THE EVALUATION OF THE BIOMASS QUALITY OF *Astragalus cicer* AND *Astragalus galegiformis* AND PROSPECTS OF ITS USE IN MOLDOVA

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Abstract. The aim of this study was to evaluate the quality indices of harvested green mass, silage and hay from *Astragalus* species: local ecotype of *Astragalus cicer* and *A. galegiformis* cv. 'Vigor', grown in an experimental field of the National Botanical Garden (Institute) of Moldova State University. It was determined that the quality indices of the harvested green mass varied among the species and were influenced by the harvesting period: 202.30-245.80 g/kg dry matter with 17.00-22.32 % crude protein, 3.19-4.36 % crude fats, 22.06-35.52 % crude cellulose, 6.17-8.03 % ash, 0.54-1.14 % calcium, 0.26-0.30 % phosphorus, 36.71-43.28 % nitrogen free extract, 0.98-1.00 nutritive unit/kg dry matter and 10.03-10.25 MJ/kg metabolizable energy, 127-166 g digestible protein per nutritive unit. The silages prepared from *Astragalus galegiformis* contained 263.8-268.7 g/kg dry matter with 7.42-7.71 % lactic acid, 0.01-0.08% butyric acid and 2.39-2.73 % acetic acid, 17.31-21.43 % crude protein, 5.20-5.55 % crude fats, 23.30-38.77 % crude cellulose, 7.38-6.06 % ash, 0.60-1.04 % calcium, 0.29-0.30 % phosphorus, 30.94-41.01 % nitrogen free extract. The hay prepared from *Astragalus species* contained 16.60-21.13 % crude protein, 2.48-3.59 % crude fats, 26.33-31.17 % crude cellulose, 7.53-7.98 % ash, 0.80-0.82 % calcium, 0.28 % phosphorus, 41.42-41.71 % nitrogen free extract with feed value 0.80-0.83 nutritive unit /kg, 7.99-8.34 MJ/kg metabolizable energy and 102-126 g digestible protein per nutritive unit. The fresh and ensiled *Astragalus* substrates for anaerobic digestion had optimal C/N=14.31-18.51 and specific methane yields varied from 273 to 287 l/kg.

Keywords: *Astragalus cicer, Astragalus galegiformis* 'Vigor', nutritive value of fodder, silage, specific methane yields.

Rezumat. Evaluarea calității biomasei de *Astragalus cicer* și *Astragalus galegiformis* L. și perspective de valorificare în Moldova. Scopul prezentului studiu a constatat în evaluarea calității masei proaspete recoltate, a masei însilozate și fânului preparat din speciile de *Astragalus*: ecotipul local de *Astragalus cicer* și soiul 'Vigor' de *Astragalus galegiformis* de pe terenul experimental din Grădina Botanică Națională (Institut) a Universității de Stat din Moldova. S-a stabilit că indicii de calitate ai masei proaspete recoltate variază în dependență de specie și perioada recoltării: 202.30-245.80 g/kg substanță uscată cu o concentrație de 17.00-22.32 % proteină brută, 3.19-4.36 % grăsimi brute, 22.06-35.52 % celuloză brută, 6.17-8.03 % cenușă, 0.54-1.14 % calciu, 0.26-0.30 % fosfor, 36.71-43.28 % substanțe extractive neazotate, 0.98-1.00 unități nutritive /kg substanță uscată și 10.03-10.25 MJ/kg energie metabolizantă și o asigurare cu proteină digestiblă de 127-166 g /unitate nutritivă. Furajul preparat murat (siloz) conține 263.8-268.7 g/kg substanță uscată cu o concentrație de 7.42-7.71 % acid lactic, 0.01-0.08% acid butiric și 2.39-2.73 % acid acetic, 17.31-21.43 % proteină brută, 5.20-5.55 % grăsimi brute, 23.30-38.77 % celuloză brută, 7.38-6.06 % cenușă, 0.60-1.04 % calciu, 0.29-0.30 % fosfor, 30.94-41.01 % substanțe extractive neazotate. Fânul preparat din speciile de *Astragalus* au un conținut de 16.60-21.13% proteină brută, 2.48-3.59 % grăsimi brute, 26.33-31.17 % celuloză brută, 7.53-7.98 % cenușă, 0.80-0.82 % calciu, 0.28 % fosfor, 41.42-41.71 % substanțe extractive neazotate cu o valore nutritivă de 0.80-0.83 unități nutritive /kg, 7.99-8.34 MJ/kg energie metabolizantă și o asigurare cu proteină digestiblă de 102-126 g /unitate nutritivă. Substraturile de masă proaspătă și masă murată pentru digestia anaerobă se caracterizează printr-un raport optimal de carbon și azot de C/N=14.31-18.51, iar randamentul specific de obținere a metanului variază de la 273 la 287 l/kg.

Cuvinte cheie: *Astragalus cicer, Astragalus galegiformis* 'Vigor', valoarea nutritivă a furajelor, siloz, randament specific de obținere a metanului.

INTRODUCTION

The genus *Astragalus* L., family *Fabaceae,* comprises 2.200-3.000 annual and perennial species and is the largest genus of angiosperms, a lot of which are used as food, fodder, honey, medicinal and ornamental plants, also as cover crops and feedstock for biorefineries, as a source of renewable energy (LI et al., 2014; SERGALIYEVA et al., 2015; CACAN et al., 2017; KORNIEVSKAYA & SILANTYEVA, 2018; RAKHMETOV et al., 2018; BONDARCHUK, 2019; AMIRI et al., 2020; DMITRIEV, 2020; IZVERSCAIA, 2020; HUNADY et al., 2021; ŢÎŢEI & ROŞCA, 2021; KÜÇÜKAYDIN et al., 2023). In the spontaneous flora of Bessarabia, there are 20 species, *Astragalus asper* Jacq., *Astragalus austriacus* Jacq., *Astragalus cicer* L., *Astragalus dasyanthus* Pall., *Astragalus onobrychis* L., *Astragalus ponticus* Pall., possess a certain forage value (IZVERSCAIA, 2020).

Astragalus cicer L. syn: *Astragalus mucronatum* DC., *Cystium cicer* (L.) Stev. known as chickpea milkvetch, chick-pea milk-vetch or cicer milkvetch, native to Eastern Europe, is a cool season, long-lived perennial plant, non-bloat legume, with vigorous creeping roots or rhizomes. The stems are large and hollow, upright when young and then becoming decumbent and trailing. The crop height is around 70-80 cm, although stems can reach a length of 1.2 m by the flowering period. The leaves have 10 to 13 pairs of leaflets, plus one terminal leaflet, ovate or oblong-elliptic. The leaf-to-stem ratio is generally higher than in alfalfa, and the ability to retain leaves is also better in mature plants. The flowers are pale yellow to white with 15 to 60 flowers growing in a compact raceme, 15-16 cm long. Cicer milkvetch flowers are cross-pollinated by bumblebees, honeybees or leaf cutter bees. The pods are globe-like inflated, 7-13 mm long, black, villous, with short cusp, sessile, bilocular, do not shatter easily and may retain seeds through winter. The seeds are bright yellow or pale green. The weight of 1000 seeds is 3.10 g.

Astragalus galegiformis L., syn: *Astragalus galegifolius* L., *Tragacantha galegiformis* (L.) Kuntze. is a caulescent, herbaceous perennial, native to the Caucasus Mountains. It produces a strong tap root, reaching a depth of 150-200 cm in the soil. It produces light green or greyish erect stems, which usually grow about 150-200 cm tall. The compound leaves are grey-green, glabrous on the upper side and sparsely hairy on the lower side, 8-15 cm long, oblong-ovate, 12-25 mm long; the stipules are 3-10 mm long, linear-lanceolate. Peduncles are 7-14 cm long. The flowers are shortly pedicellate, pendulous, in lax, cylindrical, 30-40-flowered racemes. The bracts are 6-8 mm long, linear. The calyx is about 5 mm long, campanulate, with sparse and short black hairs and with 2-3 mm long, subulate to triangular teeth. The corolla is pale yellow; the keel 14-16 mm long. It blooms in May-June, is cross pollinated, produces fruits in July. *Astragalus galegiformis* is an excellent source of nectar and pollen for honeybees. Its melliferous potential is 200-300 kg of honey per hectare. The pods are 12-15 mm long, plano-convex, laterally compressed, glabrous, long-stipitate, mucronate, containing 4–6 seeds. The seeds are kidney-shaped or elliptical, strongly compressed on the sides, seed scar rounded with pale surrounded by 3.7–3.9 × 2.5–2.7 mm. The surface is smooth, shiny, greenish-brown or brown. The weight of 1000 seeds is 9-13 g.

The *Astragalus cicer* and *Astragalus galegiformis* are researched in various universities and research centres (DAVIS, 1982; TOWNSEND, 1993; LOEPPKY et al., 1996; GERVAIS, 2000; ACHARYA et al., 2006; OSTAPKO & SHINKARENKO, 2003; KSHNIKATKINA et al., 2005; BORAEVA & BEKUZAROVA, 2010; YU et al., 2010; CHIBIS et al., 2011; KORNIEVSKAYA & SILANTYEVA, 2018; RAKHMETOV et al., 2018; SHEAFFER et al., 2018; BONDARCHUK, 2019; LARDNER et al., 2019; PEPRAH et al., 2021; KELLN et al., 2023).

In the Catalogue of Plant Varieties of the Republic of Moldova there is 1 registered cultivar of *Astragalus galegiformis.*

The aim of this study was to evaluate the quality indices of harvested green mass, silage and hay from *Astragalus cicer* and *Astragalus galegiformis* and the prospects of using them as fodders for farm animals and as substrates for the biomethane production.

MATERIALS AND METHODS

The local ecotype of *Astragalus cicer* and the cultivar *Astragalus galegiformis* '*Vigor'* cultivated in the experimental plot of the National Botanical Garden (Institute) "Alexandru Ciubotaru", Chişinău, 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 green mass samples were collected in the second growing season. The hay was dried directly on the field. The *Astragalus galegiformis* silage was prepared directly from harvested 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 green mass and ensiled 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 analysing such indices as: crude protein, crude cellulose, crude fats, nitrogen-free extract, ash, calcium, phosphorus, silage pH index, concentration of organic acids (lactic, acetic and butyric) in free and fixed state; the analyses were carried out in the Laboratory of Nutrition and Forage Technology of the Scientific-Practical Institute of Biotechnology in Animal Husbandry and Veterinary Medicine; the amount of nutritive units and metabolizable energy in fodders and the content of digestible protein per nutritive unit were calculated according to (NOVOSELOV et al., 1983; PETUKHOV et al., 1989).

The carbon content of the substrates was determined using an empirical equation according to BADGER et al., (1979). The specific methane yields of the substrates were evaluated using the gas forming potential of nutrients (BASERGA, 1998) corrected by the nutrient digestibility.

RESULTS AND DISCUSSIONS

Analysing the results of the assessment of biological peculiarities, it has been found that the studied *Astragalus* species were characterised by different growth and development rates. Thus, at the flowering stage, *Astragalus galegiformis* 'Vigor' plants reached 180-190 cm in height, while *Astragalus cicer* plants – 87-100 cm. After the first cut, the *Astragalus cicer* plants regenerated more slowly, but *Astragalus galegiformis 'Vigor'* can be cut up to three times per year.

The dry matter content of the harvested whole plants and its biochemical composition are important indicators of forage quality. The quality indices of the harvested green mass from the studied *Astragalus* species are presented in Table 1. We found that the dry matter content of whole plants and its quality indices varied depending on the species and mowing period: 202.30-245.80 g/kg dry matter with 17.00-22.32 % crude protein, 3.19-4.36 % crude fats, 22.06-35.52 % crude cellulose, 6.17-8.03 % ash, 0.54-1.14 % calcium, 0.26-0.30 % phosphorus, 36.71-43.28 % nitrogen free extract, 0.98-1.00 nutritive unit/kg dry matter and 10.03-10.25 MJ/kg metabolizable energy, 127-166 g digestible protein per nutritive unit. The first-cut *Astragalus cicer* dry matter had optimal content of crude protein, high content of crude fats, nitrogen free extract, minerals and calcium, while the first-cut *Astragalus galegiformis 'Vigor'* had a high amount of protein and crude cellulose.

The second-cut green mass of *Astragalus galegiformis 'Vigor'* was characterized by a higher concentration of crude protein, crude fats, nitrogen free extract, calcium and phosphorus, and a lower content of crude cellulose as compared with the first-cut green mass of *Astragalus galegiformis 'Vigor'*, which had a positive effect on the digestibility, nutritional value and energy supply of the fodder.

Some authors mentioned various findings about the green mass quality of the *Astragalus* species. According to MEDVEDEV & SMETANNIKOVA (1981), the *Astragalus uliginosus* plant dry matter contained 14.4-22.1%CP, 26.8 - 27.6 % CF, 3.8-4.4 % crude fats and 38.9-49.6% nitrogen free extract. DAVIS (1982) remarked that the dry matter from *Astragalus cicer* contained 14.4-15.0 % crude protein, 17.7 -18.5% crude fibre, 4.5-5.5 mg/g tannin and 0.51-58% oxalate, while the *Astragalus galegiformis* dry matter composition was 15.5 % crude protein, 15.1 % crude fibre, 7.7 mg/g tannin and 0.34 % oxalate. OSTAPKO & SHINKARENKO (2003) mentioned that the chemical composition of *Astragalus cicer* dry matter fodder was 18.1 % crude protein, 4.1% crude fats, 26.4 % crude cellulose, 9.9 % sugars; *Astragalus falcatus* fodder contained 19.1 % crude protein, 4.7 % crude fats, 21.9 % crude cellulose, 11.6 % sugars; *Astragalus galegiformis* – 25.1 % crude protein, 3.2% crude fats, 26.2 % crude cellulose, 8.6 % sugars and *Astragalus onobrychis* 17.5 % crude protein, 2.9% crude fats, 21.1 % crude cellulose, 11.8 % sugars, respectively. KSHNIKATKINA et al., (2005) reported that the chemical composition of the dry matter of *Astragalus galegiformis* was: 17.39 % crude protein, 1.76 % crude fats, 25.56 % crude cellulose, 4.56 % ash, 1.2 % calcium and 0.8 % phosphorus. BHATTARAI et al., (2008) mentioned that the forage quality of *Astragalus filipes* was 14.7% crude protein, 42.0 % NDF, 34.8 % ADF. BORAEVA & BEKUZAROVA (2010) remarked that *Astragalus galegiformis* plants contained 18.77 % crude protein, 43.88 % crude cellulose, 3.11 % sugars. XU et al., (2011) reported that a whole plant of *Astragalus adsurgens*, harvested in the budding stage, contained 290 g/kg dry matter with 14.4 % crude protein, 45.5 % NDF, 30.3 % ADF, 8.1 % ADL, 4.7 % WSC. ASAADI & YAZDI (2011) mentioned that the forage value of *Astragalus brevidens* mowed in different phenological stages was: 10.16-20.49 % crude protein, 46.94-54.87 % ADF, 46.94- 54.87 % DMD and 5.98-7.33 MJ/kg metabolizable energy. CHIBIS et al., (2011) revealed that the dry matter from *Astragalus galegiformis* plants cut in the flowering period contained 167.1 g/kg crude protein, 121 g/kg digestible protein, 10.4 MJ/kg metabolizable energy and 140 g digestible protein per nutritive unit. AMIRI et al., (2012) found that the quality indices of the green mass from *Astragalus macropelmatus* harvested in early bloom period were: 286.7 g/kg dry matter with 13.12 % crude protein, 3.33 % crude fats, 8.54 % ash, 47.27 % NDF, 28.64 % ADF, 65.57 % DMD, 9.32 MJ/kg ME and RFQ=131. CEVHERI et al., (2013) noted that the forage quality of *Astragalus hamosus* was 245.g/kg DM, 9.93% crude protein, 37.7 % NDF, 27.0 % ADF, 11.1% ash, 0.72 % calcium, 0.09 % phosphorus. MAYOUF & ARBOUCHE (2014) found that the chemical composition and nutritive value of *Astragalus armatus* in the flowering stage was: 12.22% crude protein, 2.61 % crude fats, 9.09 % ash, 30.01 % ADF, 44.66 NDF, 65.52% DDM and 2.52 Mcal/kg metabolizable energy. SHADNOUSH (2015) reported that the forage from *Astragalus* sp. contained 15.0% crude protein, 1.9% crude fats, 27.1% crude cellulose, 47.7 % NDF, 34.3 % ADF, 7.9% ash and the feed value was 51.5 % DMD, 60.5 % OMD and 4.1 Mcal/kg metabolizable energy, but – from *Medicago sativa* – 16.9% crude protein, 2.9% crude fats, 30.5% crude cellulose, 46.0 % NDF, 33.8 % ADF, 9.8% ash and feed values 49.3 % DMD, 58.0 % OMD and 4.2 Mcal/kg metabolizable energy. TELEUŢĂ & ŢÎŢEI (2014) found that the biochemical composition of the dry matter from the studied *Astragalus* species was: 14.60-23.40 % crude protein, 1.70-3.21% crude fats, 30.61-35.40 % crude cellulose, 32.65-46.48 % nitrogen free extract, 6.46-9.60 % ash and 129.62-225.09 g digestible protein per nutritive unit. DJAMILA & RABAH (2016) remarked that the dry matter content and nutrient composition of *Astragalus gombiformis* green fodder was: 551.7 g/kg dry matter with 12.5% crude protein, 61.49 % NDF, 44.52 % ADF, 7.81% ADL. CACAN et al., (2017) mentioned that the green mass of *Astragalus onobrychis* harvested in the flowering stage contained 20.07 % crude protein, 0.63 crude fats, 47.14 % NDF, 18.3 % ADF, 7.05 % ash, 55.48 % DMD and 8.01 MJ/kg metabolizable energy. GOLUBEVA et al., (2016) noted that the fodder value of green mass from *Astragalus glycyphyllus* was 20.5% crude protein, 25.6% crude cellulose, 0.9 nutritive unit/kg dry matter and 9.5 MJ/kg metabolizable energy. HOU et al., (2017) mentioned that, under the conditions of meadow steppe in China, the chemical composition of *Astragalus melilotoides* harvested in full-bloom stage was as follows: 36.51 % dry matter with 4.09% ash, 12.08% crude protein, 1.97% fats, 59.73 % NDF, 48.95 % ADF. MAKAROV (2017) revealed that the species *Astragalus uliginosus* contained 26.75-30.48 % crude protein, 1.94-2.53 % crude fats, 17.76-22.71 % crude cellulose, 9.91-10.34 % minerals, 1.90-1.93 % calcium, 0.29-0.32 % phosphorus, 34.88-41.95 % nitrogen free extract, 10-15 mg/% carotene; *Astragalus sulcatus* contained 25.6 % crude protein, 2.5 % crude fats, 16.5 % crude cellulose, 7.5 % minerals, 1.2 % calcium, 0.3 % phosphorus, 47.0 % nitrogen free extract; *Astragalus davuricus* contained 26.2 % crude protein, 1.4 % crude fats, 21.5 % crude cellulose, 10.9 % minerals, 1.3 % calcium, 0.5 % phosphorus, 40.2 % nitrogen free extract; *Astragalus inopinatus* contained 25.6 % crude protein, 3.5 % crude fats, 13.8 % crude cellulose, 10.9 % minerals, 2.2 % calcium, 0.3 % phosphorus, 45.5 % nitrogen free extract; *Astragalus onobrychis* contained 25.5 % crude protein, 2.3 % crude fats, 20.6 % crude cellulose, 7.8 % minerals, 1.1 % calcium, 0.3 % phosphorus, 41.1 % nitrogen free extract. NASERI et al., (2017) remarked that the forage quality of the *Astragalus fridae* green mass harvested in different phenological stages was: 4.58-9.10 % protein, 36.83-41.67% crude fibre, 45.09-52.62 % NDF, 25.10-30.62% ADF, 14.38-20.33%WSC, 4.30-6.39 % ash, 66.08 % DMD, 8.51-10.28 MJ/kg metabolizable energy. USKOV et al., (2017) found that the concentrations of nutrients and energy in the harvested fresh mass of *Astragalus* plants were 46.1 g/kg crude protein, 32.5 g/kg digestible protein, 11.6 g/kg crude fats, 59.3 g/kg crude cellulose, 95.8 g/kg nitrogen free extract, 22.8 g/kg minerals and 2.34 MJ/kg metabolizable energy. LEE (2018) reported that the species *Astragalus spinosus* contained 10 % crude protein, 53% ADF, 64%NDF and 8 % ash, while *Medicago sativa* – 21 % crude protein, 30% ADF, 7% ADL, 42%NDF and 10% ash. SHEAFFER et al., (2018) mentioned that the species *Astragalus cicer*, under irrigated conditions, contained 18.2 % crude protein, 30.7% ADF, 36.7% NDF and 50.1% NDFD, while under non-irrigated conditions – 22.7 % crude protein, 29.6% ADF, 36.6% NDF and 58.41% NDFD. TAYSUMOV et al., (2018) revealed that the species *Astragalus glycyphyllos* and *Astragalus onobrychis* in the first half of the summer contained 16 % crude protein, while the species *Astragalus galegiformis* – 13 % crude protein. BAŞBAĞ M et al., (2019) reported that the quality characteristics of *Astragalus hamosus* herbage collected from different locations were: 17.5-25.6 % crude protein, 25.8-41.7 % NDF, 13.5-28.0 % ADF, 1.25-1.29 % calcium, 0.20-0.45 % phosphorus, 66.0-78.4 % DDM, RFV=127-139. BONDARCHUK (2019) mentioned that, under the conditions of the Right-Bank Forest-Steppe of Ukraine, the biochemical composition of *Astragalus galegiformis* was: 20.91 % crude protein, 455 % crude fats, 4.69 % ash, 34.84 % crude cellulose, 45.6 % nitrogen free extract, 0.65 % calcium and 0.11 % phosphorus. LARDNER et al., (2019) remarked that the chemical composition of *Astragalus cicer* fresh forage, which contained 318-334 g/kg dry matter, was 16.1-16.9 % crude protein, 2.1-2.5 % crude fats, 41.8-46.1 % NDF, 34.0-37.5 % ADF, 7.2-7.7 % ADL, 7.8-8.0 % ash, 1.14-1.27 % calcium, 0.18-0.22 % phosphorus, RFV=127-139, while *Medicago sativa* fresh forage contained 324 g/kg dry matter with 14.1 % crude protein, 2.4 % crude fats, 54.2 % NDF, 43.2 % ADF, 8.3 % ADL, 7.4 % ash, 1.41 % calcium, 0.18 % phosphorus. PEPRAH et al., (2021) mentioned that the green mass of *Astragalus cicer* harvested in July contained 10.0 % crude protein, 53.1 % NDF, 9.2 % ADL, 58.3 % TDN, 59.9% IVODM, 0.91 % calcium and 0.13 % phosphorus, while the green mass harvested in the September contained 8.8 % crude protein, 55.2 % NDF, 10.8 % ADL, 51.9 % TDN, 55.0% IVODM, 1.08 % calcium and 0.09 % phosphorus. PITCHER et al., (2022) remarked that the cicer milkvetch monoculture pasture was characterized by 21.3-27.8 % protein, 1.8-2.2 % fat, 24.8-31.9 % NDF, 21.9-28.6 % ADF, 3.4-3.9% ADL. KELLN et al., (2023) remarked that the forage quality of *Astragalus cicer* harvested in the late flowering stage was 16.9 % crude protein, 46.6 % NDF, 30.9 % ADF, 0.93 % calcium and 0.30 % phosphorus, *Medicago sativa* forage – 20.5 % crude protein, 41.1 % NDF, 33.1 % ADF, 1.10 % calcium and 0.30 % phosphorus, *Onobrychis viciifolia* forage – 16.3 % crude protein, 42.4 % NDF, 35.2 % ADF, 1.10% calcium and 0.20 % phosphorus. CACAN et al., (2023) found that the studied *Astragalus* taxa collected in the wild contained 0.69-2.02 % calcium and 0.17-0.36 % phosphorus.

Table 1. The biochemical composition and the feed value of the green mass of the studied *Astragalus* species.

Indices	***Astragalus cicer***	***Astragalus galegiformis***	
	first cut	**first cut**	**second cut**
Dry matter, g/kg green mass	204.60	202.30	245.80
Crude protein, % dry matter	17.00	18.40	22.32
Crude fats, % dry matter	3.95	3.19	4.31
Crude cellulose, % dry matter	29.70	35.52	22.06
Nitrogen free extract, % dry matter	41.47	36.71	43.28
Ash, % dry matter	7.88	6.17	8.03
Calcium, % dry matter	0.83	0.54	1.14
Phosphorus, % dry matter	0.26	0.28	0.30
Nutritive unit /kg green mass	0.20	0.20	0.25
Nutritive unit/ kg dry matter	0.99	0.98	1.00
Metabolizable energy, MJ/kg green mass	2.05	1.87	2.52
Metabolizable energy, MJ/kg dry matter	10.04	10.03	10.25
Digestible protein, g/ nutritive unit	127	138	166

In modern dairy farming, forage crops are harvested at a stage when the yields and nutritional value are maximal; they are then preserved in order to provide a continuous and consistent supply throughout the year. Ensiling is a preservation method for moist forage crops, based on a lactic acid solid-state fermentation (WEINBERG & ASHBELL, 2003). During the sensorial assessment, it was found that the *Astragalus galegiformis 'Vigor'* silage from first-cut plants had dark green leaves and brownish-yellow stem colour, while that from the second-cut plants had a homogeneous greenish-yellow colour. The *Astragalus galegiformis 'Vigor'* silages had a pleasant smell like pickled vegetables, the texture of the plant mass stored as silage was preserved well, without any mould and mucus. The quality indices of the silage prepared from *Astragalus galegiformis 'Vigor'* are shown in Table 2. It has been determined that the *Astragalus galegiformis 'Vigor'* silages contained 263.8-268.7 g/kg dry matter with 7.42-7.71 % lactic acid, 0.01-0.08% butyric acid and 2.39-2.73 % acetic acid, 17.31-21.43 % crude protein, 5.20-5.55 % crude fats, 23.30-38.77 % crude cellulose, 7.38-6.06 % ash, 0.60-1.04 % calcium, 0.29-0.30 % phosphorus, 30.94-41.01 % nitrogen free extract. The feed value of the prepared silages was characterized by 0.27 nutritive unit /kg silage, 2.53-2.62 MJ/kg metabolizable energy and 126-157 g digestible protein per nutritive unit. We would like to mention that *Astragalus galegiformis 'Vigor'* silage from second-cut plants was characterised by higher content of crude protein, nitrogen free extract and reduced level of crude cellulose. It was found that, during the process of ensiling, the concentration of crude fats increased essentially in comparison with the initial green mass.

Several literature sources have described the quality of fermented fodder from *Astragalus* species. YE et al., (1996) revealed that Chinese milkvetch, *Astragalus sinicus*, silage had pH 4.1 and contained 18.9 % crude protein, 54.9 % NDF, 38.0 % ADF and 3.3 % ADL. YU et al., (2010), found that the dry matter content and the concentrations of nutrients in the silage prepared from fresh mass of *Astragalus cicer* were: 21.92-23.22 % dry matter, 17.80-17.91 % crude protein, 47.05-48.84 % NDF, 37.79-39.98 % ADF, 10.30-11.75 % ash, 3.88- 3.95 % fats, pH = 4.17-5.48, 6.2-19.9 g/kg lactic acid, 1.1-11.0 g/kg acetic acid, 0-0.6 g/kg butyric acid, but in the silage prepared from wilted mass – 36.50-37.97 % dry matter, 18.16-19.39 % crude protein, 47.55-48.45 % NDF, 39.40-40.38 % ADF, 10.07-10.08 % ash, 3.91- 4.11 %

fats, pH = 4.51-4.85, 8.2-17.6 g/kg lactic acid, 2.6-8.2 g/kg acetic acid, butyric acid was not detected. According to XU et al., (2011), the dry matter content and the biochemical composition of silage from *Astragalus adsurgens* treated with distilled water was: 259 g/kg dry matter, pH = 5.48, 17.6 g/kg lactic acid, 10.8 g/kg acetic acid, 5.8 g/kg butyric acid, 142 g/kg crude protein, 467 g/kg NDF, 315 g/kg ADF, 86 g/kg ADL, 7.1 g/kg WSC, 530 g/kg DMD, but the silages treated with inoculant and enzymes – 260 g/kg, pH = 4.83, 34.5 g/kg lactic acid, 7.8 g/kg acetic acid, 1.3 g/kg butyric acid, 161 g/kg crude protein,, 407 g/kg NDF, 272 g/kg ADF, 74 g/kg ADL, 7.1 g/kg WSC, 602 g/kg DMD. FENG et al., (2012) showed that the silage from *Astragalus adsurgens* was characterised by 304.8 g/kg DM with 15.03% crude protein, 32.51 % NDF, 23.98 % ADF, 1.87 % WSC and 8.10 % ash. USKOV et al., (2017) remarked that the silage from *Astragalus* green mass conserved with benzoic acid contained 230 g/kg dry matter with pH 4.2, 8 g/kg lactic acid and 4 g/kg acetic acid, 41.6 g/kg crude protein, 12.7 g/kg crude fats, 56.3 g/kg crude cellulose, 97.5 g/kg nitrogen free extract and 2.34 MJ/kg metabolizable energy (Table 2).

Table 2. The quality indices of the silage from *Astragalus galegiformis 'Vigor'*.

Indices	first cut	second cut
Dry matter, g/kg silage	263.8	268.7
pH index	5.00	4.76
Total organic acids, g/kg dry matter	105.1	98.2
Free acetic acid, g/kg dry matter	6.3	8.5
Free butyric acid, g/kg dry matter	0	0
Free lactic acid, g/kg dry matter	10.2	12.5
Fixed acetic acid, g/kg dry matter	21.0	15.4
Fixed butyric acid, g/kg dry matter	0.8	0.1
Fixed lactic acid, g/kg dry matter	61.8	61.7
Total acetic acid, g/kg dry matter	27.3	23.9
Total butyric acid, g/kg dry matter	0.8	0.1
Total lactic acid, g/kg dry matter	77.1	74.2
Acetic acid, % total acids	25.98	24.34
Butyric acid, % total acids	0.76	0.10
Lactic acid, % total acids	73.26	75.56
Crude protein, % dry matter	17.36	21.43
Crude fats, % dry matter	5.55	5.20
Crude cellulose, % dry matter	38.77	23.30
Nitrogen free extract, % dry matter	30.94	42.01
Ash, % dry matter	7.38	8.06
Calcium, % dry matter	0.60	1.04
Phosphorus, % dry matter	0.32	0.29
Nutritive unit /kg silage	0.27	0.27
Nutritive unit/ kg dry matter	1.01	1.01
Metabolizable energy, MJ/kg silage	2.62	2.53
Metabolizable energy, MJ/kg dry matter	9.98	9.43
Digestible protein, g/ nutritive unit	126	157

Table 3. The biochemical composition and the feed value of hay from the studied *Astragalus* species.

Indices	***Astragalus cicer* first cut**	***Astragalus galegiformis* second cut**
Dry matter, g/kg hay	866.00	887.46
Crude protein, % dry matter	16.60	21.13
Crude fats, % dry matter	2.48	3.59
Crude cellulose, % dry matter	31.17	26.33
Nitrogen free extract, % dry matter	41.71	41.42
Ash, % dry matter	7.98	7.53
Calcium, % dry matter	0.82	0.80
Phosphorus, % dry matter	0.28	0.28
Nutritive unit /kg hay	0.80	0.83
Nutritive unit/ kg dry matter	0.92	0.94
Metabolizable energy, MJ/kg hay	7.99	8.34
Metabolizable energy, MJ/kg dry matter	9.23	9.42
Digestible protein, g/ nutritive unit	102	126

The rising prices of concentrate feeds are forcing farmers to be more aware of basic feed production. Hay is the most important part of the diet of farm animals, particularly in autumn and winter. Increased feed intake through high quality hay is becoming more important as animal performance increases. The biochemical composition and the feed value of the hay from the studied *Astragalus* species are shown in Table 3. We would like to mention that the dry matter of the prepared hays contained 16.60-21.13% crude protein, 2.48-3.59 % crude fats, 26.33-31.17 % crude cellulose, 7.53-7.98 % ash, 0.80-0.82 % calcium, 0.28 % phosphorus, 41.42-41.71 % nitrogen free extract. The feed value of the prepared hays was: 0.80-0.83 nutritive unit /kg, 7.99-8.34 MJ/kg metabolizable energy and 102-126 g digestible protein per nutritive unit. As compared with the green mass, in the process of hay preparation, a decrease was seen in the content of crude protein, crude fats and an increase in the crude cellulose content, which lead to a decrease in the energy and digestible protein values.

Literature sources indicate some variation in the chemical composition and nutritional value of hay from *Astragalus* species. According to MAYOUF & ARBOUCHE (2014), the chemical composition and nutritive value of hay prepared from *Astragalus armatus* was 913.8g/kg dry matter with 12.22 % crude protein, 2.61% crude fats, 44.61 % NDF, 30.01 % ADF, 9.09% ash, 65.32%DMD, RFV=138 and 2.52 Mcal/kg metabolizable energy. During our previous research (ŢÎŢEI et al., 2017), we found that the hay from cicer milkvetch (*Astragalus cicer*) contained 16.81 % crude protein, 1.69% crude fats, 29.36 % crude cellulose, 43.43% nitrogen free extract, 7.71 % ash, while the hay from alfalfa (*Medicago sativa*) 16.00 % crude protein, 1.87% crude fats, 34.66 % crude cellulose, 37.47 % nitrogen free extract, 10.00 % ash, respectively. ZHOU et al., (2018) remarked the hay quality of *Astragalus adsurgens* was 16.27 % crude protein, 33.43 % NDF, 27.60 % ADF. SOUHIL et al., (2022) mentioned that hay from *Astragalus gombiformis* was characterised by 945.4g/kg dry matter with 87.08% organic matter, 22.34 % crude protein, 34.04 % NDF, 21.80 % ADF, 4.67% ADL, but the hay from vetch-oat mixture – 939.1g/kg DM, 94.18% OM, 11.24 % crude protein, 58.52 % NDF, 31.68 % ADF, 4.52% ADL, respectively. ULGER et al., (2019) reported that the quality indices of the hay prepared from *Astragalus argaeus*, cut in different maturity stages, were 12.42-15.52 % crude protein, 1.07-1.44% crude fats, 40.30-52.32 % NDF, 21.61-32.59 % ADF, 10.75-19.47% ash, 44.98-60.99% ODM and 6.52-8.81 MJ/kg metabolizable energy. ÖRÜN & ERDOĞAN (2022) found that the hay from *Astragalus microcephalus* contained 8.24 % crude protein, 0.65% crude fats, 54.51% ADF, 64.64%NDF, 3.12% condensed tannins, 6.20% ash, 46.43% DMD and 42.81% IVDND, RFV=67.

Table 4. The specific methane yields of the substrates from the studied *Astragalus* species.

Indices	***Astragalus cicer*** **first cut**	***Astragalus galegiformis***			
		first cut		**second cut**	
	green mass	**green mass**	**silage**	**green mass**	**silage**
Digestible protein, g/kg DM	125.80	136.20	128.50	165.20	158.50
Digestible fats, g/kg DM	22.50	18.20	31.60	24.60	29.60
Digestible carbohydrates,g/kg DM	504.10	506.10	484.00	468.00	466.60
Nitrogen, g/kg DM	27.2	29.4	27.8	35.7	34.3
Carbon, g/kg DM	511.78	521.28	514.56	510.94	510.78
Carbon/nitrogen ratio	18.82	17.73	18.51	14.31	14.89
Specific methane yield, L/kg VS	280	282	273	286	287

The production of biomethane by anaerobic digestion of phytomass substrates provides important advantages in the processes of decarbonisation and energy transition for clean and sustainable energy production, in the context of circular economy. It has been determined that methanogenic bacteria need a suitable carbon to nitrogen ratio for their metabolic processes, and ratios higher than 30:1 were found to be unsuitable for optimal digestion, while 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 quality indices of the studied substrates from *Astragalus* species and their specific methane yields are presented in Table 4. The nitrogen content in the *Astragalus* substrates ranged from 27.2 g/kg to 35.7 g/kg, the estimated content of carbon – from 510.9 g/kg to 521.3 g/kg, the C/N ratio varied from 14. 3 to 18.8 and met the established standards. The specific methane yields in the studied substrates varied from 273 to 287 l/kg. The best specific methane yields were achieved in the silage substrate from second-cut plants of *Astragalus galegiformis*. As a result of our previous researches (TELEUȚĂ & ŢÎŢEI 2016; ŢÎŢEI et al., 2017), we found that the calculated gas forming potential of the fermentable organic matter of the green mass from *Astragalus ponticus* was 513 l/kg volatile solid matter (VS) and the methane potential reached 269 l/kg VS, and the hay substrate from *Astragalus cicer* – 448 l/kg biogas and 240 litre/kg biomethane, respectively. HUNADY et al., (2021) reported that the calculated theoretical methane yield of the biomass from *Onobrychis viciifolia*, *Astragalus cicer*, *Dorycnium germanicum* and *Vicia sylvatica* ranged from 0.141 to 0.160 m^3/kg.

CONCLUSIONS

The quality indices of the green mass from the studied *Astragalus* species varied among the species and were influenced by the cutting period: 202.30-245.80 g/kg dry matter with 17.00-22.32 % crude protein, 3.19-4.36 % crude fats, 22.06-35.52 % crude cellulose, 6.17-8.03 % ash, 0.54-1.14 % calcium, 0.26-0.30 % phosphorus, 36.71-43.28 % nitrogen free extract, 0.98-1.00 nutritive unit/kg dry matter and 10.03-10.25 MJ/kg metabolizable energy, 127-166 g digestible protein per nutritive unit.

The prepared silages from *Astragalus galegiformis ‘Vigor'* contained 263.8-268.7 g/kg dry matter with 7.42-7.71 % lactic acid, 0.01-0.08% butyric acid and 2.39-2.73 % acetic acid, 17.31-21.43 % crude protein, 5.20-5.55 % crude fats, 23.30-38.77 % crude cellulose, 7.38-6.06 % ash, 0.60-1.04 % calcium, 0.29-0.30 % phosphorus, 30.94-41.01 % nitrogen free extract.

The hay prepared from the *Astragalus* species contained 16.60-21.13 % crude protein, 2.48-3.59 % crude fats, 26.33-31.17 % crude cellulose, 7.53-7.98 % ash, 0.80-0.82 % calcium, 0.28 % phosphorus, 41.42-41.71 % nitrogen free extract, with feed value 0.80-0.83 nutritive unit /kg, 7.99-8.34 MJ/kg metabolizable energy and 102-126 g digestible protein per nutritive unit.

The fresh and ensiled *Astragalus* substrates for anaerobic digestion had optimal C/N=14.31-18.51 and specific methane yields varied from 273 to 287 l/kg.

The local ecotype of *Astragalus cicer* and the cultivar *Astragalus galegiformis 'Vigor'* can be cultivated as multipurpose crops, to produce various types of fodder, containing balanced amounts of digestible protein for farm animals or as substrates to be used in biogas generators for the production of renewable energy.

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