special role because, for example, oxidation products existing in food and absorbed in the human body have a combined action on the enzyme system, on the use of vitamins and proteins.

As for the proteolytic modifications, they were initially located in a beneficial proteolytic register, not exceeding certain limits, a fact characterized by the improvement of nutritional-biological properties, but later harmful forms for the consumer also developed, appearing factors such as biogenic amines (histamines, betaines, etc.) or toxic compounds, such as iodine, hydrogen sulphide, phenols, mercaptans and ammonia.

Conclusively, we can state that the lipolytic changes depend on the morphological structure of the meat, the presence of marbling and pearling, the content of saturated and unsaturated fatty acids and the ratio between them, the duration and conditions of storage, the type of salting, the presence of heavy metals, pesticides, the presence of hemoglobin and the intensity of enzymatic activity (lipooxidase action).

As for the dynamics of proteolysis in the redirected pork, it was influenced by the age of the animal, the fineness of the muscle fiber, the ratio between the interfibrillar and interfasciolar connective tissue, the freezing temperature, the degree of biotic pollution of the meat, the nature of the biota, etc.

Key words: *proteolysis, lipolysis, refrigerated meat, Mangalitsa*

INTRODUCTION

Although refrigeration is considered more of a method of preserving and not preserving pork, the proteolytic and lipolytic reactions that occur influence and accelerate the appearance of some categories of changes that can generate new decisions regarding the method of valorizing fresh meat and eventual semi-processing of it.

Knowing and evaluating the lipolytic and proteolytic changes, as well as the favoring factors, allows an optimization of the storage

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period and the possibility of maintaining the optimal microclimate parameters, thus avoiding the occurrence of sensory and nutritional deterioration phenomena of refrigerated meat.

MATERIAL AND METHODS

In order to determine the lipolytic and proteolytic changes in pork meat, which appeared during the refrigerated storage period, work was carried out on a number of 20 carcasses, obtained from castrated males and females belonging to the Mangalitsa breed, the variety red-brick, with body weights at slaughter of over 130 kg, the samples required for the analyzes being collected before the carcasses are refrigerated at 0-4°C and then at intervals of 2, 5, 7, 9 and 11 days of storage. The control sample and the experimental samples were taken from the muscles of the anterior calf (back region), of the croup (m. *Gluteus medius*) and from the back muscles (m. *Longissimus dorsi*).

For proteins, the pH of the samples, the humidity, the total nitrogen, the ammoniacal nitrogen were determined and the amino acids were dosed.

For lipids, in order to assess the hydrolytic transformations, the free acidity was determined, and the oxidative processes were highlighted by determining the peroxide index (PV), the content in malondialdehyde (MDA-TBARS), in epihydric aldehyde and the content of the samples in fatty acids.

RESULTS AND DISCUSSIONS

a. Knowing *the level of proteolytic changes* allows optimizing the storage period of raw meat (carcasses, half-carcasses, anatomical parts and butchery specialties), in order to prevent the appearance of some alteration changes, which can affect the sanitation and safety of the meat for consumption.

Also, the knowledge of proteolytic modifications gives the possibility to generate and use the maturation factor, which has an important role in the sensory-nutritional and technological qualities of the meat, as well as in digestion, by increasing the coefficient of digestive utilization of the meat, as the amino acid content increases .

If the proteolysis exceeds the ripening phase, harmful compounds may appear in the products, either intermediate types such as mercaptans, iodine, hydrogen sulphide, phenols, ammonia, etc. or end type, such as biogenic amines.

The samples for the determinations were taken from a number of 20 carcasses (60 samples), of males and females belonging to the Mangalitsa breed, the red-brick variety, collected before the carcasses were refrigerated at 0-4°C and then at intervals of 2, 5, 7,9 and 11 days of storage-storage

The control sample (P0) and the experimental samples (P1-P5) were taken from the muscles of the croup (*Gluteus medius*), the results obtained being detailed in tab. 1.

Table 1 Dynamics of physico-chemical transformations in refrigerated Mangalitsa red pork meat

N = 60

Sample code	Harvest time	Statistical estimators	Moisture (g%)	Proteins (g%)	pH value	Total nitrogen (g%)	Aminic nitrogen (mg%)	Ammonia (mg%)	Total amino acid content (mg/g)
P.0	Before refrigeration	$\bar{X}\pm s_{\bar{X}}$	72.12 ±0.40	73.70 ±0.20	5.62 ±0.23	2.67 ±0.32	119.0 ±5.10	17.12 ±0.42	89.12 ±6.31
P.1	After 2 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	71.83 ±0.16	73.43 ±0.13	5.81 ±0.10	2.60 ±0.10	120.23 ±1.20	18.53 ±0.16	89. 42 ±2.46
P.2	After 3 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	70.27 ±0.44	72.25 ±0.48	5.90 ±0.60	2.53 ±0.32	135.17 ±4.31	19.68 ±0.23	95.08 ±1.40
P.3	After 7 days refrigeration	$\bar{X}\pm s_{\bar{X}}$ "t" signif.	69.84 ±0.21 *	71.83 ±0.56 *	6.18 ±0.61 *	2.48 ±0.12 *	139.43 ±2.16 *	24.19 ±0.31 *	104.12 ±3.03 *
P.4	After 9 days refrigeration	$\bar{X}\pm s_{\bar{X}}$ "t" signif.	69.12 ±0.76 *	71.28 ±0.17 *	6. 24 ±0.31 *	2.37 0.07 *	146.85 ±2.16 **	28.87 ±0.32 **	156.45 ±3.60 **
P.5	After 11 days refrigeration	$\bar{X}\pm s_{\bar{X}}$ "t" signif.	68.53 ±0.17 **	70.87 ±0.12 **	6.33 ±0.13 **	2.23 ±0.09 **	148.0 ±5.65 **	30.83 ±0.12 **	213.32 ±8.43 **

Note:* $p < 0.05$; ** $p < 0.01$

The analysis of the data in table 1 highlights the fact that during refrigerated storage, pork from the Mangalitsa breed registers an increase in pH, from 5.62±0.23 (before refrigeration) to 6.33 ±0.13 units (after 11 days), a decrease in moisture, in the same 11-day interval, from 72.12±0.40 % to 68.53 ±0.17 %, of protein substances, from 73,70±0.20% to 70.87±0.17%, and of total nitrogen, from 2.67±0.32% to 2.23±0.09%.

As a consequence of the proteolytic enzyme activity, ammonia increased from 17.12±0.42 mg % to 30.83±0.12 mg %, and amino nitrogen from 119±5.10 mg to 148 ±5.65mg %.

The total amino acid content increased from an average of 89.12±6.31mg/g, before refrigeration, to 213.32±8.43mg/g, after 11 days of keeping the meat at 0÷4°C.

The results of the undertaken research fall within the data of some specialized studies, in which it is certified that the temperature is a determining factor that influences the proteolytic changes in the meat; the lower the temperature, the slower the proteolysis takes place, but without stopping completely. Also, proteolytic changes can be influenced by other internal factors, such as breed specialization, age, fattening status, morphological structure and hygienic quality of the meat.

Highlighting the dynamics of the amino acid content of Mangalitsa pork, during the refrigerated storage period, shows that there is a change and a reduction in the general weight of some amino acids, compared to the total amino acid content of the collected samples, a fact due both to the inhibition of some enzyme systems, as a result of refrigeration, as well as an exacerbation of the activity of other amino acids, as a result of the creation of new relationships between enzymes and the degradation substrate (tab. 2).

According to tab. 2, pork meat stored in a refrigerated state, towards the end of storage, has higher amounts of Lysine (8.03 mg/g protein), Arginine (6.42 mg/g protein), Leucine (7.73 mg/ g protein), Aspartic Acid (10.48 mg/g protein), Valine (5.27 mg/g protein), and smaller amounts of Methionine (2.52 mg/g protein), Cystine (2.27 mg/ g protein) and Proline + Alanine (2.28 mg/g protein), although the pork was enriched in the entire spectrum of amino acids.

In the pre-refrigeration state, the total free amino acid content was 71.66 mg/g crude protein, so that after 5 days of refrigeration it reached 73.37 mg/g crude protein, after 9 days this content increased to over 74 mg amino acids /g, and at 11 days to record 75.70 mg/g crude protein.

Table 2 Evolution of the content of free amino acids in the refrigerated meat of red Mangalitsa

N = 60

No.	Amino acid type	The content in free amino acids (mg/g proteină)					
		Before refrigeration	After 2 days of refrigeration	After 5 days of refrigeration	After 7 days of refrigeration	After 9 days of refrigeration	After 11 days of refrigeration
1.	Leucine	7.25	7.30	7.42	7.51	7.60	7.73
2.	Izoleucine	4.51	4.58	4.66	4.80	4.88	4.92
3.	Tyrosine	3.36	3.38	3.47	3.50	3.53	3.58
4.	Methionine	2.35	2.38	2.40	2.44	2.49	2.52
5.	Proline + Alanine	1.90	2.01	2.12	2.19	2.23	2.28
6.	Threonine	2.62	2.65	2.69	2.71	2.78	2.84
7.	Phenyalanine	3.05	3.12	3.19	3.25	3.29	3.32
8.	Histidine	3.15	3.18	3.22	3.27	3.32	3.37
9.	Arginine	6.26	6.29	6.35	6.38	6.40	6.42
10.	Lysine	7.86	7.89	7.93	7.96	7.99	8.03
11.	Cystine	2.10	2.13	2.17	2.20	2.24	2.27
12.	Serin	4.25	4.28	4.33	4.37	4.41	4.46
13.	Glycine	3.22	3.27	3.32	3.38	3.41	3.45
14.	Valine	5.02	5.08	5. 12	5.18	5.21	5.27
15.	Glutamic acid	4.56	4.59	4.63	4.67	4.70	4.76
16.	Aspartic acid	10.20	10.27	10.35	10.38	10.43	10.48
Total		71.66	72.40	73.37	74.19	74.91	75.70

Table 3 Dynamics of lipolytic transformations in the refrigerated red Mangalitsa pork fat

N= 60

Sample code	Harvest time	Statistical estimators	Moisture fat (%)	Total fat (%)	Acidity acid (g% oleic)	Iodine index (gI%)	Peroxide index (meq O2/kg)	MDA (mg/kg)	Aldehydes
G0	Before refrigeration	$\bar{X}\pm s_{\bar{X}}$	42. 8 ±0.12	37.4 ±0.31	0.46 ±0.003	68.3 ±0.11	0.85 ±0.07	0.25 ±0.008	-
G1	After 2 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	42.0 ±0.35	37.1 ±0.07	0.58 ±0.005	67.8 ±0.04	1.2 ±0.06	0.32 ±0.014	-
G2	After 3 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	41.6 ±0.13	36.8 ±0.15	0.65 ±0.007	66.8 ±0.28	1.56 ±0.01	0.55 ±0.017	-
G3	After 7 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	41.0 ±0.27	36.2 ±0.18	0.72 ±0.001	66.2 ±0.14	1.64 ±0.04	0.63 ±0.008	traces
G4	After 9 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	40.8 ±0.71	35.7 ±0.06	0.78 ±0.004	65.8 ±0.14	1.76 ±0.08	0.83 ±0.008	traces
G5	After 11 days refrigeration	$\bar{X}\pm s_{\bar{X}}$	40.2 ±0.13	35.3 ±0.74	0.83 ±0.008	65.2 ±0.33	1.83 ±0.07	1.30 ±0.004	traces

b). Data on lipolytic transformations

According to specialized literature, the essential lipolytic transformations that occur in the case of refrigerated pork carcasses refer to those of the hydrolytic and oxidative type. The hydrolysis of triglycerides, in particular, results in glycerin and fatty acids, which leads to an increase in the acidity of the refrigerated raw material, with influence on its subsequent processing, and the oxidation of fats leads to the appearance of some products responsible for the appearance of the rancid taste and smell, with related toxicological consequences.

In order to carry out the required analyzes and determinations, samples were collected from the dorsal area of the carcasses, before refrigeration, 2 days after refrigeration, 5 days, 7 days, 9 days and 11 days, the carcasses being stored in a refrigerated state at a temperature of 0-4°C.

During the re-cooling period in slaughterhouse conditions, according to the data in table 3, small quantitative depreciations of the carcasses occur, the percentage of water in the fat decreasing to a maximum of 40.2±0.13% (after 11 days of storage), and the of fats was between 37.4±0.31%, before refrigeration, to reach 35.3±0.74% after more than 11 days of storage, under controlled environment conditions.

The acidity of the meat, expressed by the value of oleic acid, registered an increase during refrigerated storage, from a value of 0.46±0.003 g% (before refrigeration), to 0.83±0.008% (after 11 months of refrigeration), between the refrigeration duration factor and the acidity value, noting a positive correlation.

Technologically, changes in acidity of the alteration type are considered those above 1.0 g% oleic acid, when the fat enters an advanced process of hydrolysis, sensory noticing a slightly acidic smell and a sour taste.

Malondialdehyde (MDA) provides information about lipid peroxidation, which can be accounted for by analyzing the resulting products. According to the data obtained, at values above 2.5 MDA mg/kg of the TBARS test, we are already witnessing the appearance of perceptible and organoleptic changes, which was not recorded in the present experiment.

There is an inverse correlation between MDA and the peroxide index, i.e. when the peroxide index decreases, the MDA value increases, which indicates the presence of secondary oxidation compounds in the meat, with potentially toxic effects. Practically speaking, relatively fresh pork meat it registers values of 2.5 MDA mg/kg, beyond these values alteration changes occur,

sensitively characterized by a strong smell and taste of rancidity.

The action of the proteases that degrade the proteins, with the release of volatile amines, recognizable by their pungent smell, as well as compounds of putrefaction, competes with the installation of the state of alteration.

In order to highlight the composition in fatty acids and the dynamics of the transformations during the freezing period, samples were collected in the same periodic regime mentioned previously, respectively before refrigeration (G0), after 2 days of refrigeration (G1), after 5 (G2), 7 (G3), 9 (G4) and 11 (G5) days of carcass refrigeration, at 0-4°C.

The iodine index, which characterizes the degree of neutralization of lipids, respectively the proportion of higher unsaturated fatty acids, recorded a decrease over time, from a value of 68.3±0.11 g I%, recorded before refrigeration, to 65.2±0.33 g I%, a value recorded after 11 days of refrigeration, a fact due to the reduction in the degree of unsaturation through the oxidation of unsaturated fatty acids.

According to the recorded data, there is an inverse correlation between the storage time of refrigerated carcasses and the iodine index, a fact confirmed by the specialized literature consulted.

The peroxide index recorded increases in value during refrigeration, being between a minimum of 0.85÷0.07 meq O2/kg, before refrigeration of the carcasses and a maximum of 1.83±0.07 meq O2/kg, after 11 days of refrigeration. When the peroxide index values exceed 2.0 meq O2/kg, severe oxidative processes set in, with sensitive changes in smell and special, rancid taste, the stage that was not found in the experiments regarding the period of storage of carcasses.

The recorded data establish the fact that, between the 9th and the 11th day of storage, a period of propagation of oxidation sets in, being followed by a phase of decline, when secondary oxidation products are already formed.

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There is an inverse correlation between MDA and the peroxide index, i.e. when the peroxide index decreases, the MDA value increases, which indicates the presence of secondary oxidation compounds in the meat, with toxic effects. Practically, relatively fresh pork meat registers values of 2.5 MDA mg/kg, especially when freezing, beyond these values alteration changes occur, sensitively characterized by a strong smell and taste of rancidity.

The action of the proteases that degrade the proteins, with the release of volatile amines, recognizable by their pungent smell, as well as compounds of putrefaction, competes with the installation of the state of alteration.

In order to highlight the composition in fatty acids and the dynamics of the transformations during the refrigeration period, samples were collected in the same periodic regime mentioned previously, respectively before refrigeration (G0), after two days of refrigeration (G1), after 5 (G2), 6 (G3), 7 (G4) and 11 (G5) days of carcass refrigeration at 0-4°C.

The obtained results are presented in tab. 4.

Table 4. Dynamics of fat composition in fatty acids in Mangalitsa refrigerated pork

N = 60

Specification	G0	G1	G2	G3	G4	G5	Literature (Mangalitsa breed)
Oleic acid C18:1 n9 (%)	43.60	43.44	43.12	42.62	42.18	41.50	40.20
Linoleic acid C18: 2 n6 (%)	4.75	4.86	5.07	5.40	6.32	7.43	7.92
Linolenic acid C 18:3 n3 (%)	1.20	1.83	2.12	2.37	3.08	3.83	3.06
Palmitic acid C16:0 (%)	21.55	23.50	24.55	25.17	26. 18	26.36	25.45
Palmitoleic acid 16:1 n7 (%)	3.21	3.40	3.56	3.62	3.59	4.15	2.45
Myristic acid C14:0 (%)	0.43	0.65	0.70	0.95	1.08	1.30	1.33
Arachidonic acid C20:4 n6 (%)	0.10	0.15	0.17	0.17	0.19	0.23	0.27
Stearic acid C18: 0 (%)	12.31	12.51	12.80	13.24	13.60	14.20	14.4
Eicosatrienoic acid C20:3 n3(%)	0.23	0.27	0.35	0.42	0.48	0.51	0.42
Vaccinic acid C 18:1 n7 (%)	3.28	3.30	3.42	3.57	3. 88	4.07	4.48
SFA (total values)	34.59	-	-	-	-	39.12	41.45
MUFA (total values)	55.96	-	-	-	-	56.25	52.43
PUFA (total values)	4.31	-	-	-	-	4.67	3.83
PUFA/SFA (** p< 0.01)	0.12	-	-	-	-	0.25	0.21
P/S (** p< 0.01)	0.19	-	-	-	-	0.25	0.29
n-6/n-3	4.50	-	-	-	-	3.80	3.00
h/H (* p< 0.05)	2.30	-	-	-	-	2.45	max.2.68
IA (* p< 0.05)	0.42	-	-	-	-	0.36	min.0.30
IT (** p< 0.01)	1.22	-	-	-	-	1.09	min.0.80

Note: SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA- polyunsaturated fatty acids; P/S – polyunsaturated fatty acids/saturated fatty acids; n-6/n-3 - omega 6 polyunsaturated fatty acids/ omega 3 polyunsaturated fatty acids; h/H – hypocholesterolemic/hypercholesterolemic index; IA- atherogenic index; It- the thrombogenic index.

IA = [(C12: 0 + (4 × C14: 0) + C16: 0)]/(MUFA + n−6 PUFA + n−3 PUFA)

IT = (C14: 0 + C16: 0 + C18: 0)/[(0.5 × MUFA) + (0.5 × n−6 PUFA) + (3 × n−3 PUFA) + (n−3PUFA/n−6 PUFA)]

h/H =(C18: 1n−9 + C18: 2n−6 + C20: 4n−6 + C18: 3n−3 + C20: 5n−3 + C22: 5n−3 + C22: 6n−3)/(C14: 0 + C16: 0)

Regarding saturated fatty acids (SFA), the first determinations show that palmitic acid (21.55%) and stearic acid (12.31%) are found in higher proportions, and myristic acid (0.43%) and arachidic acid (0.23%), so that, at the last determination of the storage period, important increases were registered, especially in palmitic acid (26.36%), stearic acid (14.40) and myristic (1.30%).

During storage, the percentage of SFA (saturated fatty acids) increased from 34.59% (before refrigeration) to 39.12%, at the end of the refrigeration period, and the percentage of MUFA (monounsaturated fatty acids) increased from 55.96% to 56.25%, in the same experimental period.

Regarding the content in polyunsaturated fatty acids (PUFA), the values recorded were between 4.31%, before refrigeration and 4.67% at the end of the experiment.

CONCLUSIONS

a). Regarding the proteolytic changes in the meat

According to the recorded data, it is highlighted that during refrigerated storage, the pork from the Mangalitsa breed recorded an increase in pH, from 5.62±0.23 to 6.33±0.13

units, a decrease in humidity, from 72.12±0.40% to 68.53±0.17%, in protein substances, from 73.70±0.20% to 70.87±0.12%, and in nitrogen total, from 2.67±0.32% to 2.23±0.09%.

As a consequence of the proteolytic enzyme activity, ammonia increased from 17.12±0.42 to 30.83±0.12 mg %, and amino nitrogen from 119±5.10 mg to 148±5.65 mg%.

The obtained results fall within the data of some specialized studies, in which it is certified that the temperature is a determining factor that influences the proteolytic changes in the meat; the lower the temperature, the slower the proteolysis takes place, but without stopping completely. Also, proteolytic changes can be influenced by other factors, such as breed specialization, age, fattening status, morphological structure and hygienic quality of the meat.

Pork stored in a refrigerated state, towards the end of storage, has higher amounts of aspartic acid (10.48 mg/g protein), Lysine (8.03 mg/g protein), Arginine (6.47 mg/g protein), Leucine (7.73 mg/g protein), and smaller amounts of Cystine (2.27 mg/g protein), Proline +Alanine (2.84 mg/g protein) and Methionine (2.52 mg/g protein), but without negatively influencing the digestive and metabolic transformation value of the meat product.

In the pre-refrigeration state, the total free amino acid content was 72.07 mg/g crude protein, so that after 7 days it reached 120.09, and after 11 days this content increased to over 130 mg amino acids (137.09 mg/ mg/g protein).

b). Regarding lipolytic changes in meat

The data of our research and observations attest to the fact that the physico-chemical transformations recorded by the fat in refrigerated meat depend on a series of factors, among which we list the specialization of the breed, the presence of marbling and marbling of the meat, the content of fatty acids, their type (saturated and unsaturated) and the ratio between them, conditions and duration of preservation, duration of storage, temperature, air currents, humidity, etc.

In order to appreciate the hydrolytic changes, the free acidity was determined, and to identify the oxidative process, the peroxide index (PV), the iodine index (IV), MDA-TBARS, the presence of epihydrinic aldehyde and the fat content in fatty acids were determined.

The recorded data establish the fact that, between the 9th day and the 11th day of storage, a period of oxidation propagation sets in, when secondary oxidation products are already formed, the oxidative status passing from the primary to the secondary state.

The action of the proteases that degrade the proteins, with the release of volatile amines, recognizable by their pungent smell, and compounds of putrefaction compete with the installation of the state of alteration.

According to the agreed protocol, PUFA/SFA (P/S) and PUFA n-6/n-3 ratios, hypo/hypercholesterolemic ratio (h/H), atherogenic index (AI) and thrombogenic index (TI) of fat were calculated .

It is also very important to highlight the general nutritional qualities of fats. In this case, IA, IT and hH are essential determinations, indicating the functional effects of fatty acids for human health.

According to recent studies, high Atherogenicity Index (IA), Thrombogenicity (IT) values are responsible for the formation of atheroma and stimulate the aggregation of platelets in our cardiovascular system. Therefore, the lower values of these indices are desirable, being considered useful for the prevention of cardiovascular disorders

Thus, during storage, the percentage of SFA (saturated fatty acids) increased from 34.59% (before refrigeration) to 39.12%, at the end of the refrigeration period, and the percentage of MUFA (monounsaturated fatty acids) increased from 55.96% to 56.25%, in the same experimental period.

Regarding the content of polyunsaturated fatty acids (PUFA), the values recorded were between 4.31%, before refrigeration and 4.37% at the end of the experiment.

The hypo/hypercholesterolemic ratio (h/H) (according to the calculation formula Fernandez et al 2007) increased in value, from 2.30 to 2.45, while the Atherogenic Index (AI) decreased from 0.42 to 0 .36, and the thrombogenic index (IT) from 1.22 to 1.09 (according to the calculation formula Ulbricht & Southgate 1991).

The results were statistically analyzed by the Student's t test, using the GraphPad Prism program.

Conclusively, according to the data regarding the proteolytic and lipolytic changes that appeared during the study period, we recommend keeping the Mangalitsa pork, in a refrigerated state, in the form of a carcass, for approx. 20 days, during which the meat and fat are kept in good nutritional conditions, generating a valuable raw material for the consumption of fresh meat.

CONFLICT OF INTEREST The authors declare that there is no conflict of interest for authorship and/or publication of this article.

REFERENCES

1. Csapo, J., Husveth, F., Csapo, Z.S., Horn, P., Hazas, Z., Varga, E., Bocs, K. (1999). Fatty acid composition and cholesterol content of the fat of pigs different breeds. Acta Agraria Kaposvariensis 3(3):1-13.
2. Fernandez, M., Ordonez, J.A., Cambero, I., Santos, C., Pin, C., de la Hoz L. (2007). Fatty acid compositions of selected varieties of Spanish dry ham related to their nutritional implications. Food Chemistry 101:107–112.
3. Givens, D.I., Kliem, K.E., Humphries, D.J., Shingfield, K.J., Morgan, R. (2009). Effect of replacing calcium salts of palm oil distillate with rapeseed oil, milled or whole rapeseeds on milk fatty-acid composition in cows fed maize silage-based diets. Animal 3(7):1067-1074.
4. Hoha, G.V., Pandelea, M., Costăchescu, E., Nistor, C.E., Măgdici, E., Păsărin, B. (2016). The quality of meat to different type Mangalitsa breeds'. USAMV Iași, Scientific Papers-Animal Science Series, 65:84-87.
5. Holló, G., Seregi, J., Ender, K., Nuernberg, K., Wegner, J., Seenger, J., Holló, I., Repa, I. (2003). Examination of meat quality and fatty acid composition of Mangalitsa. Acta Agraria Kaposváriensis 7(2):19-32.
6. Lugasi, A., Gergely, A., Horvari, J., Barna, E., Lebovics, V.K., Kontraszti, M., Herman, I., Gundel, J. (2006). Meat quality and human nutritional importance of Mangalica. Hungarian J Anim Prod 55:263-277.
7. Păsărin, B. (2017). Creșterea suinelor, Editura „Ion Ionescu de la Brad", Iași
8. Păsărin, B., Hoha, G.V., Nistor, C.E, Simeanu, Cristina (2022). Elements regardind the lipolisys and proteolisys of frozen meats from the Mangalitsa breeds, USAMV Iași, Scientific Papers-Animal and Food Science, Serie nouă 2022
9. Parunović, N., Petrović, M., Matekalo-Sverak, V., Radojković D., Vranić D., Radović Č. (2012). Cholesterol and total fatty acid content in m. longissimus dorsi of Mangalitsa and Swedish Landrace. Acta Alimentaria 41, 161-171.
10. Petrović, M., Radović, Č., Parunović, N., Radojković, D., Savić, R. (2012). Composition of carcass sides and quality of meat from swallow-belly Mangalitsa reared in two systems. Biotechnol Anim Husbandry 28, 303-311.
11. Petrović, M., Radović, Č., Parunović, N., Mijatović, M., Radojković, D., Aleksić, S., Stanišić, N., Popovac, M. (2010). Quality traits of carcass sides and meat of Moravka and Mangalitsa pig breeds. Biotechnol Anim Husbandry 26,21-27.
12. Parunović, N., Petrović, M., Matekalo-Sverak, V., Radović, Č., Stanišić, N. (2013). Carcass properties, chemical content and fatty acid composition of the musculus longissimus of different pig genotypes. South African Journal of Animal Science 43 (2):123-136.
13. Petrescu-Mag, I.V., Stoian, R.O., Todoran, C. (2017). Pork production in Romania. Porc Resq. 7(1):32-38.
14. Petrović, M., Wähner, M., Radović, Č., Radojković, D., Parunović, N., Savić, R., Brkić, N. (2014). Fatty acid profile of m. longissimus dorsi of Mangalitsa and Moravka pig breeds. Archiv Tierzucht 57(17):1-12.
15. Szabo, P. (2006). Fatty acid composition of the tissues of Mangalica and other pig genotypes. Hungarian J Anim Prod 55:293-311.
16. Wood, J.D., Enser, M., Fisher, A.V., Nute, G.R., Sheard, P.R., Richardson, R.I., Hughes, S.I., Whittington, F.M. (2008). Fat deposition, fatty acid composition and meat quality: A review. Meat Sci 78(4):343-358.
17. Zăhan, M., Miclea, V., Hettig, A., Miclea, I., Raica, P., Roman, I. (2010). The Use of Molecular and Biochemical Markers in Mangalitsa Breed Characterization. Bulletin of the University of Agricultural Science and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies 67, 452-455
18. Zhang, S., Knight, T.J., Stalder, K.J., Goodwin, R.N., Lonergan, S.M., Beitz, D.C. (2007). Effects of breed, sex, and halothane genotype on fatty acid composition of pork longissimus muscle. J Anim Sci 85, 583-591
19. Žemva, M., Malovrh, Š., Kovač, M. (2009). Quality of intramuscular and subcutaneous fat in Krskopolje pigs and commercial fatteners]. In: Kovač M, Malovrh Š Control of pig production. Part V. University in Ljubljana, Biotechnical Faculty, Department for pig, biometric and selection, 109-124.