Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE EVALUATION OF THE QUALITY INDICES OF PHYTOMASS FROM ENERGY CROPS AND AGRICULTURAL RESIDUES

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Abstract

The objective of this research was to evaluate the quality indices of the solid dry phytomass from energy crops Miscanthus giganteus 'Titan', Silphium perfoliatum 'Vital', Sorghum bicolor, var. saccharatum 'SAŞM1' and agricultural residues – stems of Brassica napus oleifera and Pisum sativum collected in the experimental plot of the NBGI Chişinău. It has been found that elemental composition the collected dry phytomass was 41.36-50.00% carbon, 4.32-6.14% hydrogen, 0.22-1.37% nitrogen, 0.03-0.10% sulphur, 2.18-5.66% ash and gross calorific value varied from 18.2 to 19.6 MJ/kg phytomass. The solid dry phytomass contained 361-520 g/kg cellulose, 191-320 g/kg hemicellulose, 83-122 g/kg acid detergent fibre and the estimated theoretical ethanol yield averaged 410-592 L/t organic dry matter. The studied energy crops were characterized by optimal quality indices of phytomass and can serve as feedstock for the production of pellets and cellulosic bioethanol. The agricultural residues have higher content of ash, nitrogen, sulphur and lower concentration of structural carbohydrates and energy value, which make them suitable to be used as a part of a diverse mix with biomass from woody species.

Key words: *agricultural residues, energy crops, Brassica napus oleifera, Miscanthus giganteus, quality indices of phytomas, Pisum sativum, Silphium perfoliatum, Sorghum bicolor.*

INTRODUCTION

Nowadays, energy has become a common topic for reporters and analysts around the world. The demand for fossil fuel, such as petroleum, coal and natural gas, increases worldwide, and a huge amount of fuel is used as an energy source. Because of such a high demand, the price of fuel keeps increasing, while the resources of fossil fuels are depleting. Besides, burning fossil fuels has several adverse effects, such as releasing greenhouse gas and increasing pollution, which, in turn has a harmful impact on human health. As a result, the depletion of fossil energy resources and the desire to decrease greenhouse gas emissions are two major issues that have driven the research for a secure and sustainable energy from a renewable source.

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. 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.

The Republic of Moldova import 95 % fossil energy resources. Therefore, the issue of renewable energy sources is still relevant. According to the Energy Strategy of the Republic of Moldova, the energy from renewable sources should be increased to 20 % by the year 2030 and ¾ of this amount will make from biomass. To determine crops that are the most suitable for energy production, its agro-biological peculiarities, biochemical composition and thermo- physical properties, environmental impact and production economy must be investigated thoroughly. As a result of the research conducted in the "Alexandru Ciubotaru" National Botanical Garden (Institute) the collection of energy plants were founded, new cultivars of energy crops were created, registered in the Catalogue of Plant Varieties and patented by the State Agency on Intellectual Property of the Republic of

Moldova. These cultivars can be placed to use of marginal, polluted, eroded, salinized lands (Țîței & Roșca, 2021; Țîței, 2023).

The main objective of this research was to evaluate the quality indices of the solid dry phytomass from energy crops *Miscanthus giganteus*, *Silphium perfoliatum*, *Sorghum bicolor*, var. *scacharatum* and agricultural residues- stems of *Brassica napus oleifera* and *Pisum sativum.*

MATERIALS AND METHODS

The local cultivars *'Titan'* of *Miscanthus giganteus, 'Vital'* of *Silphium perfoliatum 'Vital', 'SAȘM 1'* of *Sorghum bicolor, var. saccharatum 'SAȘM1'* and agricultural residues, namely, stems of *Brassica napus oleifera* and *Pisum sativum* collected in the experimental plot of the "Alexandru Ciubotaru" National Botanical Garden (Institute) of MSU, Chişinău, located at latitude 46°58′25.7″N and longitude 28°52′57.8″E, served as subjects of the research. The harvested phytomass was chopped into small pieces using a stationary forage chopping unit. The chopped phytomass was then crushed in a beater mill, equipped with a sieve with mesh diameter of 6 mm. To perform the analyses, the milled phytomass samples were dried in an oven at 85°C and then milled (<1 mm) and homogenized. After that, the total carbon, hydrogen, nitrogen and sulphur amounts were determined by dry combustion in a Vario Macro CHNS analyser; pelleting equipment was used to perform biomass densification; the ash content and energy value of dry biomass and pellets were determined according to standard protocols at the Technical University of Moldova.

To determine the cell wall components in the dry mass of tested species, the amounts of neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were assessed using the near infrared spectroscopy (NIRS) technique PERTEN DA 7200 at the Research-Development Institute for Grassland Brasov, Romania. The amount of cellulose was calculated as ADF minus ADL and hemicelluloses – NDF minus ADF. The Theoretical Ethanol Potential (TEP) was calculated according to the equations of Goff et al. (2010) based on conversion of cellulose and hemicellulose into hexose (H) and pentose (P) sugars:

$$H = [\%Cel + (\%HC \times 0.07)] \times 172.82$$

$$P = [\%HC \times 0.93] \times 176.87$$

$$TEP = [H + P] \times 4.17$$

RESULTS AND DISCUSSIONS

The use of phytomass as solid fuel for energy supply requires characterizing elemental chemical components. The main constituents of dry biomass are carbon, oxygen and hydrogen. The energy released during the combustion process is positively correlated with the carbon and hydrogen contents as a function of the energy value of these elements. In contrast, high oxygen and nitrogen values decrease the calorific value. The higher hydrogen content determines and leads to a higher net caloric value. Nitrogen, sulphur and chlorine concentrations are some of the main causes of air pollution from biomass combustion. A higher percentage of these elements generally results in a higher level of air contaminants being released.

Table 1. The elemental composition of the dry phytomass from the studied species, %

Indices	*Miscanthus giganteus*	*Silphium perfoliatum*	*Sorghum bicolor*	*Brassica napus*	*Pisum sativum*
Carbon	50.00	46.28	49.35	45.60	41.37
Nitrogen	0.47	0.22	0.41	0.92	1.37
Hydrogen	5.86	6.14	5.60	5.14	4.32
Sulphur	0.03	0.03	0.06	0.07	0.10
Oxygen	43.60	47.33	44.58	48.30	52.84

The average elemental composition of the studied species for energy biomass is presented in Table 1. We found that the phytomass from *Miscanthus giganteus* and *Sorghum bicolor* is characterized by a very high concentration of carbon and very low concentration of nitrogen and sulphur, as compared with *Brassica napus* and *Pisum sativum* phytomass. The phytomass from *Silphium perfoliatum* is characterized by lower levels of nitrogen and higher - of hydrogen, as compared with other investigated species.

Different results regarding the elemental composition of the dry biomass from the studied species are given in the specialized literature. Karaosmanoglu et al. (1999) mentioned that rapeseed straw and stalks consisted of 45.17% carbon, 5.15% hydrogen, 0.75% nitrogen, 42.92% oxygen, 0.14% sulphur. Greenhalf et al. (2012) reported that rapeseed straw contained 48.35% carbon, 5.80% hydrogen, 1.15% nitrogen and 44.70% oxygen, but wheat straw – 47.24% carbon, 6.00% hydrogen, 0.66% nitrogen and 46.09% oxygen. Huang (2014) revealed that *Miscanthus giganteus* contained 44.21% carbon, 6.21% hydrogen, 0.56% nitrogen, 0.45% chlorine. Moon et al. (2014) found that *Miscanthus giganteus* had 44.00% carbon, 5.8% hydrogen and 0.023-0.038% sulphur. Stolarski et al. (2014) reported that *Silphium perfoliatum* harvested in March contained 47.40% carbon, 5.70% hydrogen and 0.36% sulphur, while *Miscanthus giganteus* – 49.80% carbon, 5.70% hydrogen and 0.026% sulphur. Šiaudinis et al. (2015) mentioned that *Silphium perfoliatum* contained 45.44% carbon, 5.28% hydrogen, 0.68% nitrogen, 38.57% oxygen, 0.07% sulphur. Ivanova et al. (2017) mentioned that pure sweet sorghum contained 343.1% carbon, 5.27% hydrogen, 0.61% nitrogen, 0.04% sulphur, 0.09% chlorine. Mohammadi et al. (2017) mentioned that *Miscanthus giganteus* pellets had 4.78% 49.45% carbon, 6.24% hydrogen. Dahunsi et al. (2019) found that *Sorghum bicolor* stalks had 41.24% carbon and 2.33% nitrogen. Babich et al. (2021) revealed that *Miscanthus giganteus* contained 47.1-49.7% carbon, 5.38-5.92% hydrogen, and 41.4-44.6% oxygen. Dok et al. (2021) reported that the pellets obtained from *Sorghum* stems had 43.98-54.19% carbon, 5.42-5.90% hydrogen, 0.45-0.76% nitrogen, 39.65-49.52% oxygen. Pegoretti et al. (2021) revealed that *Miscanthus giganteus* had 43.7% carbon, 6.21% hydrogen, 0.31% nitrogen, 0.1% sulphur. Szufa et al. (2021) mentioned that *Miscanthus giganteus* biomass contained 48.5% carbon, 6.20% hydrogen, 0.27% nitrogen, 42.56% oxygen, 0.05% sulphur, 0.015% chlorine. Szyszlak-Bargłowicz et al. (2021) mentioned that *Miscanthus giganteus* contained 48.45% carbon, 6.09% hydrogen, 0.24% nitrogen and 0.04% sulphur. Güleç et al. (2022) revealed that *Miscanthus* biomass had 0.10% nitrogen, 47.09% carbon, 0.10% sulphur, 6.30% hydrogen, but pea plant waste – 0.90% nitrogen, 44.06% carbon, 0.39% sulphur, 4.73% hydrogen, respectively. Šuric et al. (2023) found that the elemental composition of the investigated *Miscanthu*s biomass was 0.08-0.15% nitrogen, 51.6-52.6% carbon, 0.1-0.17% sulphur, 5.4-6.12% hydrogen. Țîței (2023) reported that biomass from *Miscanthus giganteus* contained 46.34% carbon, 5.95% hydrogen, 0.33% nitrogen, 0.05% sulphur, while from *Silphium perfoliatum*- 45.07% carbon, 5.96% hydrogen, 0.21% nitrogen, 0.03% sulphur. Angelova & Koleva (2024) remarked that the *Silphium perfoliatum* biomass had 0.846% nitrogen, 40.5% carbon, 0.052% sulphur, 5.7% hydrogen, 46.03% oxygen, 0.074% chlorine. Mohammadi et al. (2024) mentioned that the key elemental components of *Miscanthus* pellets were 45.47 % carbon, 5.62% hydrogen and 48.91% oxygen.

Table 2. The ash content and the energy value of phytomass and pellets from the studied species

Indices	*Miscanthus giganteus*	*Silphium perfoliatum*	*Sorghum bicolor*	*Brassica napus*	*Pisum sativum*
Ash content of phytomass, % DM	2.18	4.24	3.64	5.85	5.66
Gross calorific value of phytomass, MJ/kg DM	19.60	18.54	18.45	18.60	18.20
Net calorific value of phytomass, MJ/kg DM	18.33	17.35	17.22	17.40	17.20
Net calorific value of pellets, MJ/kg DM	16.20	15.11	15.26	15.70	15.20

While handling, transporting, storing and using biomass as fuel in its original form considerable difficulties are to be faced. For this reason, the densification of biomass, in the form of pellets and briquettes, is usually preferred and aimed at reducing the volume of biomass, which subsequently leads to lower transportation costs, easier usage and increased quantity of energy per unit of volume.

Pellet fuels are also more consistent in their structure, and therefore more suitable for the automated fuel system in the corporate and individual boilers. The ash content and the energy value of phytomass and pellets from the studied species are illustrated in Table 2. Ash content is one of the main factors of biomass quality, since higher amounts of ash decrease the quality of fuels, especially solid ones. The *Miscanthus giganteus* phytomass is characterized by excellent ash content (2.18%). The *Sorghum bicolor* phytomass had optimal ash concentration, while the *Silphium perfoliatum* phytomass has higher ash content, but lower than agricultural residues – stems of *Brassica napus oleifera* and *Pisum sativum.* The gross calorific value is higher in *Miscanthus giganteus* biomass (19.60 MJ/kg) and lower in *Pisum sativum* stems (18.20 MJ/kg). The level of net calorific value of dry phytomass from *Silphium perfoliatum*, *Sorghum bicolor, Brassica napus oleifera* and *Pisum sativum* does not differ considerably (17.20-17.40 MJ/kg). The pellets made from *Miscanthus giganteus* phytomass are characterized by net calorific value of 16.20 MJ/kg. The net calorific value of the pellets made from *Brassica napus oleifera* reached 15.70 MJ/kg, which was higher than in pellets from *Silphium perfoliatum*, *Sorghum bicolor* and *Pisum sativum* (15.11-17.26 MJ/kg).

Some authors mentioned various findings about the physical and mechanical properties of phytomass and pellets from the studied species. Karaosmanoglu et al. (1999) mentioned that rapeseed straw and stalks had 12.64% moisture content, 5.87% ash, 75.55% volatile matter, 18.58% fixed carbon and 141.17 kg/m^3 bulk density. Zabaniotou et al. (2008) revealed that rapeseed residues contained 3.95% ash, 71.01% volatile matter, 23.04% fixed carbon, 16.8 MJ/kg gross calorific value and 16.37 MJ/kg net calorific value. Greenhalf et al. (2012) determined that rapeseed straw had 6.58% ash, 76.9% volatile matter, 11.88% fixed carbon, 18.94 MJ/kg gross calorific value, but wheat straw 4.89% ash, 79.92% volatile matter, 15.18% fixed carbon and 18.69 MJ/kg gross calorific value, respectively. Maroušek (2013) reported that rapeseed straw pellets had 15.4 MJ/kg calorific value and 944 kg/m^3 specific density. Huang (2014) revealed that *Miscanthus giganteus* contained 1.70% ash, 74.28% volatile matter, 17.7 MJ/kg gross calorific value, 16.09 MJ/kg net calorific value. Melgarejo et al. (2014) found that residual biomass from *Pisum sativum* contained 11.65 % moisture content, 83.61 % volatile matter, 12.28% fixed carbon, 4.11% ash, and 11040 kcal/kg calorific power. Moon et al. (2014) reported that the pellets from *Miscanthus giganteus* had 2.2% ashes, 4.025 kcal/kg gross calorific value. Stolarski et al. (2014) reported that harvested in March *Silphium perfoliatum* had 3.04% ash, 18.70 MJ/kg gross calorific value and 13.35 MJ/kg net calorific value, but *Miscanthus giganteus* 2.06 % ash, 19.12 MJ/kg gross calorific value and 11.12 MJ/kg net calorific value. Heuzé et al. (2015) reported that pea straw contained 824-924 g/kg dry matter 8.1-12.12.1% ash, and 18.1 MJ/kg gross calorific value. Jasinskas et al. (2016) reported that pellets from *Silphium perfoliatum* had 11.6% humidity, 9.96%ash, 16.82 MJ/kg calorific value and density 1072.3 kg/m^3. Ivanova et al. (2017) mentioned that sweet sorghum biomass contained 3.9% ash, 70.8% volatile matter, 18.9MJ/kg gross calorific value and 17.7MJ/kg net calorific value. Ferreira et al. (2017) reported that *Sorghum* pellet properties were: 3% ash, 14.45% fixed carbon, 4525.0 kcal/kg gross calorific value, 3605.31 kcal/kg net calorific value and 735.1 kg/m^3 bulk density. Gageanu 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. Muntean et al. (2018) determined that biomass from *Miscanthus giganteus* contained 2.51% ash and 19.3 MJ/kg gross calorific value, while the biomass from *Sorghum almum* – 3.71% ash and 18.6 MJ/kg gross calorific value. Babich et al. (2021) mentioned that *Miscanthus giganteus* had 2.7% ash, 73.6-73.9% volatile matter, 19.3–19.8% coke residue and specific heat of combustion ranged from 17 to 20 MJ/kg. Bury et al. (2021) found that the heat of combustion of *Silphium perfoliatum* varied from 14.59 MJ/kg in the first year to 17.68 MJ/kg in the third year. Szyszlak-Bargłowicz et al. (2021) mentioned that the *Miscanthus giganteus* biomass had 7.20% water, 2.36% ash, 73.61% volatile matter, 16.40% fixed carbon, 17.578 MJ/kg gross calorific value, 16.303 MJ/kg net calorific value. Dok et al. (2021) determined that the pellets obtained from the *Sorghum* stems were characterized by 4226-4412 kcal/kg gross calorific value and 512.3-705.5 kg/m^3 bulk density. Pegoretti et al. (2021) revealed that *Miscanthus giganteus* had 2.67% ash, 19.0MJ/kg gross calorific value, 17.76 MJ/kg net calorific value. Güleç et al. (2022) remarked that *Miscanthus* biomass had 9.60% ash, 79.00 % volatile matter, 11.40% fixed carbon, 18.07 MJ/kg gross calorific value, but pea plant waste – 5.80% ash, 78.00% volatile matter, 15.90% fixed carbon, 17.35 MJ/kg gross calorific value. Mill (2022) mentioned that the harvested *Miscanthus* biomass contained 15.0% water, 3.7% ash and 17.5 MJ/kg net calorific value. Witaszek et al. (2022) reported that *Silphium perfoliatum* had 15.58 MJ/kg heat of combustion measured in the calorimetric test and 14.08 MJ/kg calorific value. Šuric et al. (2023) determined that *Miscanthus* plants harvested in the spring period contained 84.64-85.15 % dry matter with 1.49-1.55 % ash, 11.68 - 12.16 % coke, 10.14 - 10.68 % fixed carbon, 82.44 -83.42 % volatile matter, 17.83-18.7 MJ/kg gross calorific value and 16.49-17.53 MJ/kg net calorific value. Țîței (2023) reported that biomass from *Miscanthus giganteus* had 1.75% ash and 19.5 MJ/kg gross calorific value, while from *Silphium perfoliatum*- 3.83% ash and 18.65 MJ/kg gross calorific value. Angelova & Koleva (2024) mentioned that the *Silphium perfoliatum* biomass contained 9.1% ash, 77.34 % volatile matter, 16.40% fixed carbon and 16.56 MJ/kg net calorific value. Mohammadi et al. (2024) reported that *Miscanthus* pellets had 8.16% moisture content, 5.13% ash, 18.39 MJ/kg gross calorific value and 1030 kg/m^3 specific density.

Table 3. The biochemical composition and the theoretical ethanol potential of phytomass from the studied species

Indices	*Miscanthus giganteus*	*Silphium perfoliatum*	*Sorghum bicolor*	*Brassica napus*	*Pisum sativum*
Acid detergent fibre, g/kg DM	617	632	537	484	446
Neutral detergent fibre, g/kg DM	937	880	779	675	649
Acid detergent lignin, g/kg DM	122	110	92	83	85
Cellulose, g/kg DM	495	522	445	401	361
Hemicellulose, g/kg DM	320	248	242	191	203
Theoretical ethanol potential, L/t ODM	592.37	558.80	498.90	492.62	409.64
- from hexose sugars, L/t ODM	372.87	388.69	332.90	298.62	270.40
- from pentose sugars, L/t ODM	219.50	170.11	166.00	131.00	139.24

Bioethanol production from lignocellulosic biomasses has been proved a promising alternative energy source, and its advantages include not only the possibility to compensate for the fast depleting petroleum resources, but also the low cost, the great potential availability and the possibility to reduce toxic emissions in the transportation sector. The bioethanol produced from lignocellulosic biomasses is currently promoted as an alternative transportation fuel, because of its antiknock properties, which help increasing octane ratings and improve fuel efficiency. The bioethanol yields are influenced by tissue composition, ratios of cellulose, hemicellulose and lignin. By analysing the cell wall composition of dry matter substrates (Table 3), we found that the highest average concentration of structural carbohydrates was generally observed in energy crops substrates from *Miscanthus giganteus* and *Silphium perfoliatum* as compared with agricultural residues – stems of *Brassica napus oleifera* and *Pisum sativum*. The *Sorghum bicolor* stalk biomass substrate has lower levels of cellulose, hemicellulose and lignin than energy crops substrates, which are due probable to the higher concentration of soluble carbohydrates, but they are still higher than in agricultural residues substrates. The theoretical ethanol yield from fermentable sugars averaged 592.37 L/t in *Miscanthus giganteus* substrate, 558.80 L/t in *Silphium perfoliatum* substrate, 498.90 L/t in *Sorghum bicolor* substrate, as compared with 492.62 L/t in *Brassica napus oleifera* substrate and 409.64 L/t in *Pisum sativum* substrate.

Several literature sources describe the composition of cell walls in studied plant species and the calculated ethanol yields. Greenhalf et al. (2012) determined that rapeseed straw had 37.55% cellulose, 31.37% hemicellulose, 21.30% lignin, 3.76% soluble, 6.02% ash. Stefaniak et al. (2012) studied the biomass composition of 152 sorghum samples and found that sorghum biomass types contained 6.3% ash, 3.3% protein, 9.0% sucrose, 13.7% lignin, 16.4% xylans, 29.1% glucans, 5.6% starch and the calculated ethanol yields reached 452 L/t; forage sorghum types – 8.4% ash, 4.5% protein, 1.1% sucrose, 13.0% lignin, 16.2% xylans, 37.2% glucans, 1.8% starch and the calculated ethanol yields were 456 L/t; sorghum-Sudan grass types – 8.8% ash, 3.7% protein, 2.4% sucrose, 13.5% lignin, 17.2% xylans, 33.2% glucans, 1.1% starch and calculated ethanol yields was 452 L/t; sweet sorghum types – 5.7% ash, 3.3% protein, 9.8 % sucrose, 13.0% lignin, 15.4% xylans, 29.9% glucans, 7.3% starch and 533 L/t. Melgarejo et al. (2014) found that residual biomass from *Pisum sativum* contained 26% cellulose, 20.5% hemicellulose and 3.92% lignin and soybean hulls 46-51% cellulose, 16–18% hemicellulose and 1.4–2% lignin. Heuzé et al. (2015) reported that pea straw contained 43.9-61.5 % NDF, 27.6-42.5% ADF, 4.5-9.8 % lignin. Lee & Kuan (2015) remarked that the contents of cellulose in dried biomass of *Miscanthus* × *giganteus* was 41.1% and theoretical ethanol yields were 0.211-0.233 g/g raw biomass if only cellulose is taken into account. Ferreira et al. (2017) found that *Sorghum bicolor* biomass residuals contained 29.05% lignin, 52.8% holocellulose and 15.6% extractives. Xue et al. (2017) remarked that *Miscanthus* straw contains about 41-45% cellulose, 20.6-33.0% hemicellulose, and 19.0-23.4% lignin. Scagline-Mellor et al. (2018) reported that *Miscanthus giganteus* biomass composition and theoretical ethanol yield was 4.54% ash, 87.78% aNDF, 5.46% ADL and 465L/T. Viel et al. (2018) remarked that the chemical characterization of agro-resources of rapeseed straw had the following indices: 53.06% cellulose, 18.13% hemicellulose, 9.63 % lignin, 17.68% soluble and 0.79% ash. Allison et al. (2019) revealed that *Miscanthus giganteus* contained 86.69-89.28% NDF, 11.08-12.06% ADL, 45.80-48.11% cellulose, 27.22-31.78% hemicellulose; *Miscanthus sacchariflorus* 84.38-87.178% NDF, 9.85-10.46% ADL, 41.17-44.18% cellulose, 31.67-33.35% hemicellulose and *Miscanthus sinensis* 84.02-85.77% NDF, 8.97-9.17% ADL, 42.08-43.27% cellulose, 32.98-33.98% hemicellulose. Almeida et al. (2019) reported that sorghum biomass had 68.39-73.06% NDF, 40.61-46.84% ADF, 4.79-7.77% ADL. 35.81-39.07% cellulose and 25.34-28.91% hemicellulose. Alaei et al. (2022) remarked that the chemical composition of green pea residues was 971.7g/kg dry matter, 9.66% crude protein, 8.49% ash, 47.33% ADF, 62.66% NDF, 44.9% cellulose, 20.4% hemicellulose, and 13.7% lignin. Hajj Obeid et al. (2022) mentioned that the chemical composition of the rapeseed straws was 51.40-55.20% cellulose, 9.30-15.00% hemicellulose, 8.40-10.90 % lignin, 20.90-29.90% soluble and 0.40-0.90% inorganic materials. Mill (2022) reported that *Miscanthus* biomass contained 43.06–52.20% cellulose, 24.83–33.98% hemicellulose 9.27–12.58% lignin, 2.16–3.47% ash. Çelik et al. (2023) revealed that sweet sorghum biomass had 30.72-40.27% cellulose and 18.34-24.90% hemicellulose. Țîței (2023) found that *Miscanthus giganteus* had 50.8% cellulose, 30.5% hemicellulose and theoretical ethanol yield was 591 L/t. Witaszek et al. (2022) reported that *Silphium perfoliatum biomass* had 30.96% cellulose, 22.6% hemicellulose and 21.62% lignin. Tóth Š. (2023) reported that the ligno-cellulose quality of *Silphium perfoliatum* green phytomass was: 31.32-48.94% ADL, 34.94–54.69% NDF, 7.21-12.54% ADL, 24.11-37.30% cellulose, 24.11 – 37.30%, 2.33–5.75% hemicellulose.

CONCLUSIONS

The local cultivars of energy crops *'Titan'* of *Miscanthus giganteus, 'Vital'* of *Silphium perfoliatum* and *'SAȘM 1'* of *Sorghum bicolor var. saccharatum* were characterized by optimal quality indices of phytomass and can serve as feedstock for the production of pellets and cellulosic bioethanol, as renewable energy sources.

The agricultural residues – stems of *Brassica napus oleifera* and *Pisum sativum* have higher content of ash, nitrogen, sulphur and lower concentration of structural carbohydrates, which make them suitable to be used as a part of a diverse mix with biomass from woody species for energy production.

ACKNOWLEDGEMENTS

This study has been supported by the subprograms no. 01.01.02 and no. 02.04.07, funded by the Ministry of Education and Research, Republic of Moldova.

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