# THE QUALITY PARAMETERS OF GREEN BIOMASS FROM EASTERN GALEGA – A NEW LEGUMINOUS CROP IN MOLDOVA

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**Abstract**

The goal of this study was to determine the quality parameters of green biomass from eastern galega (*Galega orientalis* Lam.) which is a new leguminous crop grown under the agroecological conditions of the Republic of Moldova. The research was conducted on the newly developed local cultivar 'Sofia', grown in monoculture on the experimental plots of the National Botanical Garden Institute of the Moldova State University (NBGI MSU), Chişinău. The quality parameters of dry matter from the first cut were: 172-200 g/kg crude protein, 114-133 g/kg ash, 333-355 g/kg crude fiber, 335-390 g/kg acid detergent fiber, 542-636 g/kg neutral detergent fiber, 49-58 g/kg acid detergent lignin, 297-341 g/kg cellulose, 187-246 g/kg hemicellulose. Digestibility parameters included 58.5-62.8% DMD, RFV= 90-108, 9.53-10.16 MJ/kg ME and 5.55-6.18 MJ/kg NEl. The biochemical biomethane potential of eastern galega substrates ranged from 324 to 353 L/kg volatile solids.
The quality indices of the green biomass harvested from new local cultivar 'Sofia' of *Galega orientalis* indicate that it can be successfully used in livestock feed rations as well as substrates for renewable energy production.

**Keywords**: biochemical composition, biomethane potential, 'Sofia' cultivar, feed value, green mass, *Galega orientalis*

*Galega orientalis* Lam., commonly known as eastern galega, fodder galega, goat's rue, is a perennial herbaceous plant from the *Fabaceae* family, native to the North Caucasus. It grows 0.8-2.0 m tall, with upright, occasionally hairy stems, and compound leaves bearing 5-10 pairs of oblong leaflets. The plant produces dense terminal racemes (18-43 cm) with 25-70 blue-lilac to pale blue flowers, blooming from May to June. Its fruit is a smooth brown pod containing 3-8 kidney-shaped seeds. Seed viability lasts 4-7 years. Pollination is entomophilous (insect-mediated). *Galega orientalis* is a versatile crop, valued for its early spring growth, high biomass production (up to 100 t/ha green mass), rich protein content, and regenerative capacity, allowing for 2-3 harvests annually. It is widely used as forage, a honey plant, medicinal herb and energy biomass source. However, some eastern galega ecotypes show limited adaptability and reduced productivity under atypical growing conditions. To improve its agricultural potential, breeding efforts should focus on developing new cultivars of *Galega orientalis* with enhanced adaptability and economically valuable traits, and the development of new technologies for their optimal cultivation and use (Teleuţă A. *et al.*, 2015a.b; Povilaitis V. *et al.,*, 2016; Meripold H. *et al.,*, 2017; Cherniavskih V.I. *et al.,*, 2020; Rakhmetov D. *et al.,* 2021; Ţîţei V. and Roşca I., 2021; Żarczyński P.J. *et al.,* 2021; Ignaczak S. et al., 2022; Cerempei V. *et al.,* 2023; Biligetu B. et al., 2024; Pap N. *et al.,* 2024; Toth S. 2024).

The goal of this study was to determine the quality parameters of green biomass from the new local cultivar 'Sofia' of *Galega orientalis*, as feed for livestock and as substrates for biogas production.

## MATERIALS AND METHODS

The new local cultivar 'Sofia' of eastern galega, *Galega orientalis*, created at the "Alexandru Ciubotaru" National Botanical Garden (Institute) of Moldova State University, registered in 2025 in the Catalogue of Plant Varieties and patented by the State Agency on Intellectual Property of the Republic of Moldova, plant variety patent no. 246/31.03.2025, maintained in pure culture in the experimental plot of the National Botanical Garden (Institute) Chişinău, served as subject of the research. Green mass samples were collected during the third – fifth growing seasons (2022–2024), the first cut was done at the flowering stage. The leaf-to-stem ratio was determined by manually separating the leaves and flowers from the stems, weighing them separately, and calculating the ratio between these

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components. Samples of 1.0 kg harvested plants were taken for this purpose. The dry matter content was determined by drying the samples to a constant weight at 105°C. For biochemical analyses, fresh biomass samples were dehydrated in a forced-ventilation oven at 60°C. After drying, the biological 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 *et al.,* (2015).

## RESULTS AND DISCUSSIONS

The climatic conditions during the investigation period (2022–2024) deviated from the norm, influencing the agro-biological characteristics of the new local cultivar 'Sofia' of eastern galega (*Galega orientalis*), as well as its productivity and quality indicators.

According to the results presented in Table 1, at the time of the first cut for green mass, the plants had reached a height of 124-139 cm. The green mass yield ranged from 4.82 to 5.82 kg/m², while the dry matter yield ranged from 1.09 to 1.23 kg/m². The proportion of leaves and inflorescences ranged from 54.9% to 58.9%. The highest dry matter yield at the first cut was recorded in the fifth growing season (2024).

Several authors have reported various findings on the productivity of *Galega orientalis* under varying environmental and soil conditions. According to Adamovics A. *et al.,* (2011), pure *Galega orientalis* swards produced 50.81 t/ha of fresh biomass and 12.16 t/ha of organic dry matter. Slepetys J. (2010) mentioned that *Galega orientalis* produces the larger share of the total herbage yield at the first cut, that is 41.9–69.4% of the annual yield, and much less herbage from the second cut – 16.0-25.7% and the third cut, which is usually done in autumn, 8.2-33.6%. The highest productivity – 11.9 t/ha – was achieved in 10-11 growing years. Similarly, Avetisyan A.T. (2013) found that at the first cut, *Galega orientalis* yielded 28.6 t/ha of green mass or 7.72 t/ha of dry matter, and at the second cut, 14.0 t/ha of green mass or 3.3 t/ha of dry matter. For comparison, *Medicago sativa* produced 18.9 t/ha of green mass or 5.63 t/ha of dry matter at the first cut, and 11.26 t/ha of green mass or 2.60 t/ha of dry matter at the second cut. Zielewicz W. *et al.,* (2013) remarked that the galega dry matter yield at the first cut was 7.48 t/ha, at the second cut 2.15 t/ha and at the third cut 3.98 t/ha. Teleuţă A. *et al.,* (2015b) reported that yield of the 'Speranţa' cultivar of *Galega orientalis* harvested in bud formation stage was 4.5 kg/m² green mass or 0.7 kg/m² dry matter with 56% leaves in the fodder; while the plants started the flowering stage, the yield reached 5.85 kg/m² green mass or 1.02 kg/m² dry matter with 56% leaves and inflorescences in the fodder. Hein W. & Wasch H. (2018) revealed that the productivity of *Galega orientalis* harvested in May was 37.6 t/ha fresh mass or 9.4 t/ha dry matter. Ţîţei V. & Coşman S. (2019) mentioned that the productivity of *Galega orientalis* 'Speranţa' in the 7th growing season, at first cut, reached 1.10 kg/m² dry matter. Cherniavskih V.I. *et al.,* (2020) reported that the dry matter yield of *Galega orientalis* at the first cut was 639.0 g/m². According to Zolotarev V. & Korovina (2021), the newly developed cultivar 'West' of *Galega orientalis* demonstrated, under favorable conditions, a green mass productivity of 65-70 t/ha or more and a dry matter yield reaching 14 t/ha. Ignaczak S. *et al.,* (2022) found that *Galega orientalis* plants at the first cut reached heights of 90-119 cm, with dry matter yields ranging from 0.544 to 0.748 kg/m². Biligetu B. *et al.,* (2024) found that *Galega orientalis* yielded was 5.39 t/ha dry matter at the first cut. Tóth S. (2024) mentioned that the potential dry matter yield of eastern galega varied from 2.69 to 21.30 t/ha at the first cut, and from 1.05 to 9.06 t/ha at the second cut.

The biochemical composition of dry matter is a key parameter in evaluating feed quality. The quality indicators of the harvested green mass from the local cultivar 'Sofia' of *Galega orientalis* are presented in Table 2. Our analysis revealed that the dry matter content and associated quality parameters varied depending on the growing season: 172-200 g/kg CP, 114-133 g/kg ash, 333-355 g/kg CF, 335-390 g/kg ADF, 542-636 g/kg NDF, 49-58 g/kg ADL, 297-341 g/kg Cel, 187-246 g/kg HC with 58.5-62.8% DMD, RFV= 90-108, 9.53-10.16 MJ/kg ME, 5.55-6.18 MJ/kg NEl. In the third growing season, the dry matter from the first cut exhibited high levels of crude protein, minerals, cellulose, and hemicellulose, along with a lower level of acid detergent lignin. In the fifth growing season, the concentration of structural carbohydrates in the dry matter was lower, which had a positive effect on the forage value and energy content of the feed compared to the third and fourth growing seasons. Additionally, the high cellulose content in the fifth season also contributed positively to forage quality and energy supply, especially in comparison to the fourth growing season.

Several authors have reported varying findings regarding the nutrient quality of the green mass of *Galega orientalis*. According to Skórko-Sajko H. *et al.,* (2005) the dry matter of *Galega orientalis* fresh mass had 906.9 g/kg OM, 245.5 g/kg CP, 57.4 g/kg PDIA, 150.1 g/kg PDIN, 103.4 g/kg PDIE, with 0.77 UFL/kg, 0.70 UFV/kg and 1.19 CFU/kg. Bull I. *et al.,* (2011) reported that the galega forage from the first cut contained 149-157 g/kg DM with 20.7-20.9 % CP, 1.7-2.3 % EE, 34.3-37.5 % CF, 8.0-8.5 % ash. Klimenko V.P. (2012) found that *Galega orientalis* harvested at the shoot development to early budding period contained 144.3 g/kg DM, 26.7% CP, 6.9% sugars, 9.70% starch, 21.23% Cel, 6.71% HC and 4.95% lignin. Truzina L.A. *et al.,* (2013) reported that the biochemical composition of *Galega orientalis* harvested in early flowering period was 220.2 g/kg CP, 44.8 g/kg EE, 301.7 g/kg CF, 362.2 g/kg NFE and 71.1 g/kg ash. Zielewicz W. *et al.,* (2013) mentioned that the concentration of nutrients in the galega forage at the first cut was 12.67% CP, 1.63% sugars, 28.77% Cel, 15.93 % HC, 8.95% ash and 4.04 % lignin. Teleuţă A. *et al.,* (2015a) found that the first cut eastern galega contained 17.80% CP, 3.55% EE, 30.56% CF, 39.47% NFE, 8.69% ash with 147 g digestible protein per nutritive unit, in contrast, alfalfa forage had 16.16% CP, 1.88% EE, 34.74% CF, 37.22% NFE, 10.00% ash, and 145 g digestible protein per nutritive unit. Hein W. & Wasch H. (2018) revealed that the nutrient content of *Galega orientalis* dry matter was 14.21-18.69% CP, 1.54-2.09% EE, 20.39-32.49% CF, 36.29-49.55% NFE, 9.28-11.43% ash, 10.95-18.78 g/kg Ca, 3.00-4.09 g/kg P. According to Skórko-Sajko H. *et al.,* (2016), the nutrient concentration and feed value of *Galega orientalis* green forage harvested at the beginning of the flowering period was: 178.9 g/kg DM, 89.39% OM, 22.97% CP, 3.33% EE, 52.80% NDF, 35.38% ADF, 3.81-4.52% ADL, 17.00% Cel, 30.85% HC, 34.68% NFE, 4.78% soluble sugars, with 18.58 MJ/kg GE, 9.62 MJ/kg ME, 5.65 MJ/kg NEl, 5.4 MJ/kg NEm, 0.79 UFL, 0.76 UFV. Slepetiene A. *et al.,* (2016) reported the chemical composition of the fodder galega biomass included 3.129% N, 47.44% C, 45.16% NDF, 43.45% ADF, 14.85%% ADL, 8.33% ash, 5.83% WSC, 1.71% HC and 28.60% Cel. Coşman S. *et al.,* (2017) reported that in *Galega orientalis* 'Speranţa', at the first cut, the dry matter content varied from 125.2 to 180.7 g/kg, with 16.18-22.94% CP, 3.26-3.90% EE, 31.95-36.85% CF, 46.5-57.9% NDF, 28.8-37.7% ADF, 3.9-6.3% ADL, 32.18-38.06% NFE, 7.51-8.86% ash, 64.0-82.0% DDM, and RFV ranging from 97 to 133. Meripõld H. *et al.,* (2017) found that pure *Galega orientalis* forage at the first cut had 17.0-17.8% CP, 48.9-49.5% NDF, and 40.8-43.9% ADF, while eastern galega mixed with grasses had 9.4-13.4% CP, 50.9-55.4% NDF, and 36.9-39.6% ADF. Chornolata L.P. *et al.,* (2018, 2023) reported that eastern galega in the budding-flowering stages contained 16.86-19.07% CP, 15.10-18.10% Cel, 12.20-14.48% HC, 6.50-7.10% lignin, 6.20-6.40% sugars, 4.90% starch, while alfalfa *Medicago sativa* green mass forage had 15.28-16.39% CP, 11.45-16.10% Cel, 12.90-13.11% HC, 4.50-6.00% lignin, 4.80-7.50% sugars, 5.27-5.65% starch. Kuchin N.N. & Ivashin I.I. (2019) observed that nutrient concentrations in *Galega orientalis* dry matter differed among phenological stages. In the budding phase, the forage contained 19.4-21.6% CP, 2.29-3.07% EE, 19.6-23.0% CF, 46.5-51.6% NFE, 6.1-6.9% ash and 10.8-11.5 MJ/kg ME, while in the flowering stage14.4-16.7% CP, 24.8-26.4% CF, 10.2-10.6 MJ/kg. ME. Burykina S.I. (2019) stated that the forage from *Galega orientalis* harvested in the budding-flowering stages contained 3.04-3.08% nitrogen, 33.08-38.88% CF, 21.50-21.66% Cel, 6.04-7.21% HC, 11.00-13.43% lignin, 2.04-2.75% sugars, 0.55-0.70% starch. Nechunaev M.A. & Falaleeva L.V. (2020) reported that *Galega orientalis* forage contained 271.3 g/kg CP, 57.7 g/kg EE, 264.1 g/kg CF, 299.7 g/kg NFE, 109.4 g/kg ash, 16.2 g/kg Ca, 3.4 g/kg P and 9.8 MJ/kg ME, while for *Trifolium pratense* – 186.7 g/kg CP, 66.2 g/kg EE, 306.5 g/kg CF, 335.6 g/kg NFE, 106.7 g/kg ash, 12.6 g/kg Ca, 3.2 g/kg P and 8.9 MJ/kg ME, respectively. Darmohray L. *et al.,* (2021) found that *Galega orientalis* harvested at the early flowering stage contained 21.09% CP, 2.95% EE, 27.29% CF, 60.55% NDF and 5.18% ash. Simonov *et al.,* (2021) reported that the studied *Galega orientalis* plants, cut in the budding - beginning of flowering stage, had 140-200 g/kg DM with 25-26 % CP, 3-6% sugars, 25-30 % CF, 0.72-0.74 nutritive units, 160-260 g digestible protein per nutritive unit and 9.0-9.7 MJ/kg ME. Ignaczak S. *et al.,* (2022) reported that at the first cut, whole plants of *Galega orientalis* contained 168–278 g/kg DM with 15.7-23.3% CP, 32.7-37.8% ADF, 45.8-52.7% NDF, 6.0-7.5% ash, and 729-800 g/kg

IVTD. Cerempei V. *et al.,* (2023) noted that *Galega orientalis* forage dry matter had 23.4% CP, 26.6% CF, 10.5% ash, 28.8% ADF, 3.6% ADL, 47.7% NDF, 25.2% Cel, 18.9% HC, 66.0% DDM, RFV=128, 10.63 MJ/kg ME and 6.76 MJ/kg NEl, while *Medicago sativa* forage contained 17.2 CP, 9.1 ash, 33.1% CF, 34.7% ADF, 5.8% ADL, 51.0% NDF, 28.9% Cel, 16.3% HC, 61.9 %DDM, RFV=113, 10.26 MJ/kg ME and 6.04 MJ/kg NEl. Kobyrenko Y. (2023) revealed that the fodder productivity of *Galega orientalis*, depending on the type of fertilizer applied, varied from 9.45 to 10.65 t/ha fodder units and digestible protein yield from 1.1 to 1.6 t/ha. Tóth S. (2023) reported that the lignocellulosic composition of green phytomass from *Galega orientalis* included 24.68-49.89% ADF, 34.56-61.69% NDF, 4.98-14.16% ADL, 18.74-40.09% CEL, and 9.17-18.01% HC with gross energy value 14.871-19.707 MJ/kg. Biligetu B. *et al.,* (2024) found that galega forage dry matter had 10-17 % CP, 20-29 % ADF and 36-46 % NDF, while sainfoin forage 8-13 % CP, 21-33% ADF and 33-44 % NDF, respectively. Kosolapova E.V. *et al.,* (2024) remarked that wilted green mass of goat's rue contained 240.3 g/kg DM, 15.77 % CP, 1.92% EE, 19.13 % CF, 4.7 % sugars, 9.0 % ash, 118.00 g digestible protein, 0.88 nutritive units and 9.76 MJ/kg ME. Pap N. *et al.,*, 2024 reported that the green biomass from fodder galega had 128 g/kg DM, 27.0% CP and 8.3% ash; while red clover forage contained 171 g/kg DM, 19.3% CP and 11.0% ash; faba bean – 188 g/kg DM, 23.4% CP and 6.2% ash; green pea – 278 g/kg DM, 13.1% CP and 4.9% ash, and timothy grass – 118 g/kg DM, 18.6% CP and 7.8% ash, respectively.

The results for the quality indices of the studied *Galega orientalis* substrates and their potential for biomethane production are presented in *table 3*. Our analysis showed that the investigated substrates had a C/N ratio ranging from 15.05 to 17.89. The levels of acid detergent lignin (49-58 g/kg) and hemicellulose (187-246 g/kg) met established standards. The biochemical methane potential of the substrates varied from 324 to 353 L/kg of organic dry matter (ODM). A notably high BMP was also observed in the *Galega orientalis* substrate from the third growing season.

Table 1

**Agrobiological characteristics of the local cultivar ‘Sofia’ of *Galega orientalis***

| Indices | Third growing season | Fourth growing season | Fifth growing seasons |
|---|---|---|---|
| Plant height, cm | 124 | 139 | 128 |
| Fresh mass yield, | 5.82 | 5.71 | 4.82 |
| Dry matter, | 1.09 | 1.17 | 1.23 |
| Content of leaves and flowers in fodder, % | 58.9 | 58.6 | 54.9 |

Table 2

**The biochemical composition and feed value of the green mass of *Galega orientalis* ‘Sofia’**

| Indices | Third growing season | Fourth growing season | Fifth growing season |
|---|---|---|---|
| Crude protein, g/kg DM | 200.00 | 172.00 | 176.00 |
| Crude fiber, g/kg DM | 355.00 | 346.00 | 333.00 |
| Ash, g/kg DM | 133.00 | 114.00 | 114.00 |
| Acid detergent fiber, g/kg DM | 390.00 | 377.00 | 335.00 |
| Neutral detergent fiber, g/kg DM | 636.00 | 592.00 | 542.00 |
| Acid detergent lignin, g/kg DM | 49.00 | 58.00 | 56.00 |
| Cellulose, g/kg DM | 341.00 | 319.00 | 297.00 |
| Hemicellulose, g/kg DM | 246.00 | 215.00 | 187.00 |
| Digestible dry matter, g/kg DM | 585.00 | 595.00 | 628.00 |
| Relative feed value | 90.00 | 94.00 | 108.00 |
| Metabolizable energy, MJ/kg DM | 11.61 | 11.78 | 12.38 |
| Net energy for lactation, MJ/kg DM | 9.53 | 9.67 | 10.16 |
| Digestible energy, MJ/kg DM | 5.55 | 5.70 | 6.18 |

Table 3

**The biochemical composition and biomethane potential of the substrates from *Galega orientalis* ‘Sofia’**

| Indices | Third growing season | Fourth growing season | Fifth growing season |
|---|---|---|---|
| Organic dry matter, g/kg | 867.00 | 886.00 | 886.00 |
| Minerals, g/kg DM | 133.00 | 114.00 | 114.00 |
| Crude protein, g/kg DM | 200.00 | 172.00 | 176.00 |
| Nitrogen, g/kg DM | 32.00 | 27.52 | 28.16 |
| Carbon, g/kg DM | 481.67 | 492.22 | 492.22 |
| Ratio carbon/nitrogen | 15.05 | 17.89 | 17.48 |
| Hemicellulose, g/kg DM | 246.00 | 215.00 | 187.00 |
| Acid detergent lignin, g/kg DM | 49.00 | 58.00 | 56.00 |
| Biomethane potential, L/kg DM | 299.00 | 287.00 | 289.00 |
| Biomethane potential, L/kg ODM | 345.00 | 324.00 | 326.00 |

Several studies have reported data on the biomethane production potential of *Galega orientalis* biomass. Dubrovskis V. *et al.,* (2008) found that galega substrates achieved a methane yield of 384.2 L/kg VS. Adam L. (2009) reported that the methane yield in a batch test for galega substrate from the first cut was 412 L/kg VS, while the second cut substrate yielded 282 L/kg VS. Bull I. *et al.,* (2011) observed that the methane yield of first-cut galega substrates ranged from 270.9 to 288.6 L/kg ODM, while second-cut substrates yielded between 303.2 and 315.1 L/kg ODM. According to Adamovics A. *et al.,* (2011), a substrate composed of 75% galega and 25% cow manure reached the highest biogas yield – 628 m³/t DOM, with a methane content of 61.2%, during anaerobic digestion. Mihic D. *et al.,* (2012) reported that *Galega orientalis* substrate reached a biogas yield of 610 L/kg ODM with a methane concentration of 62.6%. Slepetienė A. *et al.,* (2016) analyzed the chemical composition of biomass substrate from third-cut fodder galega, reporting: 3.129% N, 47.44% C, 45.16% NDF, 43.45% ADF, 14.85% ADL, 8.33% ash, 5.83% WSC, 1.71% HC, and 28.60% Cel. Povilaitis V. *et al.,* (2016) found that the elemental composition of fodder galega substrates included 2.71-2.99% nitrogen, 43.67-47.35% carbon, 0.13-0.17% sulphur, and a C/N ratio of 15.91-16.33. Ababii A. *et al.,* (2023) reported that the biochemical methane potential of *Galega orientalis* green mass substrate was 371 L/kg VS. Vishnevskaya O.V. (2017) noted that substrates derived from *Galega orientalis* plants had methane yields of 291-301 L/kg VS, while those from *Dactylis glomerata* yielded 237-241 L/kg VS. Titei V. and Roşca I. (2021) found that the biomethane production potential of *Galega orientalis* substrates varied from 300 to 360 L/kg VS.

## CONCLUSIONS

The local cultivar 'Sofia' of *Galega orientalis* demonstrated good adaptability under variable climatic conditions (2022-2024), with stable biomass yields across growing seasons.

The forage quality was high, with favorable levels of crude protein, cellulose, hemicellulose, and energy value indicators.

The biomass also showed strong potential for renewable energy production, with a biochemical methane potential ranging from 324 to 353 L/kg ODM and an optimal carbon to nitrogen ratio.

The results confirm that the local cultivar *'Sofia'* of *Galega orientalis* can be effectively utilized both as a high-quality forage crop and a valuable substrate for biomethane production, especially in the context of climate-resilient and sustainable agriculture.

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