THE EVALUATION OF THE QUALITY INDICES OF - AGRICULTURAL RESIDUES- STRAW OF SOME *POACEAE* SPECIES

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Abstract

The objective of this research was to evaluate the quality indices of agricultural residues straws of *Avena nuda, Dactylis glomerata, Lolium perenne, Triticum aestivum ssp. spelta, Zea mays saccharata* collected in the experimental plot of the NBGI Chişinău. It has been found that biochemical composition of the collected dry phytomass was 47-64 g/kg CP, 38-72 g/kg ash, 382-473 g/kg CF, 407-501 g/kg ADF, 692-797 g/kg NDF, 38-64 g/kg ADL, 369-437 g/kg Cel, 254-299 g/kg HC. The forage value of studied straws was 49.9-57.2% DMD, 8.26-9.37 MJ/kg ME, 4.28-5.35 MJ/kg NEl. The substrates from studied straws achieved biochemical biomethane potential 271-309 L/kg organic dry matter and theoretical ethanol yield averaged 476-523 L/t organic dry matter. The net calorific value of studied straws varied from 14.7 to16.4 MJ/kg.

Keywords: agricultural residues, biochemical composition, biomethane potential, calorific value, feed value, straw, theoretical ethanol yield

Agriculture is one of the largest sectors, which produces high amounts of biomass that can be an important input for the bioeconomy.

Traditionally, some crop residues have been used as animal fodder, roof thatching, composting, soil mulching, matchstick and paper production.

Forest and crop residues biomass are the first and oldest source of energy that people used for heating, cooking and other purposes.

A considerable attention in recent years is given to alternative energy sources, and especially to plant biomass, which in contrast to the fossil fuels is continuously renewed in the nature. The lignocellulosic biomass from crop residues and energy crops can serve as a sustainable source of biodiesel, bioethanol, biogas, biohydrogen and solid fuel production, in order to mitigate the fossil fuel shortage and climate change issues.

Sweet corn *Zea mays saccharata* is a highly valued crop worldwide, cultivated for its tender kernels consumed as a vegetable, and global demand for sweet corn has increased steadily over the past two decades due to changing dietary preferences, urbanization, and rising health consciousness, leading to intensified research efforts focused on breeding, agronomy, and sustainability adaptability to various agro-climatic conditions. The cereals crops, naked oat *Avena nuda* and spelt wheat, *Triticum aestivum ssp. spelta* have received attention again in the past two decades, due to its healthy nutritional components and bioactive compounds, and including this crops and varieties in organic production it is the possible to increase the diversity of grains in the human diets.

The important temperate grasses are orchardgrass *Dactylis glomerata* and perennial ryegrass *Lolium perenne*, they are suitable for restoration and creation of temporary meadows, weeding of sports fields and lawns, and the requirement for seeds has skyrocketed in recent years.

In order to choose the most efficient way to valorize the straw from crops, it is necessary to know the quality indices and its economic potential as fodder or as raw material for the production of biofuels.

The goal of this study was to determine the quality indices of agricultural residues straws of *Avena nuda, Dactylis glomerata, Lolium perenne, Triticum aestivum ssp. spelta, Zea mays saccharata*, and prospect its use as feed for livestock and as substrates for bio fuels production.

MATERIALS AND METHODS

Agricultural residues in the form of straw from *Avena nuda*, *Dactylis glomerata*, *Lolium*

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perenne, *Triticum aestivum* ssp. *spelta*, and *Zea mays saccharata*, collected from the experimental plots of the NBGI in Chişinău, were used as research subjects. For this purpose, 100 kg samples of straw were collected from each species. The dry matter content was determined by drying the samples to a constant weight at 105°C. For biochemical analysis, the straw biomass was dehydrated in a forced-ventilation oven at 60°C. After drying, the material was finely ground using a laboratory ball mill. Biomass quality was evaluated by analyzing the following indices: crude protein (CP), crude fiber (CF), crude ash (CA), total soluble sugars (TSS), acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL). These parameters were determined using near-infrared spectroscopy (NIRS) with the PERTEN DA 7200 analyzer at the Research and Development Institute for Grassland, Braşov, Romania. Additional parameters - hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl), total digestible nutrients (TDN), relative feed value (RFV), and relative forage quality (RFQ) - were calculated according to standard procedures. The carbon content of the substrates was estimated using an empirical equation by Badger *et al.* (1979), and the biochemical methane potential (BMP) was calculated following the method described by Dandikas V. *et al.* (2015). The Theoretical Ethanol Potential (TEP) was calculated according to the equations of Goff B.M. *et al.* (2010) based on conversion of cellulose and hemicellulose into hexose (H) and pentose (P) sugars. For densification, straw biomass was chopped into small pieces measuring 2-3 cm using a chopping unit. The chopped biomass was then crushed in a beater mill equipped with a 6 mm mesh sieve. Pelleting equipment was used to densify the biomass. Pelleting and selected quality indices of the dry biomass and pellets were determined following standard protocols at the Technical University of Moldova.

RESULTS AND DISCUSSIONS

The biochemical composition of agricultural residues, specifically – straw, is of critical importance in formulating homogeneous diets for livestock, particularly ruminants, as well as for use as a substrate in renewable energy production.

According to the results presented in Table 1, the dry matter of the studied straws contained the following ranges: 47-64 g/kg CP, 38-72 g/kg ash, 382-473 g/kg CF, 407-501 g/kg AD), 692-797 g/kg NDF, 38-64 g/kg ADL, 369-437 g/kg Cel and 254–299 g/kg HC.

Table 1

The biochemical composition of the studied agricultural residues- straws

Indices	*Avena nuda*	*Dactylis glomerata*	*Lolium perenne*	*Triticum aestivum spelta*	*Zea mays saccharata*
Crude protein, g/kg DM	51	64	63	51	47
Crude fiber, g/kg DM	453	448	392	473	382
Ash, g/kg DM	38	71	68	54	72
Acid detergent fiber, g/kg DM	464	498	414	501	407
Neutral detergent fiber, g/kg DM	718	797	681	778	692
Acid detergent lignin, g/kg DM	47	64	51	64	38
Cellulose, g/kg DM	417	434	363	437	369
Hemicellulose, g/kg DM	254	299	267	277	285

The straws of the perennial grasses *Dactylis glomerata* and *Lolium perenne* were characterized by higher levels of crude protein and ash. The content of fibrous components and lignin varied significantly between species. Lower values were observed in *Lolium perenne* and *Zea mays saccharata*, while notably higher levels were recorded in *Dactylis glomerata* and *Triticum aestivum* ssp. *spelta*.

The *figures 1-5* present the nutritional energy values of the straw biomass from the studied species. Notably, *Lolium perenne* and *Zea mays saccharata* straw displayed a higher degree of digestibility, relative forage value, and availability of metabolizable energy and net energy for lactation. *Avena nuda* straw showed more favorable nutritional indices compared to the straw of *Dactylis glomerata* and *Triticum aestivum* ssp. *spelta*.

Several authors have reported varying findings regarding the quality indices of straw biomass. According to Youngberg H. and Vough L. (1977) the nutrient content in perennial ryegrass straw – forage type was 2.5-7.2% CP, 72.1 % NDF, 41.7-52.6%ADF, 39.7-48.3% IVDDM; in orchardgrass straw 3.1-7.2% CP, 79.0 % NDF, 44.0-53.8%ADF, 28.2-42.0% IVDDM; but in wheat straw 1.8-3.7% CP, 52.1-56.9%ADF. Fisher M. J. (2004) reported that the biochemical composition of perennial ryegrass straw was 4.6% CP 63.0% NDF, 33.0% ADF, 55% TDN (Stanisavljević R. *et al.*, 2009) revealed that depending on the vegetation space and application of mineral fertilizers the yield of *Dactylis* *glomerata* remains, namely – straw, varied from 1.24 to 3.09 t/ha, the chemical composition of leaf biomass was 3.96-5.27% CP, 81.58-92.77% NDF, 44.94-52.83% ADF, but stem and panicle biomass 1.81-3.35% CP, 90.08-94.86% NDF and 45.36-55.29% ADF, respectively. Barbash V. *et al.*, (2011) mentioned that wheat straw had 4.2% ash, 26.4 % pentosans, 46.2 % cellulose, 18.6% lignin. Bohnert D.W. *et al.*, (2011) remarked that crude protein concentration in perennial ryegrass straw was 6.0%, but in orchardgrass straw 4.8%. Li S-M. *et al.* (2014) documented that naked oat straw had 3.3%CP and 45.2%% CF. Suthar M. *et al.*, (2012) mentioned that the crude protein content in sweet corn varieties, after harvesting the cobs, varied from 3.83 to 5.14%. Li H.Y. *et al.*, (2014) found that maize stover had 933.8 g/kg DM, 95.16% OM, 4.05% CP, 1.31% EE, 71.93% NDF, 41.36% ADF, 6.16% ADL. Isikgora F.H.&Remzi Becer C. (2015) remarked that the chemical composition of wheat straw was 35.0-39.0% cellulose, 23.0-30.0 % hemicellulose, 12.0-16.0% lignin; oat straw 31.0-35.0% cellulose, 20.0-26.0% hemicellulose, 10.0-15.0% lignin and corn stalks 35.0-39.6% cellulose, 16.8-35.0% hemicellulose, 7.0-18.4% lignin and grasses 25.0–40.0% cellulose, 25.0–50.0% hemicellulose, 10.0–30.0 % lignin, respectively. Kiro M. (2015) reported that wheat straw contained 73.75 % holocellulose, 39.17 % α-cellulose, 21.65 % lignin, 4.57 % soluble, 5.53% ash. Wattanaklang B. *et al.*, (2016) reported that the nutrient content of the maize stover was as follows: 5.8% crude protein, 27.38% crude fiber, 1.90% ether extract and 20.8% ash. Lukiwati D.R. *et al.*, (2018) found that the digestibility of fermented sweet corn stover was 552.3-646.8g/kg IVDMD and 517.1-628.4 g/kg IVOMD. Barros R.D.R.O. *et al.*, (2019) reported that spelt straw biomass had 14.9% moisture, 38.25 % cellulose, 24.28% hemicellulose, 14.77 % lignin, 5.71 % ash and 7.14% nitrogen free extract. Lukiwati D. R. (2019) stated that sweet corn stover contained 5.70-8.04% CP, 0.34-0.56% P and 0.17-0.53%Ca.

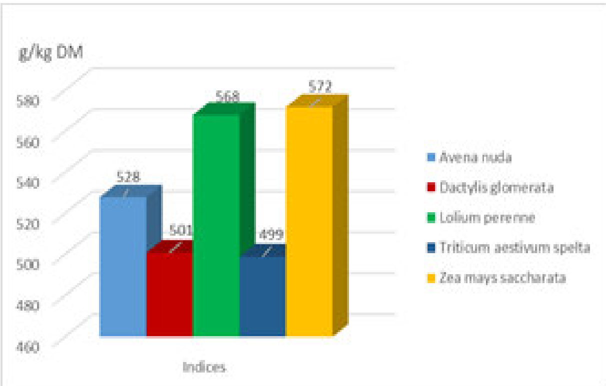

Figure 1 **Digestible dry matter**

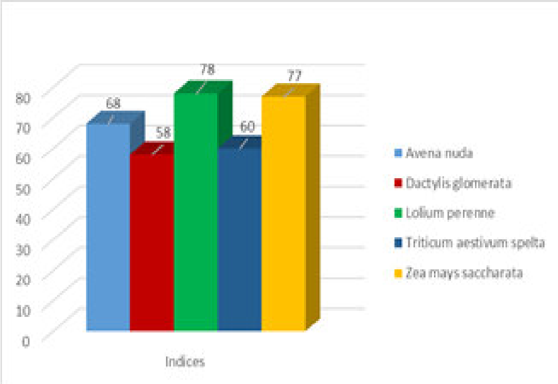

Figure 2 **Relative feed value**

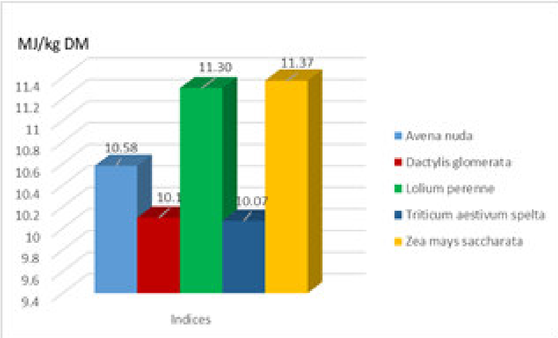

Figure 3 **Digestible energy**

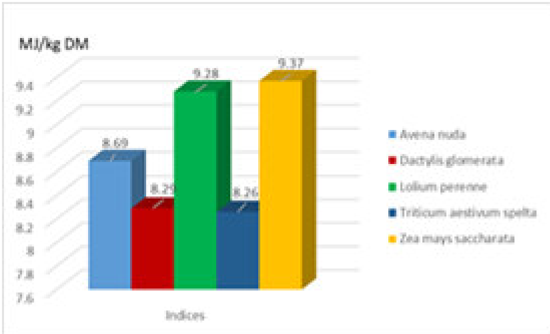

Figure 4 **Metabolizable energy**

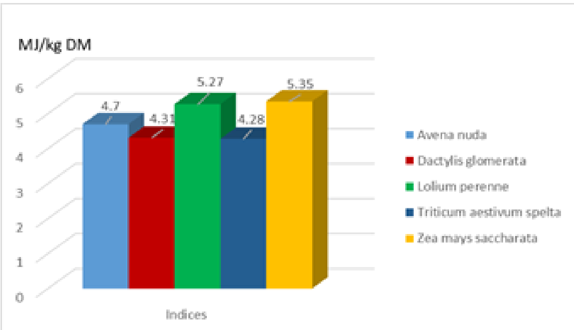

Figure 5 **Net energy for lactation**

Hejduk S. and Macháč R. (2019) mentioned that the concentration of nutrients in the Italian ryegrass 68.3 g/kg ash, 64.1 g/kg CP, 399 g/kg CF, 656 g/kg NDF, 442 g/kg ADF, 215 g/kg HC, but in perennial ryegrass straw 71.3 g/kg ash, 81.4 g/kg CP, 382 g/kg CF, 629 g/kg NDF, 412 g/kg ADF and 217 g/kg HC. Zhou X. *et al.*, (2019) revealed that the nutrient content in sweet corn stover was 72.3 g/kg CP, 18.1 g/kg EE, 134.1 g/kg WSC, 667.8 g/kg NDF, 426.3 g/kg ADF, 80.8 g/kg starch. Doroftei V. *et al.*, (2021) mentioned that biochemical composition of grass straws: 36-83 g/kg CP, 400-555 g/kg CF, 46-98 g/kg ash, 647-918 g/kg NDF, 424-604 g/kg ADF, 53-86 g/kg ADL, 371-518 g/kg Cel, 223-314g/kg HC, with nutritive and energy value 10.3-39.3 % DMD, 8.8-36.2 % ODM, 7.08-9.14 MJ/kg ME and 3.10-5.45 MJ/kg NEl, but wheat straw 37 g/kg CP, 488 g/kg CF, 498 g/kg ADF, 775 g/kg NDF, 68 g/kg ADL, 430 g/kg Cel, 277 g/kg HC, 45 g/kg ash, 13 g/kg TSS. Zheng M. *et al.*, (2021) showed that the naked oat straw digestibility of nutrients was 395.1 g/kg IVDMD, 302.5 g/kg IVNDFD and 288.0 g/kg IVADFD. Cerempei V. *et al.*, (2022) reported that straw collected from the studied cultivars of *Festuca* species contained 28-83 g/kg CP, 417-562 g/kg CF, 469-595 g/kg ADF, 720-889 g/kg NDF, 60-91 g/kg ADL, 0-60 g/kg TSS, 251-294g/kg HC, 406-504 g/kg Cel, while straw from *Avena sativa* 'Sorin' 62 g/kg CP, 487 g/kg CF, 82 g/kg ash, 499 g/kg ADF, 800 g/kg NDF, 56 g/kg ADL, 443 g/kg Cel, 301 g/kg HC, 161 g/kg TSS, respectively. Ma Y. *et al.*, (2022) revealed that the dry matter and nutrient content of naked oat straw was 906.6 g/kg DM, 5.94% CP, 63.83% NDF, 38.28% ADF, 7.99% ash, 3.81% starch, with estimated feeding value 53.61% TDN, 59.08% DDM, RFV=86.11 and RFQ=81.95. Gong X *et al.*, (2022) mentioned that maize straw had 31.99 % cellulose, 25.33 % hemicellulose and 21.17 % lignin. Nasir A.A.A. and Kamaruddin N.A. (2023) found that the leaves of sweet corn contained 19.04% CP, 5.22%EE and 5.44% ash, while sweet corn stalk had 10.47% CP, 1.32% EE, 4.56%ash and 27.05 % CF. Khan A. *et al.*, (2024) reported that maize stalk contained 41.43% cellulose, 26.10% of hemicellulose and 8.13% lignin.

The high volatility in fossil energy prices, along with environmental concerns such as climate change associated with their use, has steadily increased interest in alternative renewable energy sources. Feedstocks with broader geographic availability and lower costs - such as agricultural and forestry residue biomass and energy crops - are particularly attractive in this context. Straw is a promising lignocellulosic feedstock with a favorable greenhouse gas emissions profile, making it suitable for the production of biofuels and bio-based chemicals. Like all lignocellulosic materials, straw is naturally recalcitrant and requires thermochemical and enzymatic pretreatment to enable access to its three main biopolymers: the polysaccharides cellulose and hemicellulose and the polyaromatic compound lignin.

Straw is currently used in commercial production of cellulosic ethanol and biomethane. The carbon-to-nitrogen ratio and biomethane potential of the straw substrates from the studied species are presented in Figures 6-8. The C/N ratio of the investigated substrates ranged from 50 to 68. Their biochemical methane potential varied between 291 and 333 L/kg ODM, or 271 to 309 L/kg DM. A notably high biomethane potential was observed in the *Zea mays saccharata* substrate, likely due to its lower lignin content. In contrast, the straw substrates from *Dactylis glomerata* and *Triticum aestivum* ssp. *spelta* exhibited lower biomethane potential compared to that of *Avena nuda*.

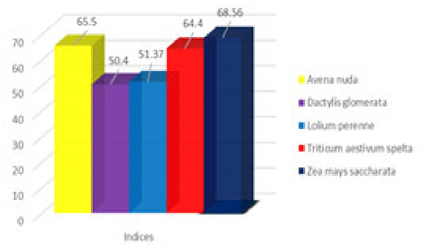

Figure 6 **Carbon to nitrogen ratio**

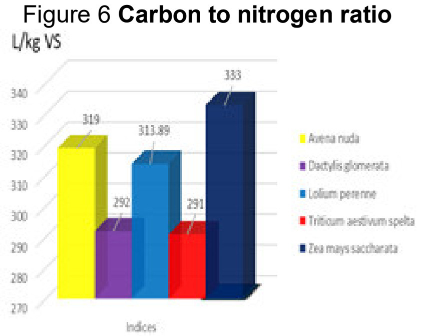

Figure 7 **Biomethane potential L/kg VS**

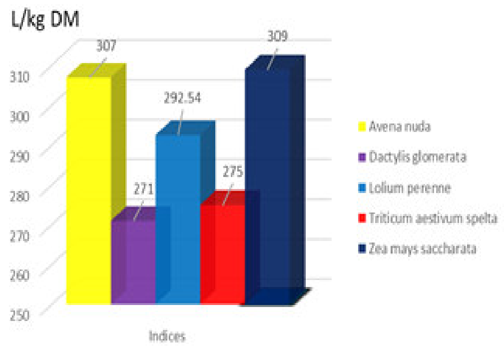

Figure 8 **Biomethane potential, L/kg DM**

Several studies have reported different data on the biomethane production potential of straw substrates. Vishnevskaya O.V. (2017) noted that substrates derived from *Dactylis glomerata* achieved methane yields 237-241 l/kg VS. Mazurkiewicz J. *et al.*, (2019) reported that the methane productivity of maize straw substrates was 201-207 m^3/t. Doroftei V. *et al.*, (2021) mentioned that grass straw substrates for anaerobic digestion have C/N=37-92 and biochemical methane potential varied from 254 to 313 l/kg ODM. Witaszek K. *et al.* (2025) noted that straw substrates derived from *Triticum aestivium* had 45.95-52.84% ADF, 77.07-87.09% NDF and methane yields varied from 200.8 to 272.08L/kg VS.

Liquid biofuels, namely cellulosic bioethanol, butanol and biodiesel, are of considerable interest to researchers, industry stakeholders and governments. Among these, cellulosic bioethanol is considered a promising drop-in fuel that could serve as an alternative to gasoline in the transportation sector. Ethanol offers several advantages over gasoline when used in internal combustion engines: it has a higher octane number, which enhances resistance to engine knock; it has a lower freezing point; and it results in lower CO_2 emissions. The production of cellulosic ethanol through biological conversion involves three key steps: pretreatment of biomass, hydrolysis of sugar polymers (such as cellulose and hemicellulose) into sugar monomers (hexoses and pentoses) and fermentation of these monomers into ethanol (Kumar & Murthy, 2011). Ethanol yield and conversion efficiency depend on several factors, including the type of biomass, plant species, variety, growth conditions and maturity stage.

Figures 9-11 present the results on quality indices and the theoretical bioethanol potential of the studied lignocellulosic substrates. The theoretical bioethanol yield from hexose sugars ranged from 275 to 329 L/ton of organic matter, while the yield from pentose sugars ranged from 174 to 205 L/ton of organic matter. The straw substrates of *Dactylis glomerata* and *Triticum aestivum* ssp. *spelta* were characterized by a high theoretical bioethanol potential. In contrast, the bioethanol potential of straw from *Avena nuda* and *Zea mays saccharata* showed no significant difference.

Several authors have reported varying results regarding the bioethanol potential of lignocellulosic substrates. According to Sveinsson T. & Hermannsson, J. (2010), ethanol production from *Phleum pratense* lignocellulosic biomass is estimated at 0.27 L of ethanol per kilogram of DM. Kumar D. & Murthy G. (2011) reported that estimated ethanol potential from C_6 sugars of tall fescue biomass achieved 360.57 L/ ton biomass; perennial ryegrass biomass- 297 L/ ton and from bentgrass 276 L/ ton. Orlygsson J. (2013) remarked that timothy substrates produced 4.2 mM of ethanol/g DM or about 0.24 litres ethanol/kg DM, or 1200-1700 l/ha ethanol. Hálfdánarson H.E. (2015) reported that ethanol production efficiency from timothy second-cut biomass was 346 L/ton of dry matter (DM), 298 L/ton DM at the third cut, and 313 L/ton DM at the fourth cut. Tang S. *et al.* (2019) reported that *Pennisetum alopecuroides* straw contained 41.8% Cel, 28.7% HC, and 17.5% lignin, with an ethanol potential reaching 744 mg/g after alkaline treatment. Goff B.M. *et al.* (2010) found that, for sorghum biomass, the theoretical ethanol potential ranged from 560 to 610 L/t of dry biomass. Doroftei V. *et al.* (2021) mentioned that the estimated theoretical bioethanol potential of grass straw substrates ranged from 432 to 605 L/t, while for wheat straw the potential was 513 L/t. Cerempei V. *et al.* (2022) reported that the theoretical bioethanol potential of straw substrates from *Festuca* species reached values between 477 and 580 L/t DM, and for oat straw, 541 L/t DM.

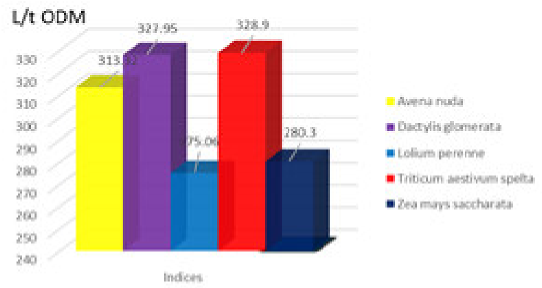

Figure 9 **Theoretical ethanol potential: from hexose sugars**

Figure 10 **Theoretical ethanol potential: from pentose sugars**

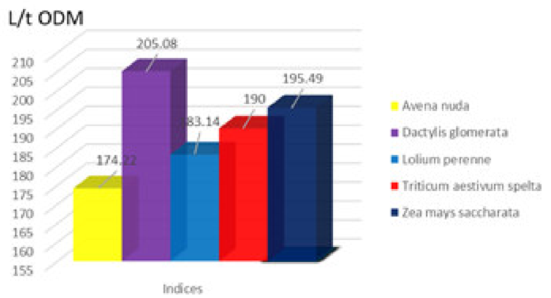

Figure 11 **Total theoretical ethanol potential**

One of the most economically advantageous methods of biomass densification is pelletization.

Through this process, raw biomass is converted into pellets with improved fuel properties, such as increased bulk density and uniform shape and size. Pelletized fuels also exhibit greater structural consistency, which is particularly beneficial for automated fuel systems in both industrial and domestic boilers. Some physical and mechanical properties of straw biomass and the resulting pellets are presented in Table 2 and Figures 12-13. Among the key quality indicators, ash content is particularly important, as high ash levels reduce the quality of solid fuels, accelerate corrosion and hinder the optimal performance of heating systems. A high ash concentration – ranging from 6.8% to 7.2% - was observed in the biomass of *Lolium perenne*, *Dactylis glomerata* and *Zea mays saccharata*, compared to lower values of 3.8% in *Avena nuda* and 5.4% in *Triticum aestivum* ssp. *spelta*. The volatile matter content in the studied straws ranged from 69% in *Zea mays saccharata* to 81% in *Avena nuda* and *Triticum aestivum* ssp. *spelta*. The biomass and pellets produced from *Avena nuda*, *Dactylis glomerata*, and *Triticum aestivum* ssp. *spelta* were characterized by an optimal energy value – higher than that of maize stalks (17.84 MJ/kg), and very low ash content (2.1%), significantly lower than that found in *Zea mays saccharata* and *Lolium perenne* straw. The bulk density of the produced pellets ranged from 443.6 kg/m³ for *Triticum aestivum* ssp. *spelta* pellets to 595.2 kg/m³ for *Dactylis glomerata* pellets. The mechanical durability of pellets made from *Zea mays saccharata* reached 97.39%, compared to 92.86% for pellets made from *Dactylis glomerata*.

Table 2

Some quality indices of biomass and pellets from studied agricultural residues- straws

Indices	*Avena nuda*	*Dactylis glomerata*	*Lolium perenne*	*Triticum aestivum spelta*	*Zea mays saccharata*
Ash content of biomass, % DM	3.8	7.1	6.8	5.4	9.2
Volatile matter , % DM	81.25	78.65	76.28	80.62	69.02
Gross calorific value of biomass, MJ/kg DM	18.5	18.4	18.0	18.4	17.7
Net calorific value of biomass, MJ/kg DM	17.2	17.1	16.7	17.0	16.4
Net calorific value of biomass, M10% MJ/kg DM	15.3	15.1	14.7	16.4	14.5
Ash content of pellets, % DM	3.8	8.0	6.4	5.9	10.1
Gross calorific value of pellets, MJ/kg DM	18.5	18.4	18.0	18.5	17.8
Net calorific value of pellets, MJ/kg DM	17.0	17.1	16.6	17.1	16.4
Net calorific value of pellets, M10% MJ/kg DM	15.0	15.1	14.7	15.1	14.5

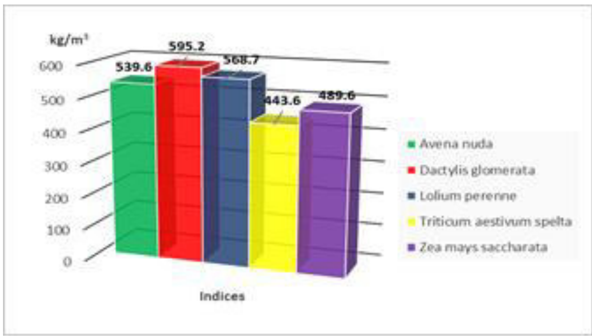

Figure 12 **Bulk density of pellets**

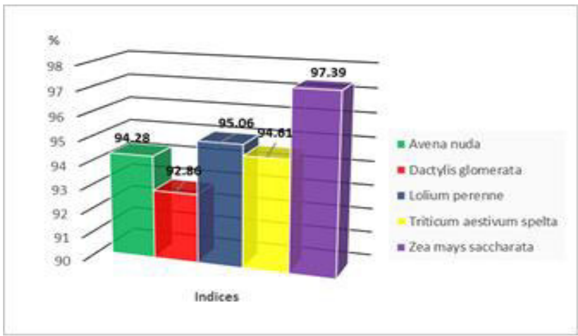

Figure 13 **Durability of pellets**

Morissette R. *et al*. (2011) reported that maize straw dry matter had 17.57 to 19.02 MJ/kg GCV and 4.73-9.25% ash. Kiš D. *et al*. (2017) found that the energy value of *Triticum aestivum* ssp. *spelta* stems ranged from 17.2 to 17.4 MJ/kg, while the chaff and glumes had a slightly lower energy value of 16.4-16.7 MJ/kg. In a previous study, Muntean I. *et al*. (2018) established that maize straw biomass contained 4.40% ash and 17.8 MJ/kg GCV, and a pellet bulk density of 701 kg/m³. In comparison, wheat straw had 4.93% ash, 17.4 MJ/kg GCV, 685 kg/m³. Petlickaite R. *et al*. (2022) reported that pellets made from maize straw had the following characteristics: 4.61% moisture (MC), 18.02 MJ/kg GCV, 16.87 MJ/kg NCV and a density of 1159.57 kg/m³. Yang W. *et al.* (2022) reported that maize stalks contained 2.86% MC, 20.90% FC, 64.49% VM, 13.49 MJ/kg NCV, and 6.58% ash. The elemental composition included 39.81% C, 5.93% H, 0.94% N, 0.23% S, and 0.61% Cl. Stolarski M.J. *et al*. (2019) found that solid fuels from wheat straw had 16.20% MC, 18.68 MJ/kg GCV, 15.26 MJ/kg NCV, 20.60% FC, 73.05% VM, and 6.35% ash; from ryegrass straw 15.35% MC, 19.03 MJ/kg GCV, 15.74 MJ/kg NCV, 21.50% FC, 75.83% VM, and 2.67% ash; corn stover had 69.80% MC, 18.28 MJ/kg GCV, 3.82 MJ/kg NCV, 20.42% FC, 75.15% VM, and 4.42% ash. Gageanu I. *et al.* (2018) reported that rapeseed stalk pellets had 10.54% moisture content, 3780.21 kcal/kg energy values, but pellets from wheat straws 8.16% moisture content, 3965.56 kcal/kg energy value, respectively. Stolarski M.J. *et al.* (2024) determined that oat straw had 11.68-12.85% MC, 19.44-20.66 % FC, 73.96-74.96% VM, 4.97-6.40% ash, 18.52-18.77 MJ/kg GCV and 14.98-15.20 MJ/kg NCV; wheat straw respectively 10.11-12.43% MC, 20.07-20.35 % FC, 72.83-75.09% VM, 4.52-6.82% ash, 18.40-18.84 MJ/kg GCV, 15.18-15.35 MJ/kg NCV; corn straw had 48.32-49.36% MC, 18.99-19.30 % FC, 76.35-77.74% VM, 4.16-4.35% ash, 18.20-18.51 MJ/kg GCV, 7.53-7.88 MJ/kg NCV. Güleç F., *et al.* (2022) reported that wheat straw biomass had 1.18% N, 45.58% C, 0.59% S, 6.04% H, 46.60% O, 5.30% ash. 76.00% VM, 18.20% FC, 17.34 MJ/kg GCV, while grass straw pellets 0.56% N, 47.89% C, 0.17% S, 5.51% H, 45.87% O, 9.80% ash, 79.00 %VM, 11.20% FC and 16.58 MJ/kg GCV. Stolarski M.J. *et al.* (2025) reported that wheat straw pellets are characterized by 7.58 % MC, 20.90 % FC, 74.98% VM, 628.85 kg/m^3 bulk density, 19.11 MJ/kg GCV.

CONCLUSIONS

Straws from *Avena nuda, Dactylis glomerata, Lolium perenne, Triticum aestivum ssp. spelta* and *Zea mays saccharata* can be used as sources of fibre in ruminant diets, for cattle and other ruminants, also as feedstock for production solid, liquid and gaseous fuels.

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