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AGROECONOMIC VALUE OF SOME *Lathyrus* AND *Vicia* SPECIES IN THE REPUBLIC OF MOLDOVA

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ABSTRACT

The efficient use of the biological potential of the leguminous plants that are adapted to the local climatic conditions becomes more and more relevant. The local ecotype of the species *Lathyrus sativus, Lathyrus sylvestris, Lathyrus tuberosus, Vicia hirsuta, Vicia sativa, Vicia tenuifolia* maintained in monoculture on experimental land in the NBGI Chişinău, served as objects of study. We found that the dry matter of the studied whole plants contained 169-257 g/kg CP, 96-125 g/kg ash, 219-346 g/kg CF, 244-371 g/kg ADF, 427-576 g/kg NDF, 34-58 g/kg ADL, 210-313 g/kg Cel, 183-205 g/kg HC, 64-150 g/kg TSS, with 59.3-69.4% DMD, RFV = 93-151, 11.87-13.55 MJ/kg DE, 9.75-11.13 MJ/kg ME, 5.77-7.22 MJ/kg NEl. The prepared hay contained 153-264 g/kg CP, 91-135 g/kg ash, 244-356 g/kg CF, 294-393 g/kg ADF, 475-606 g/kg NDF, 36-65 g/kg ADL, 258-329 g/kg Cel, 191-214 g/kg HC, 6-99 g/kg TSS, with 59.2-66.0% DMD, RFV = 90-129, 11.57-12.95 MJ/kg DE, 9.50-11.09 MJ/kg ME, 5.51-7.10 MJ/kg NEl. The haylage is characterized by pleasant smell and color, pH = 4.40-4.95, 4.7-6.1 g/kg acetic acid, 27.9-38.0 g/kg lactic acid, butyric acid was not detected, 159-180 g/kg CP, 105-125 g/kg ash, 296-343 g/kg CF, 316-360 g/kg ADF, 460-579 g/kg NDF, 51-55 g/kg ADL, 263-309 g/kg Cel, 142-219 g/kg HC, 43-106 g/kg TSS, 60.9-64.1% DMD, RFV = 98-129, 12.03-12.61 MJ/kg DE, 9.88-10.35 MJ/kg ME, 5.89-6.37 MJ/kg NEl. The harvested fresh mass and the haylage prepared from the studied species can be used as substrates in biogas production via anaerobic digestion for renewable energy production, with carbon nitrogen (C/N) ratios 12-20. The biochemical methane potential reached 320-378 litre/kg organic matter. The investigated leguminous species are an important forage source for livestock, many birds, bees and entomophagous insects, and they are excellent plants for erosion control and for reseeding and increasing the economic value of permanent and temporary grasslands. The harvested biomass can be used as alternative fodder for farm animals or as substrates in biogas generators for the production of renewable energy.

Keywords: biochemical composition, biochemical methane potential, forage quality, *Lathyrus* species, *Vicia* species.

INTRODUCTION

Climate change, from a more general point of view, affects crop production, animal production and the socioeconomic structure of the country, negatively affecting energy and food security and the rate of economic development.

World plant biodiversity, its conservation and prospects for practical use are becoming an increasingly pressing problem in the 21st century. Plant genetic resources are essential for feeding Europe and enabling an innovative bioeconomy. There are about 50000 edible spontaneous plant species, but a small number of these species have been domesticated and cultivated (ECPGR, 2021).

The *Fabaceae* species are of great agroeconomic 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 (Lewis et al., 2005; Luscher et

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al., 2013; Stoddard, 2013; Stinner, 2015; Foster et al., 2021; Petcu et al., 2022). The interest in systems based on legumes has increased significantly over the recent years due to their importance for sustainable and organic farming. In the European Union, the interest in forage legumes has increased for several economic and environmental reasons (European Parliament resolution 2011, 2018; ECPGR, 2021).

The diversification of legume forage production has to be achieved by mobilization, acclimatization and implementation of new species and non-traditional crops from local flora and other floristic regions. Considering the limited natural and technical resources in the Republic of Moldova, the efficient use of the biological potential of the *Fabaceae* plants that are adapted to the local climatic conditions becomes more and more relevant. In this context, the plants of the genera *Vicia* and *Lathyrus* have gained a lot of attention recently.

The genus *Lathyrus* L. is the largest genus in the economically important tribe Fabeae and includes about 160 species, which are distributed throughout temperate regions of the northern hemisphere and also occur in the tropical East Africa and South America. The genus *Vicia* L. belongs to the tribe Vicieae and includes about 230 species, which are distributed throughout the temperate regions of Europe, Asia, North America and South America.

Members of the genera *Lathyrus* and *Vicia* include food and fodder crops, ornamentals, soil nitrifiers, dune stabilizers, important agricultural weeds. *Lathyrus* and *Vicia* species already occupy special niches in farming systems because of their adaptation to a wide range of conditions and ability to grow where other traditional food and forage legumes are not suited. In the spontaneous flora of the Basarabia the family Fabaceae is represented by 146 species of 35 genera, including 19 species of the genus *Vicia* and 15 species on the genus *Lathyrus* (Izverscaia, 2020). In România, there are 21 genera of legumes with 198 species and 581 taxa, including 19 *Lathyrus* species with 73 taxa and 30 *Vicia* species with 88 taxa, to which must be added a huge number of ecotypes, providing an image of the genetic resources which await investigation (Maruşca, 1999).

The main objectives of this study were to evaluate the quality of green mass, hay and haylage from *Lathyrus sativus, Lathyrus sylvestris, Lathyrus tuberosus, Vicia hirsuta, Vicia sativa* and *Vicia tenuifolia* and the prospects of its use as fodder for farm animals or as substrates for renewable energy production.

MATERIAL AND METHODS

The local ecotype of the species *Lathyrus sativus*, *Lathyrus sylvestris*, *Lathyrus tuberosus*, *Vicia hirsuta*, *Vicia sativa*, *Vicia tenuifolia* maintained in monoculture in the experimental plot of the National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subjects of the research. The experimental design was a randomized complete block design with four replications, and the experimental plots measured 50 m^2. The plant growth, development and productivity were assessed according to accepted methodical indications in NBGI.

The green mass samples were collected in the flowering stage. The leaf/stem ratio was determined by separating leaves and flowers from the stem, weighing them separately and establishing the ratios for these quantities. For this purpose, samples of 1.0 kg harvested plants were taken. The dry matter content was detected by drying samples up to constant weight at 105°C. The prepared hay was dried directly in the field. The haylage was produced from wilted green mass, cut into small pieces and compressed in glass containers. The containers were stored for 45 days, and after that, they were opened and the organoleptic assessment and the determination of the organic acid composition of the persevered forage were done in accordance with the Moldavian standard SM 108. The fresh mass and fermented fodder samples were dehydrated in an oven with forced ventilation at a temperature of 60°C. At the end of the fixation, the biological material was finely ground in a laboratory ball mill. The quality of the biomass was evaluated by analyzing such indices as: crude protein (CP), crude fibre (CF), crude ash (CA), total soluble

sugars (TSS), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL) which have been determined by near infrared spectroscopy (NIRS) technique PERTEN DA 7200 of the Research and Development Institute for Grassland Braşov, Romania. The concentration of hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), digestible energy (DE), the metabolizable energy (ME), the net energy for lactation (NEl) and the 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 biogas potential (Yb) and the methane potential (Ym) were calculated according to Dandikas et al. (2015).

RESULTS AND DISCUSSION

Analyzing the results of the assessment of agro-biological peculiarities of the studied Fabaceae species, it can be noted that in the flowering period, at the time when the green mass was harvested, the semi-erect shoots of *Lathyrus sativus* reached 89.7 cm, the yield was 3.31 kg/m^2 green mass or 0.80 kg/m^2 dry matter with 43.0% leaves and flowers in the harvested mass. At the time of harvesting, the shoots of *Lathyrus tuberosus* were on average 130 cm tall, the yield was 3.79 kg/m^2 green mass or 0.91 kg/m^2 dry matter, with the foliage constituting 48% of the total weight of a plant. *Lathyrus sylvestris* plants reached 207.8 cm in height, provided a natural fodder yield of 5.13 kg/m^2 or 1.27 kg/m^2 dry matter with 57.3% leaves and flowers. *Vicia hirsuta* - 135.6 cm, 3.65 kg/m^2 green mass or 0.97 kg/m^2 dry matter with 50.9% leaves and flowers, *Vicia sativa* - 141.4 cm, 4.78 kg/m^2 green mass or 0.93 kg/m^2 dry matter with 58.3% leaves and flowers while *Vicia tenuifolia* reached in the budding-flowering stage 122 cm in height, the yield at the first cut was 3.62 kg/m^2 fresh mass or 0.65 kg/m^2 dry matter with 66.7% leaves.

The morphological structure of the whole plant has a significant impact on the nutrient content of the green mass. Analysing the results of the biochemical composition of dry matter (Table 1), we found that the dry matter of the studied whole plants contained 169-257 g/kg CP, 96-125 g/kg ash, 219-346 g/kg CF, 244-371 g/kg ADF, 427-576 g/kg NDF, 34-58 g/kg ADL, 210-313 g/kg Cel, 183-205 g/kg HC, 64-150 g/kg TSS, with 59.3-69.4% DMD, RFV = 93-151, 11.87-13.55 MJ/kg DE, 9.75-11.13 MJ/kg ME, 5.77-7.22 MJ/kg NEl. We would like to mention that *Lathyrus sativus* fodder was characterised by higher content of crude protein and reduced concentration of cell wall fractions (NDF, ADF, ADL) which had a positive effect on the digestibility, nutritional value and energy supply of the feed. *Lathyrus sylvestris* had optimal amounts of crude protein, total soluble sugars, cellulose and acid detergent lignin, nutritive and energy values as compared with *Lathyrus tuberosus* fodder. *Vicia hirsuta* fodder contained higher amounts of crude protein and minerals and lower amount of soluble sugars than *Vicia sativa* and *Vicia tenuifolia.* The lowest level of crude fibre, acid detergent fibre, neutral detergent fibre and cellulose was found in *Vicia sativa* fodder. The relative feed value and energy concentrations were optimal in *Vicia sativa* fodder, but reduced as compared with *Lathyrus sativus* and *Lathyrus sylvestris*.

The results of the estimation of quality of green mass from *Vicia* and *Lathyrus* species are given in the specialized literature. According to Medvedev and Smetannikova (1981), the harvested mass from *Lathyrus sativus* contained 18.2% CP, 2.3% EE, 23.4% CF, 32.6% NFE; from *Lathyrus sylvestris* - 31.3% CP, 4.7% EE, 24.3% CF, 33.1% NFE, 6.7% ash; from *Lathyrus tuberosus* - 25.2% CP, 3.0% EE, 26.0% CF, 37.0% NFE, 5.7% ash. Yildirim et al. (2001) revealed that wild plants of *Lathyrus tuberosus* contained 20.87% DM with a nutritional value of 67.5 g/kg DP, 161.25 mg/kg ascorbic acid, 22.9 g/kg Ca, 6.6 g/kg P, 15.44 g/kg K. Burlacu et al. (2002) reported that *Vicia sativa* harvested in the flowering period contained: 170 g/kg DM, 10.5% ash, 18.4% CP, 28.2% CF, 58.2% DOM, 18.24 MJ/kg GE, 11.13 MJ/kg DE, 8.94 MJ/kg ME.

Burlyaeva et al. (2012) reported that the concentration of protein substances in the green mass of *Lathyrus tuberosus* was 18.2-20.3%, *Lathyrus sylvestris* - 17.5-20.5%, *Lathyrus latifolius* - 20.6-21.2%, *Lathyrus cicera* - 28.4%, *Lathyrus* - 23.8-24.6%, *Lathyrus sativus* - 24.4-27.2%, *Lathyrus tingitanus* - 17.6% and *Lathyrus ochrus* - 23.0%. Ates et al. (2013), presented the quality characteristics of grazing dry herbage from three *Vicia* spp: *Vicia ervillia* contained 21.5% CP, 28% NDF, 19.5% ADF, 72% IVDMD; *Vicia sativa* - 21.5% CP, 31% NDF, 22% ADF, 60% IVDMD; *Vicia villosa* ssp. *dasycarpa* 16.5% CP, 40% NDF, 31% ADF, 46% IVDMD. Maevsky et al. (2013) found that *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. Vishnyakova et al. (2014) found the *Lathyrus* and *Vicia* samples collected in different habitats had the following protein content in green mass: 13.81-17.41% in *Lathyrus komarovii,* 10.32-16.93% *Lathyrus humilis,* 15.15-18.01% *Lathyrus palustris,* 16.18-20.94% *Lathyrus japonicas,* 19.92-21.85% *Lathyrus davidii,* 16.57-19.00% *Lathyrus subrotundus*. 20.4-21.9% *Vicia sativa,* 18.1-20.6% *Vicia amoena,* 18.4-22.3% *Vicia cracca*, 19.5% *Vicia tenuifolia,* 20.60-23.38% *Vicia villosa*. Heuze et al. (2015, 2016) mentioned the average feed value of *Vicia sativa* was: 193 g/kg DM, 23.0% CP, 2.5% EE, 25.4% CF, 36.7% NDF, 28.9% ADF, 6.1% lignin, 9.8% ash, 69.8% DOM, 18.6 MJ/kg GE, 12.4 MJ/kg DE and 9.8 MJ/kg ME, but *Lathyrus sativus* forage - 217 g/kg DM, 21.4% CP, 2.9% EE, 25.8% CF, 38.2% NDF, 27.1% ADF, 10.5% ash, 69.4% DOM, 18.5 MJ/kg GE, 12.3 MJ/kg DE and 9.7 MJ/kg ME. Maršalkienė (2015) suggested that, according to the investigation of annual vetch species, the crude protein content in plant mass was: 18.2% *Vicia sativa,* 18.5% *Vicia hirsuta,* 19.3% *Vicia angustifolia,* 21.9% *Vicia villosa*. In our previous research (Teleuţă and Ţîţei, 2016), it was established that the tested *Lathyrus* perennial species have a high productivity and nutritive value: *Lathyrus sylvestris* achieved 10534 nutritive units/ha, 114 GJ/ha ME, 2085 kg/ha DP, 198 g digestible protein per nutritive unit; *Lathyrus latifolius* - 9891 nutritive units/ha, 106 GJ/ha ME, 1887 kg/ha DP, 190 g digestible protein per nutritive unit; *Lathyrus pisiformis* - 6291 nutritive units/ha, 54 GJ/ha ME, 1038 kg/ha DP, 166 g digestible protein per nutritive unit. In the budding-flowering stage, *Vicia tenuifolia* fresh mass yield (1 cut) was 4.18 kg/m^2, characterized by 23.50% CP, 3.65% EE, 29.08% CF, 37.53% NFE, 8.10% ash and 192 g digestible protein per nutritive unit (Ţîţei and Coşman, 2018). Vysotskaya and Shimko (2018) reports that the fresh mass of *Lathyrus tuberosus* contains 23.29% DM with a nutritional value of 116 g/kg DP, 231.9 g/kg CF, 498.8 g/kg NFE, 86 mg/kg carotene, 9.9 g/kg Ca, 3.4 g/kg P, 0.95 nutritive units/kg, 10.81 MJ/kg ME. Atis and Acikalin (2020) reported that the dry matter from the harvested forage of *Lathyrus sativus* contained 20.2-22.6% CP, 37.5-40.9% NDF, 24.1-26.6% ADF RFV = 155.5-174.3. Hay is one of the main and the most nutritious rough forage for the cattle, sheep, horses, rabbits and other animals, both in winter and throughout the year, a rich source of nutrients, vitamins and minerals, especially for the young animals, pregnant females and breeding males. It helps the motor functions of the stomach, or the muscular activity of the digestive system and promotes rumination, indispensable for proper digestion in ruminants.

The quality and productivity of hay mainly depends on the plants species, the age at which these plants have been harvested, on the botanical structure of the herbage, on techniques and technology of hay preparation, on conditions of its storage and on many other factors. Each factor and even combinations of them can have an impact on hay fodder value.

Table 1. The biochemical composition and the fodder value of the green mass of the studied *Fabaceae* species

Indices	*Lathyrus sativus*	*Lathyrus sylvestris*	*Lathyrus tuberosus*	*Vicia hirsuta*	*Vicia sativa*	*Vicia tenuifolia*
Crude protein, g/kg DM	257	196	169	208	194	172
Crude fibre, g/kg DM	219	270	346	316	297	325
Minerals, g/kg DM	125	115	96	113	102	96
Acid detergent fibre, g/kg DM	244	301	371	346	326	345
Neutral detergent fibre, g/kg DM	427	489	576	536	523	519
Acid detergent lignin, g/kg DM	34	51	58	50	48	59
Total soluble sugars, g/kg DM	140	133	68	64	109	118
Cellulose, g/kg DM	210	250	313	296	278	286
Hemicellulose, g/kg DM	183	188	205	190	187	174
Digestible dry matter, g/kg DM	694	655	600	620	635	620
Relative feed value	151	125	97	108	113	111
Digestible energy, MJ/ kg	13.55	12.85	11.87	12.22	12.50	12.06
Metabolizable energy, MJ/ kg	11.13	10.55	9.75	10.04	10.26	9.90
Net energy for lactation, MJ/ kg	7.22	6.57	5.77	6.05	6.28	6.06

Analyzing the results regarding the quality of hay prepared from the studied *Fabaceae* species (Table 2), we would like to mention that hay dry matter contained 153-264 g/kg CP, 91-135 g/kg ash, 244-356 g/kg CF, 294-393 g/kg ADF, 475-606g/kg NDF, 36-65 g/kg ADL, 258-329 g/kg Cel, 191-214 g/kg HC, 6-99 g/kg TSS. The digestibility, nutritive value and the energy value of the prepared hay was 59.2-66.0% DMD, RFV = 90-129, 11.57-12.95 MJ/kg DE, 9.50-11.09 MJ/kg ME, 5.51-7.10 MJ/kg NEl. During the process of preparing hay, we observed an increase in the concentration of crude fibre, cellulose and a decrease in the total soluble sugar content, dry matter digestibility and relative feed value and energy concentration as compared to the initial green mass. The *Lathyrus sativus* hay is characterized by high content of crude protein, ash, hemicellulose, but low acid detergent lignin and cellulose concentration, which had a positive effect on digestibility, relative feed value, metabolizable energy and net energy for lactation. The amounts of crude protein and total soluble sugars became lower, but the concentration of cell wall increased significantly in the *Vicia hirsuta* hay. It has been determined that the hay prepared from *Lathyrus sylvestris* and *Vicia sativa* did not differ significantly in the content of crude protein (197-198 g/kg), but *Lathyrus sylvestris* hay had a lower concentration of acid detergent fibre, neutral detergent fibre and a very high concentration of total soluble sugars, which led to higher digestibility and energy value of the fodder. The hay prepared from *Vicia tenuifolia* is characterized by optimal content of crude protein, total soluble sugars, cell wall fractions (NDF, ADF, ADL), digestibility, nutritional value and energy value of the feed.

Some authors mentioned various findings about the quality of hay prepared from *Vicia* and *Lathyrus* species. Gonean (1961) remarked that, under the climatic conditions of Armenia, *Vicia variabilis* (syn. *Vicia tenuifolia*) hay was characterized by 18.26-24.72% CP, 1.95-2.40% EE, 33.23-35.41% CF, 30.71-37.31% NFE, 6.49-8.16% ash, including 1.75-2.5% Ca, 0.43-0.70% P. Forster (1988) found that *Lathyrus sylvestris* hay contained 23.80% CP, 43.39% NDF, 38.78% ADF, 12.58% lignin, 21.78% Cel, 4.84% HC, 6.52% ash, 0.58% Ca, 0.29% P, and *Medicago sativa* hay - 17.30% CP, 44.68% NDF, 32.43% ADF, 8.32% lignin, 25.92% CeL, 11.74% HC, 7.35% ash, 0.95% Ca, 0.28% P, respectively. Hadjipanayiotou et al. (1983) mentioned that, in Cyprus, the chemical composition of *Vicia sativa* hay was 18.6% CP, 2.2% EE, 25.8% CF, 47% NDF, 33% ADF, 6.3% lignin, 11.5% ash, 60% DOM, 11.0-12.0 MJ/kg DE. Poland et al. (2003) reported that the nutritional quality of *Lathyrus sativus* hay was 18.2% CP, 48.6% NDF, 36.3% ADF, 60.6% TDN and - of *Medicago sativa* hay - 18.1% CP, 44.6% NDF, 35.0% ADF, 61.7% TDN. Burlacu et al. (2002)

mentioned that *Vicia sativa* hay contained: 850 g/kg DM, 10.0% ash, 16.5% CP, 2.6% EE 32.0% CF, 54.0% DOM, 18.22 MJ/kg GE, 10.39 MJ/kg DE and 8.35 MJ/kg ME. Ates et al. (2013) reported that the quality of *Lathyrus sativus* hay was 21% CP, 32% NDF, 18% ADF, 75% DOMD and straw 14% CP, 45% NDF, 25% ADF, 60% DOMD, respectively. Vahdani et al. (2014) reported that grass pea hay with seedpods contained: 953.7 g/kg DM, 908.3 g/kg OM, 232.4 g/kg CP, 43.0 g/kg EE, 318.5 g/kg CF, 397 g/kg NDF, 383 g/kg NDF_{OM}, 300 g/kg ADF; 96.5 g/kg HC, 13.4 g/kg TP,17.6 g/kg TT, 0.2 g/kg CT, 8.75% g/kg, 11.8 g/kg $_B$ - ODAP, 772.0 g/kg OMD, 10.7 MJ/kg ME. Das et al. (2015), mentioned that the nutritional value of *Lathyrus sativus* hay was: 93.47% OM, 14.99% CP, 2.18% EE, 31.85% CF, 44.75% NFE, 58.08% NDF, 41.51% ADF; 9.3% ADL, 16.57% HC, 32.21% Cel, 6.22% ash. Heuze et al. (2015, 2016), mentioned that the hay made from *Lathyrus sativus* and *Vicia sativa* contained 19.1-19.7% CP, 1.8-2.9% EE, 24.5-28.5% CF, 38.6-43.4% NDF, 28.7-32.7% ADF, 6.5% lignin, 9.9-10.7% ash, 13.3-14.5 g/kg Ca, 2.1-2.9 g/kg P, 64.4-68.3% DOM, 18.1-18.6 MJ/kg GE, 11.0-12.0 MJ/kg DE and 8.7-9.5 MJ/kg ME. According to Mihailović et al. (2016) the hay yield and forage crude protein yield of some legumes species grown in Serbia were: *Lathyrus sativus* 11.8 t/ha and 1882 kg/ha CP, *Lathyrus sylvestris* 9.9 t/ha and 1584 kg/ha CP, *Lathyrus tuberosus* 5.7 t/ha and 907 kg/ha CP, *Vicia sativa* subsp. *sativa* 10.5 t/ha and 1674 kg/ha CP, *Vicia hirsuta* 4.5 t/ha and 723 kg/ha CP. Kaya (2021) evaluating of the forage quality of vetch species grown in a native pasture in Turkey, reported that fodder value of *Vicia sativa* hay was 17.5% CP, 0.7% EE, 26.0% ADF, 48.6% NDF, 7.6% ash, 71.0% DOM and 9.5 MJ/kg ME, but - of *Vicia tenuifolia* hay - 17.2% CP, 1.2% EE, 39.2% ADF, 61.5% NDF, 6.3% ash, 60.2% DOM and 7.8 MJ/kg ME. In our previous publications (Ţîţei et al., 2017; Ţîţei and Coşman, 2018) we mentioned that the hay from *Lathyrus sylvestris* contained 23.71% CP, 2.85% EE, 34.00% CF, 32.63% NFE, 6.76% ash, 0.71 nutritive unit/kg, 7.71 MJ/kg ME for cattle and 9.44 MJ/kg ME for sheep, 194.4 g/kg DP, 6.20 g/kg Ca, 2.20 g/kg P, 273.0 g DP/nutritive unit; *Vicia tenuifolia* hay contained 21.94% CP, 1.49% EE, 31.78% CF, 36.71% NFE, 8.08% ash, 0.76 nutritive unit/kg, 8.27 MJ/kg ME for cattle, 189.0 g DP/nutritive unit, but *Medicago sativa* hay - 15.10-16.00% CP, 1.57-1.87% EE, 34.66-36.26% CF, 37.47-37.77% NFE, 9.30-10.00% ash, 0.67-0.73 nutritive unit/kg, 7.10-7.94 ME for cattle and 8.68 MJ/kg ME for sheep, 148.40-153.00 g DP/nutritive unit, 14.2 g/kg Ca, 2.0 g/kg P.

Table 2. The biochemical composition and the fodder value of the hay from the studied *Fabaceae* species

Indices	*Lathyrus sativus*	*Lathyrus sylvestris*	*Lathyrus tuberosus*	*Vicia hirsuta*	*Vicia sativa*	*Vicia tenuifolia*
Crude protein, g/kg DM	264	197	153	189	198	174
Crude fibre, g/kg DM	244	286	352	356	322	333
Minerals, g/kg DM	135	122	91	110	106	99
Acid detergent fibre, g/kg DM	294	317	381	393	345	354
Neutral detergent fibre, g/kg DM	475	479	595	606	510	521
Acid detergent lignin, g/kg DM	36	54	65	65	50	57
Total soluble sugars, g/kg DM	58	99	62	6	70	83
Cellulose, g/kg DM	258	263	316	328	295	300
Hemicellulose, g/kg DM	191	162	214	213	165	184
Digestible dry matter, g/kg DM	660	642	592	593	620	611
Relative feed value	129	125	93	90	113	109
Digestible energy, MJ/ kg	12.95	12.63	11.73	11.57	12.24	12.07
Metabolizable energy, MJ/ kg	10.63	10.37	9.63	9.50	10.05	9.91
Net energy for lactation, MJ/ kg	6.65	6.38	5.65	5.51	6.05	5.93

In recent years, developments and awareness in animal husbandry have increased the interest in more efficient and quality forage production. Wilting legume herbage prior to ensiling has many advantages including reducing effluent production and improved fermentation characteristics of ensiling forage. Legume haylage is an important source of nutrients for livestock, is a great way to preserve nutrients for autumn - middle spring, a period when pastures are less productive and it has substantial effects on the nutritive value of the prepared feed diet and animal performance. When opening the glass vessels with haylages prepared from studied perennial legumes species, there was no gas or juice leakage from the preserved mass, it had agreeable colour and aroma, the consistency was retained in comparison with the initial green mass, without mould and mucus. It was found that *Lathyrus sylvestris* haylage had homogeneous green-yellow colour with pleasant smell, specific to pickled vegetables; the colour of the *Lathyrus tuberosus* haylage was yellowish-green leaves and yellow stems with specific smell of pickled fruit, *Vicia tenuifolia* haylage consisted of green-brown leaves and yellow stems with pleasant smell specific to pickled vegetables. The results regarding the quality of the prepared legume haylages are shown in Table 3. It has been determined that the fermentation characteristics of prepared legume haylages depended on the species, thus, *Lathyrus* haylage is caractrerized by lower pH index and higher content of free organic acids than *Vicia tenuifolia* haylage. The content of fixed organic acids in haylages vary essentially, most fixed organic acids were *Vicia tenuifolia* haylage. The concentration of total organic acids is reduced in *Lathyrus tuberosus* haylage. Butyric acid was detected only in *Vicia tenuifolia* haylage (0.1 g/kg). According to the Moldovan standard SM 108, the pH index and the ratio of acetic acid and lactic acid of the studied *Lathyrus sylvestris* and *Vicia tenuifolia* haylages correspond to the 1st class quality.

It was found that during the process of ensiling, the concentrations of crude protein, total soluble sugars and acid detergent lignin decreased, but the level of minerals, crude fibre, cellulose, hemicellulose increased in comparison with the *Lathyrus sylvestris* green mass, which had a negative effect on the digestibility, nutritional value and energy supply of the feed. In *Lathyrus tuberosus* haylage, the amount of crude protein, cell wall fractions (NDF, ADF, ADL) decreased, but the level of minerals and total soluble sugars increased in comparison with the initial green mass. We would like to mention that *Vicia tenuifolia* haylage contained optimal amounts of crude protein, ash and a low amount of structural carbohydrates, which contributed to the increased dry matter digestibility, relative feed value and energy content. The net energy for lactation in the prepared *Lathyrus tuberosus* and *Vicia tenuifolia* haylages was at the same level, but very high as compared with *Lathyrus sylvestris* haylage. According to Foster et al. (1996), flat pea (*Lathyrus sylvestris*) silage contained 422 g/kg DM, 26.4% CP, 38.9% NDF, 30.9% ADF, 63.0% IVOMD (*in vitro* organic matter disappearance), but alfalfa silage contained 464 g/kg DM, 20.9% CP, 40.1% NDF, 30.7% ADF, 62.3% IVOMD. Flat pea contained 1.1% DABA (2.4-diaminobutyric acid) which did not adversely influence palatability of the diet.

Table 3. The biochemical composition and the nutritive value of the haylage from studied *Fabaceae* species

Indices	*Lathyrus sylvestris*	*Lathyrus tuberosus*	*Vicia tenuifolia*
pH index	4.40	4.52	4.95
Organic acids, g/kg DM	32.5	22.1	35.3
Free acetic acid, g/kg DM	2.0	2.2	0
Free butyric acid, g/kg DM	0	0	0
Free lactic acid, g/kg DM	9.0	5.0	5.0
Fixed acetic acid, g/kg DM	2.7	3.6	6.1
Fixed butyric acid, g/kg DM	0	0	0.1
Fixed lactic acid, g/kg DM	18.8	11.3	24.1
Total acetic acid, g/kg DM	4.7	5.8	6.1
Total butyric acid, g/kg DM	0	0	0.1
Total lactic acid, g/kg DM	27.8	16.3	29.2
Acetic acid, % of organic acids	14.46	26.24	17.20
Butyric acid, % of organic acids	0	0	0.30
Lactic acid, % of organic acids	85.54	73.76	82.50
Crude protein, g/kg DM	187	159	180
Crude fibre, g/kg DM	343	300	296
Minerals, g/kg DM	125	117	105
Acid detergent fibre, g/kg DM	360	320	318
Neutral detergent fibre, g/kg DM	579	507	460
Acid detergent lignin, g/kg DM	43	50	55
Total soluble sugars, g/kg DM	62	106	93
Cellulose, g/kg DM	309	270	263
Hemicellulose, g/kg DM	219	187	142
Digestible dry matter, g/kg DM	609	633	641
Relative feed value	98	116	130
Digestible energy, MJ/ kg	12.03	12.47	12.61
Metabolizable energy, MJ/ kg	9.88	10.23	10.35
Net energy for lactation, MJ/ kg	5.89	6.35	6.37

The increasing energy demand that has been noticed worldwide, the risk of depletion of fossil energy sources and their injurious impact on environment led to our coal-based society recognizing the potential of renewable energy sources. Replacing oil, coal, natural gas with renewable energy alternatives has become a major global issue of the XXI century and a key to sustainable economy development. Versatile energy sources such as biomass, including briquettes, pellets, bioethanol, biodiesel and biogas production, can play an important role in terms of energy supply and positive environmental effects. The use of plant substrates for biogas production has recently become of major interest in Europe. Biogas generators produce not only methane for heat and electricity, but also digestate and fugate, which are believed to be good fertilizers, since they are rich in plant available nutrients such as nitrogen, phosphate and potash, and could serve as a replacement for fossil based mineral fertilizers. Plant substrates may be used in biogas generators as fresh mass and as ensiled mass. The use of legumes as feedstock for multiple energy purposes increases the potential of bioenergy and contributes to the reduction of greenhouse gas emissions, through symbiotic nitrogen fixation and compensates inorganic N fertilizer in conventional farms, if the digestate is applied as a fertilizer to the non-legume crops (Stoddard, 2013). The quality of legume substrates and their biochemical methane potential are illustrated in Table 4. The carbon to nitrogen ratio constitutes a basic factor governing the correct course of methane fermentation. 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, due to low pH, poor buffering capacity and high concentrations of ammonia in the substrate. The nitrogen content in the studied legume fresh mass substrates ranged from 27.0 to 41.1 g/kg, the

estimated content of carbon - from 486.6 to 502.2 g/kg, the C/N ratio varied from 11.8 to 17.3, but the ensiled substrates contained 25.4-29.9 g/kg nitrogen, 486.0-500.6 g/kg carbon and C/N=16.2-19.3. Essential differences were observed between the acid detergent lignin concentrations, which in fresh mass substrates ranged from 51.0 to 59.0 g/kg, except *Lathyrus sativus* fresh substrate, which contained 34.0 g/kg; in the ensiled substrates, this index ranged from 43.0 to 55.0 g/kg. The tested substrates contained acceptable amounts of hemicellulose and low amounts of lignin 174.0-219.0 g/kg. The biochemical methane potential of legume substrates varied from 320 l/kg VS to 378 l/kg VS. The best methane potential was achieved by *Lathyrus sativus* fresh substrate, followed *Vicia hirsuta* and *Vicia sativa* substrates. The reduced content of acid detergent lignin in ensiled substrates may influence positively the activity of bacteria and decomposition processes, thus, the biochemical methane potential achieved was 327-350 l/kg VS. It has been found that *Lathyrus sylvestris* haylage has higher biochemical methane potential as compared with the other investigated ensiled substrates.

Table 4. Biochemical composition and biomethane production potential of substrates from the studied *Fabaceae* species

Indices	*Lathyrus sativus*	*Lathyrus sylvestris*		*Lathyrus tuberosus*		*Vicia hirsuta*	*Vicia sativa*	*Vicia tenuifolia*	
	fresh mass	fresh mass	haylage	fresh mass	haylage	fresh mass	fresh mass	fresh mass	haylage
Crude protein, g/kg	257.0	196.0	187.0	169.0	159.0	208.0	194.0	172.0	174
Minerals, g/kg	125.0	115.0	125.0	96.0	117.0	113.0	102.0	96.0	99.0
Nitrogen, g/kg	41.1	31.4	29.9	27.0	25.4	33.3	31.0	27.5	27.8
Carbon, g/kg	486.1	491.7	486.1	502.2	490.6	492.8	498.9	502.2	500.6
Ratio carbon/nitrogen	11.8	15.7	16.2	18.0	19.3	14.8	16.1	18.3	18.0
Hemicellulose, g/kg	183.0	188.0	219.0	205.0	187.0	190.0	187.0	174.0	184.0
Acid detergent lignin, g/kg	34.0	51.0	43.0	58.0	50.0	50.0	48.0	59.0	55.0
Biomethane potential, L/kg	378	338	350	322	332	343	343	320	327

According to Oleskowicz-Popiel (2010), the methane yield of *Vicia villosa* substrate was 279 L/kg VS. Molinuevo-Salces et al. (2014) found that the specific methane yield after 57 days of anaerobic digestion was 195 L/kg VS in *Trifolium pratense* substrate and 186 l/kg VS in *Vicia sativa* substrate. Ahlberg and Nilsson (2015) reported that, in *Vicia villosa* biomass, there was very high protein content (25.6%) and it produced high methane yield (305-343 L/kg). In our previous research (Teleuţă and Ţîţei, 2016; Ţîţei and Coşman, 2018) we assessed the gas-producing potential of fermentable organic matter of *Lathyrus sylvestris* fresh mass substrate, and found that it reached 448 L/kg or 253 L/kg methane yields and *Vicia tenuifolia* fresh mass substrate reached 503 L/kg or 284 L/kg methane yields, and *Medicago sativa* fresh mass substrate produced 448-515 L/kg biogas or 244-270 L/kg methane yields. Hunady et al. (2021) calculated the theoretical methane yield and revealed that the values of biomass from *Galega orientalis*, *Lathyrus pratensis*, *Trigonella foenum-graecum* and *Melilotus alba* ranged from 0.161 to 0.172 m^3/kg VS, the methane yield of biomass from *Onobrychis viciifolia*, *Astragalus cicer*, *Dorycnium germanicum*, *Vicia sylvatica* ranged from 0.141 to 0.160 m^3/kg VS and the absolutely lowest value - 0.12-0.14 m^3/kg VS - was calculated for *Medicago sativa.* Petcu et al. (2022) found that in winter peas herbage C/N=9.24-12.63.

CONCLUSIONS

The investigated *Fabaceae* species *Lathyrus sativus*, *Lathyrus sylvestris*, *Lathyrus tuberosus*, *Vicia hirsuta*, *Vicia sativa*, *Vicia tenuifolia* are an important forage source for livestock, many species of birds, bees and entomophagous insects, and they are excellent plants for erosion control,

associated with other forage legumes and grasses for reseeding and increasing the economic value of permanent and temporary grasslands.

The harvested biomass can be used as fodder for farm animals or as co-substrate in biogas generators for the production of renewable energy.

The local ecotypes of these species can serve as initial material to be used for selecting, breeding and implementing new cultivars of forage legume plants for agricultural production.

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