

AGROECONOMIC POTENTIAL OF SMOOTH BROME (*Bromus inermis*) AND TALL FESCUE (*Festuca arundinacea*) UNDER THE CLIMATIC CONDITIONS OF THE REPUBLIC OF MOLDOVA

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Abstract

This study was aimed to evaluate the quality indices of green biomass and hay of local ecotype of smooth brome (*Bromus inermis* Leyss.) and tall fescue (*Festuca arundinacea* Schreb.) cultivated at the “Alexandru Ciubotaru” National Botanical Garden (Institute) of Moldova State University. The biochemical composition of the green biomass varied between grass species: 12.4-13.1% crude protein (CP), 33.6-34.7% crude fibre (CF), 62.9-66.6% neutral detergent fibre (NDF), 36.9-37.8% acid detergent fibre (ADF), 2.8-3.6% acid detergent lignin (ADL), and 11.7-13.5% total soluble sugars (TSS). The forage quality of the green biomass included 594-602 g/kg dry matter digestibility (DMD), 553-563g/kg total digestible nutrients (TDN), relative feed value (RFV) of 87-90, and metabolizable energy (ME) of 9.67-9.76 MJ/kg. The hay had 10.3-12.4% CP, 36.0-36.9% CF, 65.0-69.1% NDF, and 6.2-9.4% TSS, with 528-543g/kg TDN and ME of 9.45-9.60 MJ/kg. The biochemical methane potential of the substrates ranged from 331 to 366 L/kg volatile solids. These findings suggest that smooth brome and tall fescue are both suitable as high-quality forages for livestock and as promising substrates for biomethane production within renewable energy systems.

Key words: biochemical methane potential, *Bromus inermis*, *Festuca arundinacea*, forage value, nutrient content.

INTRODUCTION

The family *Poaceae* is one of the largest plant families, of high economic and ecological value. According to *The Plant List*, the genus *Bromus* family *Poaceae* comprises approximately 170 accepted species, and the genus *Festuca* records 664 accepted species names. Floristic research has identified 11 *Bromus* species and 8 *Festuca* species present in the territory of the Republic of Moldova.

Bromus inermis Leyss. (syn. *Bromopsis inermis* (Leyss.) Holub, *Festuca inermis* (Leyss.) DC., *Forasaccus inermis* (Leyss.) Lunell, *Schedonorus inermis* (Leyss.) P. Beauv., *Zerna inermis* (Leyss.) Lindm.), commonly known as smooth brome, is a creeping, rhizomatous, perennial C₃ grass native to Europe and parts of Asia. It is a widespread species that has been introduced to various regions, including North America. The plant has erect stems, which can grow up to 150 cm in height. Leaf sheaths are either glabrous or shortly hairy, while the leaf blades are flat, 15-40 cm long and 5-10 mm wide. Both surfaces and margins of the leaf blades are scabrid, glabrous, or sparsely ciliate

at the edges. The leaf tips are acuminate, and the ligule measures 1-2 mm. The inflorescence is an open panicle, 5-20 cm long, with 1 to 4 branches per node. The spikelets are purple-brown, typically 15-30 mm long, with 6-12 florets. The rachilla internodes are 2-3 mm long and spinulose. The glumes are lanceolate with membranous margins. The lower glume is 4-7 mm long and 1-veined, while the upper glume is 6-10 mm long and 3-veined. Lemmas are oblong-lanceolate, 8-12 mm long, 5-7-veined, glabrous, scabrid at the base, may be awned (up to 3-4 mm) or awnless. The paleas are shorter than the lemmas and have ciliate keels. Anthers measure 3-4 mm in length. *Bromus inermis* is an open-pollinated, self-incompatible species, with flowering occurring from late May to early July. The caryopses are elliptical, 5-8 mm long, and range in colour from pale yellow to dark brown. The 1000-seed weight is about 2-3 g. The chromosome numbers are 2n = 14, 28, or 56. Seeds remain viable for 6-10 years. This species is commonly found along roadsides, riverbanks, field edges, meadows, woods, and pastures. It reproduces through seeds, tillers, and rhizomes.

Tall fescue, *Festuca arundinacea* Schreber (syn. *Lolium arundinaceum* (Schreb.) Darbysh.; *Schedonorus arundinaceus* (Schreb.) Dumort.) is a long-lived perennial grass native to Europe, belonging to the C₃ photosynthetic group. It has robust, upright stems that range from 60 to 200 cm in height. The leaves grow in basal tufts, with blades measuring 20-70 cm in length and 3-12 mm in width. Each tuft can produce 10 to 30 flowering stems. The inflorescence is a panicle, which can be open or narrowly branched, ranging from 12 to 35 cm in length. The spikelets typically contain three to nine florets, and the lemmas can be either awnless or short-awned. The fruit is a caryopsis with an adherent pericarp, which is brownish-yellow, glabrous, oblong to ellipsoid, and measures 6-9 mm in length, with a 1000-seed weight of 1.8-2.6 g. Tall fescue develops a deep and extensive root system that can reach up to 150 cm in depth. This root system produces secretions that aid in nutrient mobilization and uptake from the soil. The species is highly adaptable, thriving in both moist and drought conditions, and grows well in soils with a pH between 5.5 and 8.0, including eroded slopes and slightly saline soils. Tall fescue reproduces by seed and also increases vegetatively by producing new tillers from the root crown.

Currently, *Bromus inermis* and *Festuca arundinacea* are being researched and cultivated in various regions around the world. (Tomić et al., 2007; Albayrak & Türk, 2013; Amalevičiūtė-Volungė et al., 2020; Fehlberg et al., 2020; Dong et al., 2021; Chornolata et al., 2023; Bozhanska et al., 2022; Mackiewicz et al., 2024). Currently, in the Catalogue of Plant Varieties of the Republic of Moldova, no cultivars of these species are officially registered. However, in the Official Catalogue of Varieties of Agricultural Plants of Romania (2024), 10 cultivars of *Festuca arundinacea* and 5 cultivars of *Bromus inermis* are listed. The cultivars of smooth brome and tall fescue developed in Romania show dry matter productivity levels ranging from 12 to 20.3 t/ha (Maruşca et al., 2016; Acatrinei (Dumitru) et al., 2023).

The aim of this study was to assess the quality indices of green mass and hay from smooth brome (*Bromus inermis*) and tall fescue

(*Festuca arundinacea*) as both forage and substrates for biogas production in Moldova.

MATERIALS AND METHODS

The local ecotypes of smooth brome (*Bromus inermis*) and tall fescue (*Festuca arundinacea*), cultivated in monoculture within the experimental sector of the National Botanical Garden (Institute) of Moldova, Chişinău, were selected as experimental material. Plant samples were collected during the first harvest, conducted at the early flowering stage. The harvested biomass was chopped into fragments measuring 1.5-2.0 cm using a laboratory forage chopper. Dry matter (DM) content was determined by oven-drying the samples at 105°C until constant weight was achieved. For chemical analyses, the chopped material was dried in a forced-air oven at 60°C and subsequently ground in a beater mill equipped with a 1 mm mesh sieve.

The principal biochemical parameters assessed included crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM), and digestible organic matter (DOM). These parameters were determined by near-infrared spectroscopy (NIRS) using a PERTEN DA 7200 NIR analyser. Hemicellulose (HC), cellulose (Cel), total digestible nutrients (TDN), relative forage quality (RFQ), digestible energy (DE), metabolizable energy (ME), and net energy for lactation (NEL) were calculated in accordance with established standard procedures. The carbon content of the substrates was estimated using the empirical equation proposed by Badger et al. (1979). The biochemical methane potential was calculated based on the equations described by Dandikas et al. (2015).

RESULTS AND DISCUSSIONS

During the first year of establishment, no significant differences were observed in the growth and developmental patterns of the studied grass species. By the end of the growing season, stem formation was recorded in some individuals. In subsequent years, vegetative regrowth resumed in March, starting

5-7 days earlier in *Bromus inermis* than in *Festuca arundinacea*. Growth rates accelerated during the second half of April. At the time of harvest (mid-May), the studied local ecotypes of smooth brome and tall fescue attained plant heights ranging from 95 to 109 cm, with smooth brome exhibiting greater mean height. The yield of the local ecotype of *Festuca arundinacea* reached 3.95 kg/m² of fresh biomass and 0.88 kg/m² of dry matter, whereas the local ecotype of *Bromus inermis* produced 4.19 kg/m² of fresh biomass and 1.13 kg/m² of dry matter.

The analysis of the biochemical composition of the harvested biomass (Table 1) indicated that

the dry matter contained 12.4-13.1% CP, 33.6-34.7% CF, 62.9-66.6% NDF, 36.9-37.8% ADF, 2.8-3.6% ADL, 33.0-35.0% Cel, 26.0-28.8% HC, 11.7-13.5% TSS, and 9.4-10.0% ash. The green forage of *Festuca arundinacea* was characterized by a higher crude protein content, whereas *Bromus inermis* forage exhibited lower mineral, cellulose, and hemicellulose concentrations, but higher levels of total soluble sugars and acid detergent lignin. No substantial differences were observed between the two ecotypes with respect to digestibility, relative feed value, or energy value of the harvested biomass.

Table 1. The biochemical composition and the nutritive value of green mass from *Bromus inermis* and *Festuca arundinacea*

Indices	<i>Bromus inermis</i>	<i>Festuca arundinacea</i>
Crude protein, g/kg DM	124	131
Crude fibre, g/kg DM	336	347
Ash, g/kg DM	94	100
Acid detergent fibre, g/kg DM	369	378
Neutral detergent fibre, g/kg DM	629	666
Acid detergent lignin, g/kg DM	36	28
Total soluble sugars, g/kg DM	135	117
Cellulose, g/kg DM	330	350
Hemicellulose, g/kg DM	260	288
Dry matter digestibility, %	60.2	59.4
Total digestible nutrients, g/kg	563	553
Digestible energy, MJ/kg DM	11.89	11.78
Metabolizable energy, MJ/kg DM	9.76	9.67
Net energy for lactation, MJ/kg DM	5.79	5.69
Relative feed value	90	87
Relative forage quality	92	86

The specialized literature reports considerable variation in the chemical composition and nutritive value of whole-plant biomass and forage of *Bromus inermis* and *Festuca arundinacea*. According to Medvedev and Smetannikova (1981), whole plants of *Bromus inermis* contained 60-81% moisture, 2.9-4.4% CP, 5.9-10.5% CF, 0.4% EE, 1.5-2.6% ash, and 7.6-18.3% NFE. For *Festuca arundinacea*, the dry matter of the forage contained 7.5-12.8% CP and 24.4-36.6% CF. May et al. (1998) reported that *Bromus inermis* forage contained 9.9-11.3% CP, 62.9-69.5% NDF, 42.1-43.3% ADF, 4.9-5.5% ADL, 6.3-7.6% ash, and 56.9-70.6% IVDMD. Burlacu et al. (2002) found that green forage of *Bromus inermis* contained 250 g/kg DM, 10.2% CP, 2.8% EE, 33.5% CF, 45.1% NFE, 7.4% ash, 58.2% NDF, 37.8% ADF, 28.3% Cel, and 18.3 MJ/kg gross energy (GE). In comparison, *Festuca arundinacea* forage contained 286 g/kg DM, 16.7% CP, 5.9% EE, 24.7% CF, 42.6% NFE, 10.1% ash,

and 18.8 MJ/kg GE. Flores et al. (2017) reported that tall fescue plants contained 56.5-67.8% NDF, 27.7-34.9% ADF, 28.8-34.0% HC, 25.0-28.1% Cel, and 3.61-10.05% lignin. Tomić et al. (2007) indicated that cultivars of *Festuca arundinacea* contained 10.26-11.80% CP and 26.98-30.46% CF. Zhao et al. (2008) found that crude protein concentration in tall fescue and festulolium forages was 111 g/kg DM, but in smooth brome grass 147 g/kg DM. Utyamishv & Reznichenko (2009) reported that at the heading stage, *Bromus inermis* forage contained 15.16% CP, 2.49% EE, 28.88% CF, 46.27% NFE, 1.12% starch, 1.95% sugars, 7.2% ash, 18.50 MJ/kg GE, and 9.43 MJ/kg metabolizable energy (ME). At the flowering stage, CP decreased to 7.42%, while CF increased to 30.63%, and digestibility declined to 552 g/kg DM, with 18.14 MJ/kg GE and 9.11 MJ/kg ME. Hayes et al. (2010) reported that the herbage of *Bromus stamineus* contained 7.0% CP, 61.3% NDF, 33.3% ADF,

7.0% ash, 58.7% dry matter digestibility (DMD), and 8.5 MJ/kg ME, whereas *Festuca arundinacea* forage contained 9.5-10.8% CP, 58.2-61.8% NDF, 35.9% ADF, 7.0-8.0% ash, 58.6-59.6% DMD, and 8.6 MJ/kg ME. Albayrak et al. (2011) found that *Bromus inermis* forage contained 10.45-11.30% CP, 57.85-59.70% NDF, 41.75-43.50% ADF, 45.16-47.45% TDN, and RFV of 85.57-88.11. Naydenova (2012) reported that green biomass of *Bromus inermis* harvested at the heading-flowering stage contained 16.55-20.29% CP, 27.83-30.04% CF, 33.45-41.62% ADF, 59.44-64.12% NDF, 2.71-5.85% ADL, 22.50-26.00% HC, 30.74-35.77% cellulose, 58.04-70.38% IVDMD, 54.17-68.65% IVOMD, 10.45-11.04 MJ/kg ME, and RFV values ranging from 132 to 172. For *Festuca arundinacea*, the corresponding values were 14.66-17.67% CP, 28.60-30.75% CF, 32.73-37.93% ADF, 52.50-61.84% NDF, 2.58-5.69% ADL, 19.77-23.91% HC, 30.15-34.61% cellulose, 60.69-63.75% IVDMD, 59.92-62.50% IVOMD, 10.00-10.30 MJ/kg ME, and RFV values of 145-159. Albayrak & Türk (2013) reported that smooth brome grass harvested in late May contained 8.5-8.7% CP, 61.1-61.3% NDF, 44.6-46.4% ADF, and an RFV of 80-82. Bulokhov (2014) showed that the dry matter of *Festuca arundinacea* green biomass contained 12.0% CP, 2.7% EE, 32.6% CF, 45.2% NFE, and 9.8% ash, with a nutritive value equivalent to 0.37 feed units per kg fresh mass and 78 g digestible protein per feed unit. McEniry & O'Kiely (2014) reported that in Ireland, *Festuca arundinacea* biomass harvested in mid-May contained 15.2% CP, 8.6% ash, 52.9% NDF, 26.7% ADF, and 16.1% soluble carbohydrates. When harvested in early June, CP decreased to 11.2%, while ash increased slightly to 9.0%, and structural fibre fractions rose to 62.3% NDF and 37.2% ADF; soluble carbohydrates declined to 9.2%. Ünal and Mutlu (2015) observed that smooth brome grass harvested at the flowering (blooming) stage contained 17.82-21.78% CP, 62.00-66.38% NDF, 34.55-37.67% ADF, and RFV of 107.72-113.89. Kshnikatkina et al. (2016) reported that the first-cut green biomass of *Festuca arundinacea* contained 9.25% CP, 6.51% DP, 1.15% EE, 29.57% CF, 52.36% NFE, 8.19% ash, 9.62 MJ/kg ME, 0.75 nutritive unit/kg

DM, and 86.9 g DP per nutritive unit. In the second cut, the respective values were 8.40% CP, 5.90% DP, 1.32% EE, 27.80% CF, 53.91% NFE, 8.42% ash, 9.74 MJ/kg ME, 0.76 nutritive units per kg DM, and 76.8 g DP per nutritive unit. Jenson et al. (2017) found that smooth brome harvested in June contained 13.4% CP and 48.1% NDF, with a neutral detergent fibre digestibility of 73.7%. Pocienė & Kadžiulienė (2016) demonstrated that tall fescue biomass, depending on fertilizer type and application rate, contained 14-20% HC, 34-36% Cel, and 6-9% lignin. Czyż et al. (2017) reported that the forage obtained from *Festuca arundinacea* cultivars at the first cut contained 14.3-15.2% CP, 29.3-30.2% CF, 2.0-2.3% EE, and 5.2-6.9% soluble sugars. Chornolata et al. (2018) reported that the green biomass of *Festuca arundinacea* harvested at the heading stage contained 10.0% CP, 1.88% EE, 5.41% ash, 22.76% CF, 41.51% NDF, 21.23% ADF, 59.95% NFE, 3.39% starch, 16.13% cellulose, 12.30% hemicellulose, and 7.10% lignin. For comparison, *Agropyron intermedium* harvested at the same stage contained 9.76% CP, 2.00% EE, 7.18% ash, 22.40% CF, 45.28% NDF, 25.25% ADF, 54.45% NFE, 1.88% starch, 17.35% cellulose, 14.55% hemicellulose, and 6.75% lignin. Tenikecier & Ateş (2018) reported that *Bromus inermis* harvested at the full flowering stage contained 14.23% CP, 55.11% NDF, 30.19% ADF, 3.88% Ca, and 0.22% P. Türk et al. (2018) found that forage from *Bromus inermis* contained 8.91% CP, 59.55% NDF, 45.11% ADF, 43.11% TDN, and RFV of 83.96. Under different nitrogen fertilization rates, CP ranged from 8.88 to 12.02%, NDF from 51.49 to 58.01%, ADF from 36.38 to 43.34%, TDN from 45.40 to 54.38%, and RFV from 88.40 to 109.38. Bandanova & Butukhanov (2019) reported that awnless brome (*Bromus inermis*) harvested at the heading stage contained 16.3% CP, 2.9% EE, 34.0% CF, 36.8% NFE, 5.3% ash, 1.32% Ca, and 0.37% P. At the flowering stage, CP decreased to 14.8%, CF increased to 37.8%, ash increased to 7.53%, and P decreased to 0.30%, while EE (3.0%), NFE (37.0%), and Ca (1.40%) showed minor variation. Kazarina et al. (2019) reported that local varieties of *Bromus inermis* contained 13.56-16.39% CP, 8.26-13.37% TSS, and 102.6-174 mg/kg

carotene. Pavlova et al. (2019) indicated that the green biomass of *Bromus inermis* grown in monoculture contained 10.6% CP, 1.7% EE, 35.0% CF, 47.5% NFE, 8.5 MJ/kg ME, 0.58 nutritive units per kg, and 63.7 g digestible protein per nutritive unit. Sokolović et al. (2019) reported that the first cut of *Bromus inermis* contained 11.61% CP, 33.23% CF, 3.09% EE, 60.19% NDF, 40.33% ADF, and 7.69% ash. Țiței et al. (2019) found that fresh forage from tall fescue (*Festuca arundinacea*) cultivars contained 114-136 g/kg CP, 74-89 g/kg CA, 582-593 g/kg NDF, 392-396 g/kg ADF, 34-41 g/kg ADL, 322-329 g/kg Cel, and 226-229 g/kg HC. Digestibility and energy values were 60.3-63.8% DDM, 57.2-62.2% OMD, 9.12-9.62 MJ/kg ME, and 5.69-5.86 MJ/kg net energy for lactation (NEI). Amalevičiūtė-Volungė et al. (2020) reported that green biomass of *Festuca arundinacea* contained 15.05% CP, 7.52% ash, 52.19% NDF, 31.3% ADF, 4.02% ADL, 16.4% water-soluble carbohydrates (WSC), 27.3% Cel, 20.9% HC, and 62.5% DDM. Coblenz et al. (2020) found that tall fescue herbage contained 75 g/kg CP, 82 g/kg ash, 107.3 g/kg WSC, 627 g/kg NDF, 356 g/kg ADF, 27.9 g/kg ADL, and 1.40 Mcal/kg NEI. Karbivska et al. (2020) reported that unfertilized *Bromus inermis* forage contained 10.6% CP, 3.3% EE, 29.9% CF, 49.9% NFE, 8.3% ash, 0.41% Ca, 0.34% P, 55% DDM, 0.69 nutritive units per kg, 8.0 MJ/kg ME, and 109 g DP per nutritive unit. Reiné et al. (2020) reported that *Festuca arundinacea* plants contained 455 g/kg DM, with 7.2% CP, 4.4% ash, 2.0% EE, 73.3% NDF, 41.1% ADF, 4.0% ADL, 56.8% DDM, 0.12% P, and 0.35% Ca. Shepelev et al. (2020) reported that the nutrient concentration in green biomass of *Bromus inermis* varieties ranged from 13.39 to 17.07% CP and 29.9 to 33.0% CF. Dong et al. (2021) found that *Festuca arundinacea* forage contained 306 g/kg DM, 7.29% CP, 24.8% ADF, 54.7% NDF, 14.4% WSC, 9.08% ash, and 6.97% EE. Baykalova and Serebrennikov (2022) reported that *Bromus inermis* cultivars harvested at the budding stage contained 17.5–25.5% CP, 24.13-28.4% CF, and 1.7-1.9 MJ/kg ME in fresh biomass. Feoktistova and Leonidov (2022) noted that *Bromus inermis* is characterized by a leaf proportion of 38-50% in the harvested biomass,

with 7.0-12.0% CP and 28.2-34.0% CF. Bozhanska et al. (2022) reported that *Bromus inermis* plants contained 13.26-15.27% CP, 2.17-2.31% EE, 34.30-41.23% CF, 35.51-41.78% NFE, 5.67-6.71% ash, 0.9-2.78% Ca, and 0.06-0.21% P. In comparison, *Festuca arundinacea* plants contained 9.89-15.26% CP, 1.49-2.40% EE, 32.06-37.27% CF, 39.55-48.38% NFE, 6.39-7.26% ash, 0.8-2.31% Ca, and 0.03-0.17% P. Acatrinei (Dumitru) et al. (2023) indicated the crude protein in Romanian cultivars of *Bromus inermis* varied from 12.74 to 14.66%. Becker et al. (2023) reported that *Festuca arundinacea* forage contained 17.6% CP and 6.2 MJ/kg net energy. Chornolata et al. (2023) found that herbage DM of *Bromus inermis* contained 6.71-8.92% CP, whereas *Festuca arundinacea* forage contained 5.21-10.10% CP. Coşman et al. (2023) reported that *Festuca arundinacea* forage contained 6.91-10.59% CP, 2.02-2.80% EE, 31.48-34.89% CF, 37.11-42.27% NFE, 9.80-11.98% ash, 0.23-0.29% Ca, 0.20-0.251% P, and 8.14-8.95 MJ/kg ME. Zaiț et al. (2023) indicated that *Festuca arundinacea* grown in pure stand contained 11.74% CP, 64.53% NDF, and 39.73% ADF, with a relative forage quality (RFQ) of 87.8. Yavuz & Kır (2023) remarked that smooth brome forage had 12.3-12.5 % CP, 53-56% NDF, 39.0-42.6% ADF, 5.3-6.5% ADL. Waliszewska et al. (2024) reported that DM of *Bromus inermis* contained 38.65% cellulose, 14.89% lignin, 68.40% holocellulose, 29.75% hemicellulose, and 8.57% ash. Nazare & Țiței, (2025) found that biochemical composition and nutritional value of green fodder from *Festuca* species was 8.6-12.4% CP, 7.5-8.9% ash, 31.5-42.4% CF, 3.0-5.5% ADL, 30.9-39.1% Cel, 23.5-29.2% HC, 4.0-12.2%TSS, 492-651 g/kg DDM, 443-601 g/kg DOM, 527-646 g/kg TDN, RFQ=70-110, 8.90-10.01 ME, 4.91-6.13 MJ/kg NEI.

Haymaking represents one of the oldest and most widely used methods of forage preservation. However, the dehydration process may alter the chemical composition and nutritive value of forage; therefore, the biochemical characteristics of hay prepared from the studied ecotypes were investigated (Table 2). The biochemical composition of the prepared hay was as follows: 10.3-12.4% CP, 10.6-10.8% ash, 36.0-36.9% CF, 38.4-39.7%

ADF, 65.0-69.1% NDF, 4.2-4.6% ADL, and 6.2-9.4% TSS. The nutritive value ranged between 580 and 590 g/kg digestible dry matter, with RFV values of 76-84, digestible energy of 11.51-11.70 MJ/kg, metabolizable energy of 9.45-9.60 MJ/kg, and net energy for lactation (NEI) of 5.47-5.62 MJ/kg. Compared with the initial green biomass, the haymaking process resulted in increased concentrations of structural cell wall components and minerals, accompanied by reductions in crude protein

and total soluble sugars. These compositional changes led to decreased dry matter digestibility and overall energy value. More pronounced reductions in crude protein and soluble sugars were observed in *Bromus inermis* hay. The hay derived from *Festuca arundinacea* was characterized by adequate crude protein, acid detergent lignin, and hemicellulose contents, but a higher cellulose concentration and slightly lower energy value compared with *Bromus inermis* hay.

Table 2. The biochemical composition and the feed value of the hay from *Bromus inermis* and *Festuca arundinacea*

Indices	<i>Bromus inermis</i>	<i>Festuca arundinacea</i>
Crude protein, g/kg DM	103	124
Crude fiber, g/kg DM	360	369
Ash, g/kg DM	108	106
Acid detergent fiber, g/kg DM	384	397
Neutral detergent fiber, g/kg DM	650	691
Acid detergent lignin, g/kg DM	46	42
Total soluble sugars, g/kg DM	62	94
Cellulose, g/kg DM	338	355
Hemicellulose, g/kg DM	266	294
Dry matter digestibility, %	59.0	58.0
Total digestible nutrients, g/kg	548	523
Digestible energy, MJ/kg DM	11.70	11.51
Metabolizable energy, MJ/kg DM	9.60	9.45
Net energy for lactation, MJ/kg DM	5.62	5.47
Relative feed value	84	78
Relative forage quality	87	80

Published data indicate considerable variability in the chemical composition and nutritive value of hay derived from *Bromus inermis* and *Festuca arundinacea*. For example, Medvedev and Smetannikova (1981) reported that the hay from *Bromus inermis* contained 8.0-12.9% CP, 24.0-29.0% CF, 2.4-2.9% EE, 4.7-8.0% ash, and 37.4-41.4% NFE. Burlacu et al. (2002) found that tall fescue (*Festuca arundinacea*) hay contained 6.9-9.0% ash, 11.5-16.7% CP, 4.7-5.9% EE, 26.9-31.2% CF, 41.5-45.7% NFE, 35.0-39.0% ADF, 4.3-5.2% lignin, and 18.9-19.0 MJ/kg GE. Angima & Kallenbach (2008) reported that, depending on fertilization rate, tall fescue hay contained 6.37-7.99% CP with RFV of 96-104, whereas smooth brome (*Bromus inermis*) hay contained 7.76-8.28% CP and an RFV of 92-94. Phillips et al. (2009) indicated that *Bromus inermis* hay contained 2.10% N, 71.44% NDF, and 37.23% ADF. Utyamishv and Reznichenko (2009) reported that the hay from *Bromus inermis* harvested at the flowering stage contained 7.89% CP, 1.9% EE, 30.0% CF, 44.9% NFE, and 8.6 MJ/kg ME. Ünal and Mutlu (2015) found that smooth brome hay harvested at the flowering stage contained 19.80% CP, 36.10% ADF, 64.18%

NDF, 60.78% DDM, and an RFV of 113.89. Bender et al. (2016) reported that tall fescue hay contained 143 g/kg CP, 107 g/kg ash, 30 g/kg lipids, 644 g/kg NDF, 81 g/kg ADL, and 16 g/kg starch. Kaplan et al. (2017) found that tall fescue hay DM contained 5.56% CP, 64.94% NDF, 41.01% ADF, 1.61% EE, and 12.03% ash, with 48.54% OMD, 7.00 MJ/kg ME, and 3.75 MJ/kg NEI. Jenson et al. (2017) reported that smooth brome harvested in June and conserved as hay contained 13.4% CP, 48.1% NDF, and 73.7% NDFD. Akdeniz et al. (2019) characterized *Festuca arundinacea* hay by 9.86% CP, 9.54% ash, 1.15% EE, 44.85% CF, 64.05% NDF, 47.64% ADF, and an RFV of 75.22. Fehlberg et al. (2020) reported that smooth brome hay contained 9.6% CP, 2.7% EE, 63.3% NDF, 35.6% ADF, and 2.12 Mcal/kg DE for horses. Foster et al. (2021) found that hay from a hybrid brome grass (*Bromus riparius* × *Bromus inermis*) contained 8.3-8.5% CP, 38.9-39.6% ADF, and 563-571 g/kg TDN. Tan and Çoruh (2021) reported that smooth brome hay harvested from plants sown in spring contained 12.36-13.24% CP, 35.15-37.54% ADF, and 40.16-47.12% NDF, whereas summer-sown stands produced hay

containing 12.38-14.01% CP, 33.94-37.66% ADF, and 35.26-47.27% NDF. Yazici and Tan (2021) found that hay from tall fescue cultivars contained 13.47-18.67% CP, 42.48-50.05% NDF, and 20.20-30.97% ADF, with RFV values ranging from 127.1 to 144.4. Coşman et al. (2023) reported the nutrient content of hay from *Festuca arundinacea* as follows: 5.88-12.31% CP, 0.83-2.60% EE, 31.07-37.20% CF, 31.50-44.95% NFE, 8.51-12.31% ash, and 8.90-64.67 mg/kg carotene. Similarly, Țiței (2023) found that prepared tall fescue hays contained 10.84% CP, 2.65% EE, 33.38% CF, 40.54% NFE, 12.59% ash, 2.60 g/kg Ca, 2.30 g/kg P, with 17.44 MJ/kg GE, 8.85 MJ/kg ME, and 4.93 MJ/kg NEL. Nazare & Țiței (2025) reported that tall fescue hay contained 10.0% CP, 39.3% CF, 8.9% ash, 42.7% ADF, 72.0% NDF, 3.5% ADL, 5.5% TSS, 37.2% Cel, and 29.2% HC, with a forage value of 548 g/kg DDM, 9.10 MJ/kg ME, and 5.13 MJ/kg NEL.

The use of grass biomass for anaerobic digestion in biogas reactors has recently gained significant interest in Europe for biomethane production as a renewable energy source. The quality indices of substrates from the studied local grass ecotypes, along with their biomethane potential, are presented in Table 3. It is important to note that the investigated substrates exhibit a favourable carbon-to-nitrogen (C/N) ratio for the activity of methanogenic bacteria (C/N = 23.85-30.25), hemicellulose concentration (260.00-294.00 g/kg), and acid detergent lignin (ADL) content (28.00-46.00 g/kg). Hay substrates were found to have higher ADL content and lower carbon and nitrogen concentrations, which negatively affected their biomethane potential. The biochemical methane potential ranged from 331 to 366 L/kg VS, with the highest biomethane potential observed in *Festuca arundinacea* green mass substrates.

Table 3. The biochemical biomethane production potential of the investigated substrates

Indices	<i>Bromus inermis</i>		<i>Festuca arundinacea</i>	
	green mass	hay	green mass	hay
Crude protein, g/kg DM	124.00	103.00	131.00	124.00
Nitrogen, g/kg DM	19.84	16.48	20.96	19.84
Ash, g/kg DM	94.00	108.00	100.00	106.00
Carbon, g/kg DM	503.33	495.56	500.00	496.66
Ratio carbon/nitrogen	25.37	30.25	23.85	25.03
Acid detergent lignin, g/kg DM	36.00	46.00	28.00	42.00
Hemicellulose, g/kg DM	260.00	266.00	288.00	294.00
Biomethane potential, L/kg VS	351.00	331.00	366.00	343.00

Several researchers have explored the biomethane potential of various grass species and their substrates, with varying results depending on factors such as substrate composition and treatment methods. Mähnert et al. (2002) reported that *Festuca arundacea* fresh mass co-substrates had 139 g/kg dry matter (DM), and gas production ranged from 688 to 836 L/kg VS over 28 days, while co-substrates contained 173 g/kg DM and 89.6% ODM, yielding 818-887 L/kg VS. Ust’ak et al. (2013) reported specific methane yields of 239 L/kg DM for substrates derived from tall fescue, 214 L/kg DM for meadow fescue, 237 L/kg DM for Italian ryegrass, and 222–238 L/kg DM for the festulolium hybrid. Similarly, McEniry and O’Kiely (2014) observed that methane production from *Festuca arundinacea* biomass ranged between 216 and 268 L/kg, depending on the harvest stage. Higher methane yields

were reported by Kandel et al. (2017), who found that first-cut biomass of *Festuca arundinacea* produced between 401 and 428 L/kg, corresponding to a methane productivity of approximately 6871 m³/ha. Țiței et al. (2019) revealed that the biomethane production potential of *Festuca arundinacea* green mass substrates were consistently between 349 and 354 L/kg VS. Żurek & Martyniak (2020) also reported biogas yields of 518.3 L/kg VS with 50.4% methane for smooth brome grass, 611.9 L/kg VS with 54.8% methane for ryegrass, and 485 L/kg VS with 50.23% methane for rescue grass. Amalevičiūtė-Volungė et al. (2021) found that the methane yields of substrate from tall fescue were 191 L/kg VS, perennial ryegrass 205.7 L/kg VS, orchard grass 213.9 L/kg VS, switchgrass 143.4 L/kg VS, and reed canary grass 123.1 L/kg VS. Zhang et al. (2021) reported that methane yields from *Festuca arundinacea*

substrates ranged from 259 to 446 L/kg VS, compared to 220 to 330 L/kg VS for lucerne substrates, and 196-436 L/kg VS for maize substrates. Czubaszek et al. (2024) found that substrates from spring-cut grass verges, predominantly composed of perennial ryegrass, had a dry matter content of 380 g/kg DM, 682.2 g/kg VS, 20.76 g/kg nitrogen, 378.8 g/kg total organic carbon, and a biogas yield of 715.05 L/kg VS with 59.7% methane content.

CONCLUSIONS

The green biomass and hay obtained from the studied local ecotypes of *Bromus inermis* and *Festuca arundinacea* were characterized by substantial nutrient concentrations, confirming their suitability as valuable feed resources for farm animals. In addition, the biochemical composition of the biomass indicates considerable potential for use as feedstock for biomethane production, contributing to renewable energy generation.

Despite these differences, both ecotypes produced forage and hay of adequate nutritive value, suggesting that smooth brome (*Bromus inermis*) may be preferable for higher yields, whereas tall fescue (*Festuca arundinacea*) offers greater protein content, supporting their effective use in livestock feeding systems.

Overall, the obtained results highlight the potential of the studied local ecotypes of *Bromus inermis* and *Festuca arundinacea* as promising genetic resources for breeding programs aimed at developing new locally adapted grass cultivars for sustainable agricultural production.

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