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SOME SEEDS CHARACTERISTIC AND BIOMASS QUALITY OF SOME *Brassicaceae* AND *Fabaceae* SPECIES IN MOLDOVA

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Abstract

The goal of our research was to fulfil the potential of traditional, underutilized and less known plant species of the families Brassicaceae and Fabaceae, which grow in the experimental plots of the "Alexandru Ciubotaru" National Botanical Garden (Institute), Chisinau, Republic of Moldova. The seeds and biomass of these plant species have high potential for use as food, forage and raw material for circular economy, including bioenergy production. The determination of physical and mechanical properties of seeds and agricultural products is important in the design of harvesting, handling and processing equipment. Our research revealed that the characteristic dimensions of seeds of the studied Brassicaceae species varied in the following ranges ℓ*: b:* $\delta \approx$ *(1.98-12.60): (1.67-3.67): (1.63-2.05) mm; the angle of repose* α*=24.6°-30.6° and the flow angle on steel is* α_1*=15.8°-31.7°, on wood* α_1*=18.1°-37.3° and on enamelled surface* α_1*=15.3°-30.5°;* M_{1000} *= 4.30-9.73 g and bulk seed density 88.3-766.9 kg/m*^{3}*. The seeds characteristic of the studied Fabaceae species was* ℓ*: b:* $\delta \approx$ *(1.53-8.00): (1.20-5.47): (1.47-5.01) mm; the angle of repose* α*=21.5°-33.0°, flow angle on steel is* α_1*=14.3°-27.7°, on wood* α_1*=14.7°-29.8° and on enamelled surface* α_1*=14.2°-27.3°;* M_{1000} *= 1.35-170.04 g and bulk seed density 370.8-830.0 kg/m*^{3}*. The harvested green mass from studied Brassicaceae species is characterized by 16.1-23.5%CP, 63.2-69.9% DMD, RFV=117-162, 10.21-11.20 MJ/kg ME, 5.18-6.76 MJ/kg NEl and from Fabaceae species 14.2-23.4% CP, 58.4-69.5% DMD, RFV=91-168, 9.51-11.15 MJ/kg ME, 5.53-7.17 MJ/kg NEl. The biochemical biomethane potential from vegetal substrates is 305-379 L/kg of organic matter.*

Key words: *biomass quality, Brassicaceae species, Fabaceae species, methane potential, nutritive value, seed characteristic.*

INTRODUCTION

World plant biodiversity, its conservation and prospects for practical use are becoming an increasingly pressing problem in the 21st century (ECPGR,2021).

Current climate change can cause reduction in the abundance of food and fodder, crop productivity and quality indices. The increase of food and fodder production in the context of climate change and increasing prices for energy resources will be based on more rational use of traditional crops and identification of new species that will expand the range of crops. The diversification of crop production has to be achieved by mobilization, acclimatization and implementation of new and non-traditional plant species from local flora and other floristic regions.

In the context of the acute shortage of protein in the food of humans and animals, it is necessary to expand the areas where protein crops are cultivated by mobilizing new species that would extend the assortment of both: crops for the production of food for humans and fodder necessary for the development of the animal husbandry sector and poultry farming, as well as raw material for various industries. The species of the family *Fabaceae* and *Brassicaceae* are of particular interest.

The family *Brassicaceae* Burnett (syn. *Cruciferae* Juss.) includes 372 genera and

4.060 accepted species. Most of them are herbaceous annuals, biennials and perennials, warm season shrubs and trees; some are used as agricultural crops and ornamental plants. Most of the species occur in the temperate zone of the Northern Hemisphere (especially in the Mediterranean and Irano-Turanian region) and much less in the Southern Hemisphere. In the spontaneous flora of Bessarabia, the *Brassicaceae* family is currently represented by 48 genera with 97 species. Many *Brassicaceae* species are known as important agricultural and horticultural crops, which provide edible roots, leaves, stems, buds, flowers and seeds, some species are used as human food in many different forms, while others are also used as fodder, energy and cover crops (Jabeen, 2020).

The family *Fabaceae* Lindl. (syn. *Leguminosae* Juss.) is the third largest family among the angiosperms, consists of about 730 genera and about 20,000 species of trees, shrubs, vines, and herbs and is worldwide in distribution. In the spontaneous flora of the Bessarabia the family *Fabaceae* is represented by 146 species of 35 genera. The *Fabaceae* species are of great agro-ecologic importance due to their symbiotic relationship with nitrogen fixing bacteria, thus, they improve the physical properties of soil, form a large amount of organic raw material for circular economy and, besides, they are an important source of proteins, beneficial to human and animal nutrition. The benefits of leguminous forage plants within farming systems have long been recognized and include a higher production of meat, milk and wool by ruminants, improvement of soil fertility, root disease management in cropping systems, increasing biodiversity and risk management in diversified systems, particularly under the conditions of climate change. Many *Fabaceae* species have valuable medicinal properties and multi-purpose use in various industries; besides, they are excellent honey plants and cover crops (Stoddard, 2013; Stinner, 2015; Petcu et al., 2022).

Underutilized and less known *Fabaceae* and *Brassicaceae* species constitute potential source of food, fodder and raw material for circular economy, including bioenergy production.

The physical properties, such as length, width, thickness, bulk and true density, 1000 seed weight, surface area, and sphericity, are basic characteristic parameters for optimization and design of internal run roller plate seed metering structure. Information on physical properties can be valuable for plant breeders, engineers, scientists, and seed industries experts, machine designers, processing structures and controls; and to determining machine performance efficiency. Variation in seed properties caused by the genetic pattern, soils and environmental conditions, or handling may influence the processing, storage and utilization of seed. Physical, mechanical and chemical characteristics of seed materials are important in designing the equipment for seeding, harvest, transport, storage, processing, cleaning, hulling and milling (Togo et al., 2018).

The goal of our research was to evaluate some seed characteristics and green biomass quality of some *Brassicaceae* and *Fabaceae* species, as fodder for livestock, as well as substrate for the production of biomethane by anaerobic digestion.

MATERIALS AND METHODS

The *Brassicaceae* species: *Crambe cordifolia, Isatis tinctoria, Raphanus sativus* var. *oleifera, Sinapsis alba* and *Fabaceae* species: *Astragalus galegiformis, Galega orientalis, Glycine max, Lablab purpureus, Lotus corniculatus, Medicago sativa, Onobrychis arenaria, Onobrychis viciaefolia, Pisum arvense, Vicia sativa, Vicia tenuifolia, Vigna radiate, Vigna unguiculata,* which grow in the experimental plot of the National Botanical Garden (Institute) of Moldova, Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″, served as subjects of research.

Samples of seeds of the studied species were collected, the evaluation of the seed characteristics of each species were carried out based on the measurement of the following parameters: length, width, thickness, friability (angle of repose α, angle of friction α_1), mass of 1000 seeds, bulk seed density. The angle α was determined by two methods: a) *general*, measuring the height *h* of the cone with a depth calliper and the diameter of the base *D* in two perpendicular planes with the metal ruler KLB 300 x 19 x 0.5 mm; the angle α was calculated according to the formula $tg\alpha = 2h/D$; b) *local*, measuring the angle α by applying the digital inclinometer on the inclined surface of the cone. The flow angle α_1 of the seeds was measured using a table with the upper surface rotating vertically. On this surface, it is possible to attach plates made of different materials. We used plates of steel 10, wood and enamelled steel. The angle α_1 was measured using a digital inclinometer. The weight of 1000 seeds were determined by using an electronic balance with accuracy of 0.01 g. The measurement was replicated 5 times for 1000 seeds selected at random. For bulk density measurement, an empty cylindrical container of 1000 ml volume was filled with the seeds, then weighing the content, the bulk weight was then recorded. This was done in 10 replications.

The dry matter content in harvested green mass was detected by drying samples up to constant weight at 105°C. For biochemical analysis, green mass samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with diameter of openings of 1 mm, and some assessments of the main biochemical parameters: crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL), total soluble sugars (TSS) have been made by near infrared spectroscopy (NIRS) technique using the equipment PERTEN DA 7200. The concentration of hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl) and relative feed value (RFV) were calculated according to standard procedures.

The carbon content of the substrates was determined using an empirical equation according to Badger et al. (1979). The biochemical methane potential was calculated according to the equations of Dandikas et al. (2015).

RESULTS AND DISCUSSIONS

The size of the seeds is an important characteristic of a plant species. The results of the evaluation of the physical characteristics of the seeds of the studied *Brassicaceae* and *Fabaceae* species species are shown in Table 1. The obtained results have demonstrated the following values of the characteristic dimensions (length - ℓ, width - b, thickness - δ) for the studied *Brasicacaeae* species seeds ℓ: b: δ ≈ (1.98-12.60): (1.67-3.67): (1.63-2.05) mm, the highest values were recorded by the species *Isatis tinctoria* and *Crambe cordifolia.* The dimensions of *Fabaceae* species seeds have the following values ℓ: b: δ ≈ (1.53-8.00): (1.20-5.47): (1.47-5.01). We noticed that the lowest seed sizes were of species *Lotus corniculatus* and *Medicago sativa,* but highest seeds dimensions of species *Vigna unguiculata* and *Glycine max.*

The flow capacity (friability) of seed material, angle of repose α and flow angle α_1 is an important practice in the design of warehouses, transport and conditioning facilities (different types of transport means, elevators, cleaning and drying devices etc.) (Ene & Mocanu, 2016).

The obtained values of the angle of repose α and angle of friction α_1 confirm the results of the dimensional and morphological analyses: the friability of *Brassicaceae species* seeds have the following values: angle of repose α = 24.6°-30.6° and angle of friction α_1 = 15.8°-31.7° - on steel, α_1 = 18.1°-37.3° - on wood, α_1 = 15.3°-30.5° - on enameled surface; *Fabaceae* species seeds - angle of repose α = 21.5°-33.0° and angle of friction α_1 = 14.3°-27.7° - on steel, α_1 = 14.7°-29.8° - on wood, α_1 = 14.2°-27.3° - on enameled surface.

The enamelled and steel surfaces, seeds have a better flow capacity than on those made of wood. Our study shows that in the *Brassicaceae* family, the *Crambe cordifolia* have the highest friability, the next level of friability, a little lower, were found at *Raphanus sativus* var. *oleifera* and *Sinapsis alba* seeds. We would like to mention that in studied Fabaceae species the *Vicia sativa, Vicia tenuifolia, Vigna radiate, Vigna unguiculata* have the highest friability and lowest friability showed *Galega orientalis, Medicago sativa, Onobrychis arenaria, Onobrychis viciaefolia.*

The weight of 1000 seeds (M_{1000}) is an important physical indicator of quality when establishing the sowing norm, but the bulk seed density is of practical interest and are necessary for designing the storage spaces, the organization of the transport, the customization of the equipment and the appreciation of some technological norms. The analysis of the mass parameters, weight of 1000 seeds and bulk seed density, of studied *Brassicaceae* and *Fabaceae* seeds (Table 2) demonstrates that their values correlate with the structure and geometric parameters. The values of the mass of 1000 seeds depending plant species. Among the researched *Brassicaceae* species, higher mass seeds values are found at *Raphanus sativus* var. *oleifera* and from *Fabaceae* species - *Pisum arvense, Glycine max, Vigna unguiculata.* The *Astragalus galegiformis, Lablab purpureus, Medicago sativa, Vicia tenuifolia, Vigna unguiculata* is distinguished by a seed bulk density that exceeds 800 kg/m^3. *Crambe cordifolia* and *Isatis tinctoria* seed siliques, *Onobrychis arenaria* and *Onobrychis viciifolia* seed pods have lowest bulk density.

Table 1. The results of the evaluation of the physical characteristics of the seeds of the studied species

Species	Dimensional parameters, mm			Angle of repose **α**, Methods			Flow angle **α₁**, Surfaces		
	ℓ	**b**	**δ**	general	local	average	steel	wood	Enamel
Brasicaceae									
Crambe cordifolia	5.33 ±0.16	4.47 ±0.28	4.15 ±0.30	25.1 ±0.3	24.0 ±1.6	24.6	15.8 ±0.2	18.1 ±0.9	15.3 ±0.6
Isatis tinctoria	12.60 ±0.70	3.67 ±0.24	1.63 ±0.19	28.0 ± 1.1	32.1 ± 1.5	30.0	31.7 ± 0.4	37.3 ± 0.9	30.5 ± 0.4
Raphanus sativus var. oleifera	3.50 ±0.24	2.43 ±0.21	2.05 ± 0.04	27.4 ±0.4	28.9 ±1.6	28.2	21.3 ±0.3	26.0 ±0.8	22.7 ±0.2
Sinapsis alba	1.98 ±0.11	1.67 ±0.03	-	25.3 ±0.5	29.3 ±1.3	27.3	22.0 ±0.6	27.4 ±1.5	24.7 ±0.3
Fabaceae									
Astragalus galegiformis	3.73 ±0.07	2.25 ±0.17	1.69 ±0.13	26.0 ±1.1	26.9 ±1.3	26.5	22.8 ±0.4	26.3 ± 0.5	-
Galega orientalis	3.56 ±0.4	1.88 ±0.22	1.44 ±0.07	32.5 ±0.9	33.4 ±0.8	33.0	27.7 ±0.3	29.8 ±0.8	27.3 ±0.4
Glycine max	7.07 ±0.25	5.4 0 ±0.27	5.20 ±0.25	27.0 ±0.6	25.5 ±0.7	26.2	15.2 ±1.1	16. ±0.9	14.7 ±0.3
Lablab purpureus	6.50 ±0.40	4.85 ±0.20	4.67 ±0.27	23.2 ±0.6	27.3 ±1.0	25.3	18.0 ±0.5	18.0 ±0.7	17.0 ±0.4
Lotus corniculatus	1.53 ±0.08	1.34 ±0.11	1.07 ±0.08	24.9 ±0.7	25.3 ±0.7	25.1	19.0 ±0.6	22.7 ±0.4	23.0 ±0.6
Medicago sativa	2.17 ±0.10	1.20 ±0.06	1.07 ±0.06	30.2 ±0.3	31.5 ±0.4	30.9	27.3 ±0.4	33.6 ±0.9	26.7 ±0.2
Onobrychis arenaria	5.62 ±0.3	3.96 ±0.21	2.33 ±0.15	28.4 ±0.7	31.8 ±1.3	30.1	23.0 ±0.1	29.0 ±0.7	22.0 ±0.1
Onobrychis viciaefolia	6.07 ±0.07	3.88 ±0.20	2.75 ± 0.18	28.4 ±0.7	31.8 ±1.3	30.1	23.0 ±0.1	29.0 ±0.7	22.0 ±0.1
Pisum arvense	5.80 ±0.20	5.05 ±0.07	5.01 ±0.03	25.9 ±0.6	26.9 ±0.4	26.4	20.5 ±1.5	21.3 ±1.6	19.0 ±1.1
Vicia sativa	4.65 ±0.33	3.73 ±0.40	_	21.7 ± 0.3	21.3 ±0.5	21.5	14.5 ±0.3	14.7 ±0.8	14.5 ±0.3
Vicia tenuifolia	3.65 ±0.25	3.16 ±0.04	3.05 ± 0.05	21.8 ±0.5	23.5 ±1.2	22.7	14.3 ±0.3	15.7 ±0.5	14.2 ±0.1
Vigna radiata	4.83 ±0.03	4.28 ±0,06	_	23.2 ±0.7	26.0 ±1.8	24.6	15.6 ±0.3	17.4 ±0.4	16.0 ±0.1
Vigna unguiculata	8.00 ±0.25	5.47 ±0.27	4.23 ±0.03	24.9 ±0.8	28.3 ±1.3	26.6	18.0 ±0.9	18.3 ±1.2	18.3 ±0.3

The results obtained in this work are included in the results of other researches. Prina (2009) remarked that *Crambe cordifolia* fruit diameter was 4.0-6.5 mm. Spataro & Negri (2008) mentioned that *Isatis tinctoria* siliques length were 9.5-14.3 mm and siliques wing 2.5-3.7 mm. Bojñnanský & Fargašová (2007), reported that seeds dimensions of *Astragalus galegiformis* was 3.7-3.9 mm length and 2.5-2.7 mm width. The authors Kibar & Öztürk (2008) and Chhabra & Kaur (2017) present the following dimensional parameters soybean hybrids and cultivars ℓ: b: δ ≈ (6.1-8.19): (4.5-7.12): (4.4-6.23) mm. Ene & Mocanu (2016) and Togo et al. (2018) reported that alfalfa seeds dimensions are given ℓ: b: δ ≈ (2.00-2.80): (1.00-1.70): (0.50-1.35) mm. Kilonzi et al. (2017) remarked that *Lablab purpureus* seeds is characterized by ℓ: b: δ ≈ (9.7-10.7): (6.80-7.40): (5.20-5.60) mm.

Table 2. The mass parameters of the studied *Brassicaceae* and *Fabaceae* seeds

Species	Bulk seed density, kg/m^3	Weight of 1000 seeds **M_{1000}**, g
Brasicaceae		
Crambe cordifolia	273.75±0.73	4.30±0.12
Isatis tinctoria	88.3±0.13	5.40±0.19
Raphanus sativus var. *oleifera*	738.02±1.33	9.73±0.33
Sinapsis alba	766.93±1.99	4.82±0.13
Fabaceae		
Astragalus galegiformis	802.92±3.13	10.11±0.38
Galega orientalis	784.23±3.77	6.27±0.05
Glycine max	719.29±2.44	147.2±0.44
Lablab purpureus	817.32±4.03	74.53±1.23
Lotus corniculatus	795.08±0.99	1.35±0.05
Medicago sativa	818.7±2.59	1.78 ±0.03
Onobrychis arenaria	370.8±2.76	14.63 ±0.12
Onobrychis viciaefolia	392.16±3.13	17.45±0.28
Pisum arvense	713.92±5.28	170.04±1.78
Vicia sativa	778.09±3.09	59.25±0.59
Vicia tenuifolia	824.7±2.04	21.14±0.35
Vigna radiata	790.06±3.26	59.00±0.35
Vigna unguiculata	830.00±2.76	124.07±1.85

Ene & Mocanu (2016) found that seeds dimensions of studied *Lotus corniculatus* crops was ℓ: b: δ ≈ (1.10-1.80): (0.80-1.60): (0.70-1.40) mm and *Onobrychis viciaefolia* seeds was ℓ: b: δ ≈ (5.00-8.20): (3.00-7.50): (2.20-4.50) mm. Taser et al. (2005) reported that length of the common vetch seeds ranged from 4.27 to 6.29 mm, the width ranged from 3.60 to 5.49 mm, while the thickness ranged from 3.15 to 4.63 mm. Davies (2011) reported that *Vigna unguiculata* seeds characteristic were ℓ: b: δ ≈ (9.87-15.21): (7.00-10.88): (5.49-8.47), M_{1000} = 253.80-671.4 g, α = 24.3-29.7°. N'Danikou et al. (2022) found that weight of 1000 seeds studied genotype of legumes crops was: 90-410 g for *Glycine max,* 21-75 g for *Vigna radiate* and 83-150 g for *Vigna unguiculata.*

The biochemical composition, nutritive and energy value of the harvested green mass from the tested species are presented in Table 3. Analysing the results of the biochemical composition of green mass, we found that the dry matter of the studied species differs essentially in the concentration of nutrients and energy. The harvested green mass from studied *Brassicaceae* species is characterized by 16.1-23.5% CP, 63.2-69.9% DMD, RFV = 117-162, 10.21-11.20 MJ/kg ME, 5.18-6.76 MJ/kg NEl and from *Fabaceae* species 14.2-23.4% CP, 58.4-69.5% DMD, RFV = 91-168, 9.51-11.15 MJ/kg ME, 5.53-7.17 MJ/kg NEl. We found that *Isatis tinctoria, Raphanus sativus* var. *oleifera, Sinapsis alba, Astragalus galegiformis, Galega orientalis, Vicia tenuifolia* green mass was characterised by very high content of crude protein, optimal cell wall fractions (NDF, ADF, ADL, hemicellulose and cellulose), nutritional value and energy supply of the feed as compared with traditional fodder plants *Lotus corniculatus, Medicago sativa, Onobrychis viciaefolia, Pisum arvense, Vicia sativa.*

The results of the estimation of fodder quality of green mass from studied *Brassicaceae* and *Fabaceae* species are given in the specialized literature. Thus, the *Crambe cordifolia* fodder has a content of 19.6% CP, 2.6% EE, 29.3% CF, 36.4% NFE, 17.9% TSS, 10.5-12.1% ash, 75.0% DOM (Medvedev & Smetannikova, 1981; Vergun et al., 2018); *Isatis tinctoria* fodder 20.2-24.9% CP, 3.0-4.5% EE, 12.5-32.4% CF, 30.7-48.5% NFE, 10.8-12.5% ash (Kshnikatkina et al., 2005; Țîței, 2016); *Raphanus sativus* var. *oleifera* fodder 15.0-25.9% CP, 2.0-.5% EE, 19.0-24.0% CF, 35.4-57.0% NFE, 14.7-23.6% ash (Medvedev & Smetannikova, 1981); the *Sinapsis alba* fodder contained 12.0-22.2% CP, 1.6-3.3% EE, 19.5- 34.0% CF, 9.1-15.8% ash, 36.4-43.3% NFE, 50.42% NDF, 43.84% ADF, 15.61% ADL, 6.58% HC, 28.23%Cel, 64.56% IVTD, RFV 101 (Medvedev & Smetannikova, 1981; Kshnikatkina et al., 2005; Kiliç et al., 2021); *Astragalus galegiformis* fodder 17.2-20.9% CP, 1.8-4.5% EE, 23.2-34.8 % CF, 45.6-48.5% NFE, 4.6-8.8% ash, 11.9 MJ/kg ME (Kshnikatkina et al., 2005; Chibis et al., 2011; Teleuţă et al., 2015; Bondarchuk, 2019); *Galega orientalis* fodder 16.18-22.84% CP, 2.95-3.90% EE, 24.58-36.85% CF, 47.50-57.90% NDF, 28.90-43.90% ADF, 3.70-6.30% lignin, 10.2 % sugar, 7.51-12.48% ash, 64-82% DMD, RFV = 97-133, 10.2 MJ/kg ME (Medvedev & Smetannikova, 1981; Kshnikatkina et al., 2005; Teleuţă et al., 2015; Teleuţă & Ţîţei, 2016; Coşman et al., 2017; Meripõld et al., 2017; Żarczyński et al., 2021); *Glycine max* fodder 15.3-30.1% CP, 1.1-4.4% EE, 31.2% CF, 45.3-66.3% NDF, 31.2-42.5% ADF, 5.8-8.1% lignin, 9.3% ash, 64.0-88.1% IVDMD, 17.5-18.1 MJ/kg GE, 11.6 MJ/kg DE and 9.2 MJ/kg ME (Heuzé et al., 2016b; Peiretti et al., 2018); *Lablab purpureus* fodder 18.4% CP, 2.6% EE, 28.2 % CF, 44.6% NDF, 32.0% ADF, 7.2% lignin, 8.9% sugar, 11.1% ash, 67% DOM, 18.2 MJ/kg GE, 11.7 MJ/kg DE and 9.2 MJ/kg ME (Heuzé et al., 2016c); *Lotus corniculatus* 16.4-21.1% CP, 3.3-4.1% EE, 25.7-35.7% CF, 48.3% NDF, 28.20% ADF, 9.9% lignin, 33.8% NFE, 4.0-6.2% sugar, 7.3-10.2% ash, 68.8% DOM, 9.8 MJ/kg ME (Medvedev & Smetannikova, 1981; Kshnikatkina et al., 2005; Heuzé et al., 2015; Teleuţă & Ţîţei, 2016; Coşman et al., 2020); *Medicago sativa* fodder 14.50-20.26% CP, 2.49-2.90% EE, 26.70-33.31 % CF, 37.20-39.41% NFE, 39.90-65.50% NDF, 30.90-55.70% ADF, 7.6% lignin, 7.02-11.50% ash, 68.50% % DOM, 18.1 MJ/kg GE, 11.9 MJ/kg DE and 9.4 MJ/kg ME (Medvedev & Smetannikova, 1981; Gryazeva, 2005; Kshnikatkina et al., 2005; Stavarache et al., 2015; Heuzé et al., 2016a; Teleuţă & Ţîţei, 2016); natural sand sainfoin fodder 16.7-20.6% CP, 2.3-4.2% EE, 21.5-30.2% CF, 46.70% NDF, 31.7% ADF, 4.8% lignin, 35.6-46.0% NFE, 10.0% sugar, 26.9% Cel, 15.0% HC, 6.0-8.8% ash, 67.7% DMD, 12.5 MJ/kg DE, 10.28 MJ/kg ME, 6.56 MJ/kg NEl, RFV= 127 (Gryazeva, 2005; Dronova et al., 2016; Teleuţă& Ţîţei, 2016; Demydas et al., 2019; Heuzé et al., 2016; Ţîţei, 2021); *Onobrychis viciifolia* contained 15.3-20.8% CP, 1.9-3.6%EE, 6.4-8.0 % ash, 21.2-33.9%CF, 39.4-47.4% NFE, 30.78 % ADF, 39.80 % NDF, 10.2 MJ/kg ME (Medvedev & Smetannikova, 1981; Kshnikatkina et al., 2005; Okcu & Şengül, 2014; Dronova et al., 2016; Teleuţă & Ţîţei, 2016; Demydas et al., 2019); *Pisum arvense* 10.2-16.9% CP, 38.1-44.1% NDF, 27.6-34.9% ADF, 9.1-11.6% ash, 61.7-67.4% DMD, RFV=131-166 (Ates, 2012; Cacan et al., 2019); *Vicia sativa* forage contained 21.5% CP, 31% NDF, 22% ADF, 60% IVDMD, but *Vicia villosa* ssp. *dasycarpa* 16.5% CP, 40% NDF, 31% ADF, 46% IVDMD (Ates et al., 2013); *Vicia tenuifolia* harvested in small pod stage contained 20.97% CP, 1.48% EE, 31.19% CF, 39.50% NFE, 6.86% ash and 51.83 mg/kg carotene (Maevsky et al., 2013).

Biomass play an important role in terms of energy supply and positive environmental effects. The valorification of phytomass substrate through anaerobic digestion is carried out in biogas generators with a wide variety of microorganisms, resulting in methane gas as a fuel for the production of heat and electricity and carbon dioxide, and the digested residue is rich in macro- and micronutrient and it is widely used in production farms as a fertiliser in organic farming. Many microorganisms promote a number of chemical processes in converting the biomass to biogas. The quality of feedstock for biogas production depends on the nutrient composition and on how accessible it is to enzymes and microbes (Vintilă & Neo, 2011; Dandikas et al., 2015). The carbon to nitrogen ratio constitutes a basic factor governing the correct course of methane fermentation. It is a commonly known fact that methanogenic bacteria need a suitable ratio of carbon to nitrogen for their metabolic processes, ratios higher than 30:1 were found to be unsuitable for optimal digestion, and ratios lower than 10:1 were found to be inhibitory, because of low pH, poor buffering capacity and high concentrations of ammonia in the substrate.

The results regarding the biochemical biomethane production potential of investigated *Brassicaceae* and *Fabaceae* substrates are shown in Table 3. The carbon to nitrogen ratio falls within the established norms, ranged from 13 to 22. Petcu et al. (2022) found that in winter peas herbage C/N=9.24-12.63.

Table 3. The green biomass quality of the studied *Brassicaceae* and *Fabaceae* species

Variant	**CP %**	**Ash %**	**CF %**	**ADF %**	**ADL %**	**NDF %**	**TSS %**	**Cel %**	**HC %**	**DDM**	**RFV**	***DE***	***ME***	***NEl***	**C/N**	***BMP***
Crambe cordifolia	16.1	10.0	30.4	33.0	5.4	50.4	9.7	27.6	17.4	63.2	117	12.44	10.21	6.23	20	326
Isatis tinctoria	23.5	11.3	26.7	29.0	4.4	43.4	7.7	24.6	14.4	68.1	146	13.32	10.94	6.69	13	356
Raphanus sativus var. *oleifera*	22.8	12.0	22.0	24.4	2.9	40.1	16.4	21.5	15.7	69.9	162	13.64	11.20	7.22	13	379
Sinapsis alba	22.9	10.9	24.9	28.3	4.8	43.9	6.3	23.5	15.6	66.9	142	13.08	10.74	6.77	14	349
Astragalus galegiformis	23.4	12.6	23.3	24.8	3.1	40.1	18.3	21.7	15.3	69.5	161	13.58	11.15	7.17	13	377
Galega orientalis	23.4	10.5	26.6	28.8	3.6	47.7	10.0	25.2	18.9	66.0	128	12.95	10.63	6.76	13	371
Glycine max	17.8	9.4	28.6	31.0	4.9	48.4	14.2	26.1	17.4	64.8	124	12.73	10.45	6.46	18	337
Lablab purpureus	17.6	9.0	26.1	28.1	4.4	45.3	19.6	23.7	17.1	67.0	168	13.13	10.78	68.0	18	345
Lotus corniculatus	18.9	10.2	29.4	32.5	5.1	51.4	9.7	27.4	18.9	63.58	115.1	12.52	10.28	6.29	17	337
Medicago sativa	17.2	9.1	33.1	34.7	5.8	51.0	8.3	28.9	16.3	61.9	113	12.50	10.26	6.04	18	321
Onobrychis arenaria	15.6	9.3	27.5	30.0	4.5	47.2	18.4	25.5	17.2	65.5	129	12.86	10.56	6.58	20	339
Onobrychis viciaefolia	16.6	9.4	24.9	27.6	4.2	43.4	19.5	23.4	15.8	67.40	144	13.20	10.84	6.85	19	345
Pisum arvense	14.2	8.9	37.1	39.2	6.5	59.8	9.1	32.7	20.6	58.4	91	11.58	9.51	5.53	22	305
Vicia sativa	20.6	12.0	28.8	31.3	4.6	50.7	10.2	26.7	19.4	64.5	118	12.68	10.41	6.43	15	349
Vicia tenuifolia	23.0	12.0	27.2	28.4	4.2	46.5	14.4	24.2	18.1	66.8	140	13.09	10.75	6.76	13	350

Essential differences were observed between concentrations of hemicellulose and acid detergent lignin. The *Raphanus sativus, Astragalus galegiformis*, *Galega orientalis* substrates had low concentration of acid detergent lignin. The biochemical methane potential of the tested *Brassicaceae* substrates ranges from 32 l/kg (*Crambe cordifolia*) to 379 l/kg (*Raphanus sativus*) and in *Fabaceae* substrates ranges from 305 kg (*Pisum arvense)* to 377 l/kg (*Astragalus galegiformis*).

Data on biomethane production potential are presented in other publications. The *Isatis tinctoria* substrate has a potential of 153- 245 l/kg (Carchesio et al., 2014; Ţîţei, 2016), *Raphanus sativus* substrate 297-474 l/kg (Molinuevo-Salces et al., 2013; Ahlberg& Nilsson, 2015), *Sinapsis alba* substrate - 251-379 l/kg (Molinuevo-Salces et al., 2013), *Medicago sativa* substrat 120-270 l/kg (Wang & Schmidt, 2010; Teleuţă & Ţîţei, 2016; Hunady et al., 2021), *Glycine max* substrat - 266 l/kg (Morozova et al., 2020), *Onobrychis* sp. substrates 140-277 l/kg (Teleuţă & Ţîţei, 2016; Hunady et al., 2021). Pabón-Pereira et al (2020) reported that biochemical methane potential was 290 l/kg ODM in *Vicia sativa* substrates, 370 l/kg ODM in *Pisum sativum* substrates and 350 l/kg ODM in *Vicia faba* substrates 350 l/kg ODM. Wang& Schmidt (2010) reported that methane potential of vetch substrate achieved 320 L/kg VS.

CONCLUSIONS

The seeds characteristic of the studied *Brassicaceae* species was: ℓ: b: δ ≈ (1.98-12.60): (1.67-3.67): (1.63-2.05) mm, the angle of repose α=24.6°-30.6° and the flow angle on steel is α_1=15.8°-31.7°, on wood α_1=18.1°-37.3° and on enamelled surface α_1=15.3°-30.5°; M_{1000} = 4.30-9.73 g and bulk seed density 88.3-766.9 kg/m^3.

The seeds characteristic of the studied *Fabaceae* species was ℓ: b: δ ≈ (1.53-8.00): (1.20-5.47): (1.47-5.01) mm; the angle of repose α=21.5°-33.0°, flow angle on steel is α_1=14.3°-27.7°, on wood α_1=14.7°-29.8° and on enamelled surface α_1=14.2°-27.3°; M_{1000} = 1.35-170.04 g and bulk seed density 370.8-830.0 kg/m^3.

The harvested green mass from studied *Brassicaceae* species is characterized by 16.1-23.5%CP, 63.2-69.9% DMD, RFV=117-162, 10.21-11.20 MJ/kg ME, 5.18 -6.76 MJ/kg NEl and from *Fabaceae* species 14.2-23.4%CP, 58.4-69.5% DMD, RFV=91-168, 9.51-11.15MJ/kg ME, 5.53-7.17 MJ/kg NEl.

The biochemical biomethane potential from *Brassicaceae* species vegetal substrates varied from 349 to 379 L/kg of organic matter and from *Fabaceae* species from 305 to 377 L/kg of organic matter.

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REFERENCES

Ahlberg, I., Nilsson, T. (2015). Investigation on the use of intermediate crops for anaerobic digestion as a renewable source of energy. *https://lup.lub.lu.se/student-papers/search/publication/5472252*

Ates, E. (2012). The mineral, amino acid and fiber contents and forage yield of field pea (*Pisum arvense* L.), fiddleneck (*Phacelia tanacetifolia* Benth.) and their mixtures under dry land conditions in the western Turkey. *Romanian Agricultural Research*, *29*. 237–244.

Ates, S., Feindel, D., El Moneim, A., Ryan, J. (2013). Annual forage legumes in dryland agricultural systems of the West Asia and North Africa Regions: research achievements and future perspective. *Grass and Forage Science*, *69*. 17–31.

Badger, C.M., Bogue, M.J., Stewart, D.J. (1979). Biogas production from crops and organic wastes. *New Zealand Journal of Science*, *22*. 11–20

Bojñnanský, V., Fargašová, A. (2007). *Atlas of Seeds and Fruits of Central and East-European Flora.* The Carpathian Mountains Region.

Bondarchuk, O. (2019). *Species Astragalus L. into the Right-Bank Forest-Steppe of Ukraine: introduction, biological and morphological features.* Dissertation for a Candidate degree in Biological Science. Kyiv. 220 p. [in Ukrainian]. *http://www.nbg.kiev.ua/upload/spetsrada/14062019/Bondarchuk_diser.pdf*

Cacan, E., Kokten, K., Bakoglu, A., Kaplan, M., Bozkurt, A. (2019). Evaluation of some forage pea (*Pisum arvense* L.) lines and cultivars in terms of herbage yield and quality. *Harran Tarım ve Gıda Bilimleri Dergisi, 23*(3), 254–262. DOI: 10.29050/harranziraat.446423

Carchesio, M., Tatàno, F., Lancellotti, I., Taurino, R., Colombo, E., Barbieri, L. (2014) Comparison of biomethane production and digestate characterization for selected agricultural substrates in Italy. *Environmental Technology*, *35*. 2212– 2226.

Chhabra, N., Kaur, A. (2017). Studies on physical and engineering characteristics of maize, pearl millet and soybean. *Journal of Pharmacognosy and Phytochemistry*, *6*(6), 01–05 https://www.phytojournal.com/archives/2017/vol6issue6/PartA/6-5-351-372.pdf

Chibis, S.P., Stepanov, A.F., Chibis, V.V. (2011). Nutritional value of *Astragalus galegiformis*. *Bulletin of Altai State Agrarian University*, *1* (75), 65–68. [in Russian].

Coşman, S., Ciopată, A.C., Coşman, V., Bahcivanji, M., Ţîţei, V. (2017). Study on the chemical composition and nutritional value of the *Galega orientalis* Lam. and the prospects of its valorification in the Republic of Moldova. *Scientific Papers, Series D, Animal Science*, *60*. 75–80.

Coșman, S., Ţîţei, V., Coșman, V., Blaj, V.A., Marușca, T., Cozari, S. (2020). The quality of fodders from bird's-foot-trefoil, *Lotus corniculatus* L. under the conditions of Moldova. *Scientific Papers. Series D, Animal Science*, *63*(2), 101–126.

Dandikas, V., Heuwinkel, H., Lichti, F., Drewes, J.E., Koch, K. (2015). Correlation between biogas yield and chemical composition of grassland plant species. *Energy Fuels*, *29*(11), 7221–7229.

Davies, R. (2011). Effects of moisture content on some physical and mechanical properties of three varieties of cowpea (*Vigna unguiculata* (L) Walp). *Agricultural Engineering International*: The CIGR e-journal. 13: 1–8.

Demydas, G.I., Lykhosherst, E.S., Burko, L.M. (2019). Content of organic and mineral substances in feed from different types of sainfoin depending on fertilizing. *Bulletin of Uman National University of Horticulture, 1*(1), 54–58. [in Ukrainian]. doi 10.31395/2310-0478-2019-1-54-58

Dronova, T.N., Burtseva, N.I., Molokantseva, E.I. (2016). The effectiveness of perennial legume grasses in fodder production and their influence on the balance of nutrients in the soil. *Scientific Agronomic Journal*, 2(99), 17–22.

ECPGR (2021). *Plant Genetic Resources Strategy for Europe*. European Cooperative Programme for Plant Genetic Resources, Rome, Italy. https://www.ecpgr.cgiar.org/resources/ecpgrpublications/publication/plant-genetic-resources

Ene, T.A., Mocanu, V. (2016). *Producerea, condiționarea și stocarea semințelor de graminee și leguminoase perene de pajiști – Tehnologii, echipamente și instalații.* ICDP, Brașov, 116 p.

Gryazeva, T.V. (2005). *Breeding of alfalfa and sainfoin in the conditions of the Rostov region.* Doctoral thesis of Agricultural Sciences. https://www.dissercat.com/content/selektsiyalyutserny-i-espartseta-v-usloviyakh-rostovskoi-oblasti [in Russian].

Heuzé, V.,Tran, G., Boval, M., Noblet, J., Renaudeau, D., Lessire, M., Lebas, F. (2016a). Alfalfa (*Medicago sativa). Feedipedia.* https://www.feedipedia.org/node/275

Heuzé, V., Tran, G., Hassoun, P., Lebas F. (2016b). Soybean forage. *Feedipedia*. https://www.feedipedia.org/node/294

Heuzé, V., Tran, G., Nozière, P., Lebas, F. (2015). Birdsfoot trefoil (*Lotus corniculatus*). *Feedipedia*. https://www.feedipedia.org/node/280

Heuzé, V., Tran, G., Sauvant, D., Renaudeau, D., Bastianelli D., Lebas F. (2016c). Lablab *(Lablab purpureus). Feedipedia.* https://www.feedipedia.org/node/297

Hunady, I., Ondrísková, V., Hutyrová, H., Kubíková, Z., Hammerschmiedt, T., Mezera, J. (2021). Use of wild plant species: a potential for methane production in biogas plants. *International Journal of Renewable Energy Research*, 11(2). https://doi.org/10.20508/ijrer.v11i2.11990.g8216

Jabeen, N. (2020). Agricultural, economic and societal importance of Brassicaceae plants. *The Plant Family Brassicaceae: Biology and Physiological Responses to Environmental Stresses*, 45–128.

Kibar, H., Öztürk, T. (2008). Physical and mechanical properties of soybean. *International Agrophysics, 22*. 239–244.

Kilonzi, S.M., Makokha, A.O, Kenji G.M. (2017). Physical characteristics, proximate composition and anti-nutritional factors in grains of lablab bean (*Lablab purpureus*) genotypes from Kenya. *Journal of Applied Biosciences*, *114*. 11289–11298.

Kılıç, Ü., Erişek, A., Garipoğlu, A., Ayan, İ., Önder, H. (2021). The effects of different forage types on feed values and digestibilities in some brassica fodder crops. *Türk Tarım ve Doğa Bilimleri Dergisi Turkish Journal of Agricultural and Natural Sciences, 8*(1), 94–102.

Kshnikatkina, A.N., Gushchina, V.A., Galiullin, A.A., Varlamov, V.A., Kshnikatkin, S.A. (2005). *Non-traditional fodder crops*. Penza, 240. [in Russian].

Maier, S., Szerencsits, M., Shahzad, K. (2017). Ecological evaluation of biogas from catch crops with Sustainable Process Index (SPI). *Energ Sustain Soc* **7**, 4 *https://doi.org/10.1186/s13705-017-0106-3*

Maevsky, V.V., Gorbunov, V.S., Gudkova, E.V., Derbiev, D.B., Ierov, D.D., Bayakov, D.A. (2013). Preliminary results of introduction of wild plants for the aim of feed. *Bulletin of Botanic Garden of Saratov State University*, *11*. 153–159. [In Russian]

Medvedev, P.F., Smetannikova, A.I. (1981). *The forage crops of European part of the USSR*. Leningrad, Kolos. 336p. [in Russian].

Meripõld, H., Tamm, U., Tamm, S., Võsa, T., Edesi, L. (2017). Fodder galega (*Galega orientalis* Lam.) grass potential as a forage and bioenergy crop. *Agronomy Research, 15*(4), 1693–1699.

Molinuevo-Salces, B., Ahring, B.K., Uellendahl, H. (2013). Catch crops as an alternative biomass feedstock for biogas plants. In Proceedings of the International Anaerobic Digestion Symposium on "*Dry Fermentation, Substrate Treatment and*

Digestate Treatment" within the BioGasWorld 2013. Berlín. 92–98.

Morozova, I., Oechsner, H., Roik, M., Hulsemann, B., Lemmer, A. (2020). Assessment of areal methane yields from energy crops in Ukraine, best practices. *Applied Sciences*, *10*(13), NA. https://link.gale.com/apps/doc/A636909868/AONE?u=anon~3fafeefe&sid=googleScholar&xid=6e961613

N'Danikou, S., Shango, A.J., Sigalla, J.P. (2022). Variation of seed traits and initial quality among selected cowpea, mungbean, and soybean accessions. *Seeds*, *1*. 303–314. https://doi.org/10.3390/seeds1040025

Okcu, M., Şengül, S. (2014). A study on the determination of the morphological, yield and quality characteristics of some sainfoin species (*Onobrychis* spp.) native to East Anatolia. *Pakistan Journal of Botany*, *46*(5), 1837–1842.

Oleskowicz-Popiel, P. (2010). *Biogas and ethanol potentials in selected biomasses for organic farming.* PhD Thesis, Technical University of Denmark. *http://orgprints.org/19318/4/19318.pdf*

Pabón-Pereira, C.P., Hamelers, H.V.M., Matilla, I., van Lier, J.B., (2020). New insights on the estimation of the anaerobic biodegradability of plant material: identifying valuable plants for sustainable energy production. *Processes, 8*. 806. https://doi.org/10.3390/pr8070806

Palabaş Uzun, S., Uzun, A., Alıcı, E. (2020). Seed morphology of some selected species of *Fabaceae, Polygonaceae, Primulaceae, Violaceae, Rosaceae* and *Phyllanthaceae*. *Journal of the Institute of Science and Technology*, *10*(3), 2028–2036. 10.21597/jist.687736.

Peiretti, P.G., Meineri, G., Longato, E., Tassone, S. (2018). Nutritive value and fatty acid content of soybean plant [*Glycine max* (L.) Merr.] during its growth cycle. *Italian Journal of Animal Science*, *17*(2), 347–352.

Petcu, V., Ciornei, L., Simion, S.-P., Grădilă, M., Burtan, S.L., Partal, E., 2022. Cover crops from winter wheat, triticale and peas cultivated in pure stands and mixtures - soil and weed suppression benefits. *Romanian Agricultural Research*, *39*. 337–343.

Prina, A. (2009). Taxonomic review of the genus *Crambe* sect. Crambe (Brassicaceae, Brassiceae).

Slepetys, J., Kadziuliene, Z., Sarunaite, L., Tilvikiene, V., Kryzeviciene, A. (2012). Biomass potential of plants grown for bioenergy production. *Renewable Energy and Energy Efficiency*, 66–72.

Spataro, G., Negri, V. (2008). Adaptability and variation in *Isatis tinctoria* L.: a new crop for Europe. *Euphytica*, *163*. 89–102.

Stavarache, M., Samuil, C., Popovici, C., Tarcau, D., Vintu, V. (2015). The productivity and quality of alfalfa (*Medicago sativa* L.) in Romanian Forest Steppe. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *43*. 179–185. 10.15835/nbha.43.1.9939

Stinner, P.W. (2015). The use of legumes as a biogas substrate - potentials for saving energy and reducing greenhouse gas emissions through symbiotic nitrogen fixation. *Energy, Sustainability and Society*, 5: 4.

Stoddard, F.L., 2013. Novel feed and non-food uses of legumes. Legume Futures Report 1.3, University of Helsinki. www.legumefutures.de

Taser, O., Altuntas, E., Özgöz, E. (2005). Physical properties of hungarian and common vetch seeds. *Journal of Applied Sciences*, *5* (2), 323–326. 10.3923/jas.2005.323.326.

Teleuţă, A. Ţîţei, V. (2016). Economic value of some leguminous plant species of the collections from the Botanical Garden (Institute) of the Academy of Sciences of Moldova. *Journal of Plant Development*, *23*. 27–35.

Teleuţă, A., Ţîţei, V., Coşman, S. (2015). Biological peculiarities and nutritional value of *Astragalus galegiformis* L. and *Galega orientalis* Lam. species in Moldova. *Journal of Botany*, *1*(10), 127–133.

Togo, J. M., Wang, D., Ma, W., He, Ch. (2018). Effects of moisture content on selected physical and mechanical properties of alfalfa seeds. *Journal of Biology, Agriculture and Healthcare*, *8*. 8–18.

Ţîţei, V. (2016). Agrobiological peculiarities and prospects for valorification of woad, *Isatis tinctoria* L., in Moldova. *Lucrări Ştiinţifice, Seria Agronomie, 59*(2), 267–272.

Ţîţei, V. (2021). Some agrobiological peculiarities and potential uses of *Glycyrrhiza glabra* L. and *Onobrychis arenaria* (KIT.) DC. in the Republic of Moldova. *Scientific Papers. Series Management, Economic Engineering in Agriculture and Rural Development*, *21*(4), 593–598.

Vergun, O., Rakhmetov, D., Shymanska, O., Fishchenko, V. (2018). The accumulation of nutrients in underground parts of plants of the genus *Crambe* L. spp. *Plant Introduction*, *78*. 3–11. https://doi.org/10.5281/zenodo.2228725

Vintilă, T., Neo, S. (2011). Biogas in Romanian agriculture, present and perspectives. *Scientific Papers: Animal Science and Biotechnologies, 44*(1), 465–473.

Wang G., Schmidt J.E. (2010). Biogas production from energy crops and agriculture residues: A review. *In Biogas Production from Energy Crops and Agriculture Residues; Ris0 DTU National Laboratory for Sustainable Energy: Roskilde, Denmark*, 1–90.

Żarczyński, P., Sienkiewicz, S., Wierzbowska, J., Krzebietke, S. (2021). Fodder galega—a versatile plant. *Agronomy.* 11. 1797. 10.3390/agronomy1109179