THE PYTOMASS QUALITY OF CHICKPEA, *CICER ARIETINUM* L., UNDER THE CONDITIONS OF MOLDOVA

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Abstract

We investigated the quality indices of the phytomass from chickpea, *Cicer arietinum*, the local cultivar *'Ichel'*, grown in monoculture in an experimental field of the National Botanical Garden (Institute), Chişinău, Republic of Moldova It was determined that the nutrient content of the dry matter of chickpea whole plants cut in the flowering - early pod stage included: 19.31% CP, 4.23% EE, 22.62% CF, 43.57% NFE, 10.26 % ash, 1.45% Ca, 0.32% P with 18.46 MJ/kg GE, 9.83 MJ/kg ME, 5.74 MJ/kg NEl. The fermentation quality and nutritive value of silage and haylage prepared from chickpea plants were characterized by the following indices: pH= 4.40-4.47, 27.6-34.5 g/kg lactic acid, 2.5-2.8 g/kg acetic acid, 0.3-0.4 g/kg butyric acid, 19.64-20.61% CP, 25.67-6.15% EE, 24.57-25.32 % CF, 36.77-39.20% NFE 10.92-11.15 % ash, 1.39-1.41% Ca, 0.35-0.39 % P, 18.75-18.90 MJ/kg GE, 9.81-9.81 MJ/kg ME, 5.47-5.55 MJ/kg NEl. The nutrient content and energy value of the prepared hay was: 19.77% CP, 2.64% EE, 27.01% CF, 39.21% NFE, 11.37% ash, 1.46% Ca, 0.31% P, 18.07 MJ/kg GE, 8.81 MJ/kg ME, 4.98 MJ/kg NEl. It has been determined that the studied fresh and ensiled substrates have C/N=15-16 and the biochemical methane potential reaches 312-322 l/kg ODM. The local chickpea cultivar *'Ichel'* can be used as an alternative forage source for farm animals or as co-substrate in biogas generators for renewable energy production.

Key words: biochemical composition, biomethane potential, *Cicer arietinum,* green mass, hay, haylage, nutritive value, silage

Feed quality is a crucial factor for better health and performance of livestock. Forage crops play a significant role in agriculture and the animal food supply chain. Climate change not only dramatically affects forage yields but also alters the nutritive value of forage.

Fabaceae species are grown across the world as pulse crops, forage and fodder for animals. As many as 60 different legume crops have been cultivated as sources of forage and feed for animals. The agricultural policy of the EU encouraging the increase of the area cultivated with legumes has a dual purpose, on the one hand, environmental, on the other, providing more protein from own sources in animal nutrition. Forage legumes are an important source of feed for livestock and possess the potential to provide a sustainable solution for food and protein security. Some of the annual grain legumes can be used, not only for the grain itself, but the whole plant as a source of green forage or hay, including the straws after grain threshing. The efficient use of the biological potential of the *Fabaceae* plants that are adapted to the local climatic conditions becomes more and more relevant (Kulkarni K.P. *et al*, 2018).

Cicer arietinum L., commonly known as chickpea, belongs to family *Fabaceae*, and is native to the south-eastern area of Turkey and adjoining Syria. This is one of the earliest cultivated legumes in the world, currently grown on an area of 17.8 million hectares (Maphosa L. *et al*, 2020). *Cicer arietinum* is an herbaceous annual plant; the stem is erect, branched, viscous, hairy, terete, green and solid. The leaves are petiolate, compound, and uni-imparipinnate (pseudoimparipinnate), the rachis is 3-7 cm long, with 10-15 leaflets that are 8-17 mm long and 5-14 mm wide, opposite or alternate with a terminal leaflet. The solitary flowers are borne in an axillary raceme. Sometimes, there are 2 or 3 flowers on the same node. The pod is about 2 cm long and usually contains two seeds. Chickpea is cultivated mainly in arid and semi-arid areas in more than 50 countries across the Mediterranean Basin, Central Asia, East Africa, Europe, Australia, and North and South America. (Maessen L.J.G., 1972; Balashov V.V. *et al*, 2012; Voshedsky N.N. *et al*,

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2020; Vargas-Blandino D., Cárdenas-Travieso R.M., 2021).

Makenova S.K. (2005) remarked that chickpea crops in the southern forest-steppe of the Omsk region, Russia, made it possible to obtain an average of 21.2 t/ha of green mass, 4.66 t/ha of fodder units and 0.91 t/ha of crude protein. Kertikov T., Kertikova D. (2016) found that the chickpea plants contained 40.8 % stems, 50.7 % leaves and 6.7 % inflorescences, the productivity was 21 t/ha fresh mass, 4.58 t/ha dry matter and 774 kg/ha crude protein.

In our region, chickpea has also been researched, thus, new productive cultivars have been created and cultivated (Arseni A.A, 1974; Celac V., Machedon M., 2010).

The objective of this research was to evaluate the quality indices of green phytomass, hay, haylage and silage prepared from chickpea, *Cicer arietinum*, and the prospects of its use as forage for farm animals or as substrates for biomethane production.

MATERIALS AND METHODS

The local cultivar *'Ichel'* of chickpea, *Cicer arietinum*, created at the Institute of Genetics, Physiology and Plant Protection by professor Valentin Celac, and grown in monoculture on the experimental sector of the National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subject of the research. Alfalfa - *Medicago sativa*, sand sainfoin - *Onobrychis arenaria,* common sainfoin - *Onobrychis vicifolia,* and bird's-foot-trefoil - *Lotus corniculatus* were used as control variants. The chickpea samples were collected in the flowering - early pod stage, and alfalfa, sand sainfoin and bird's-foot-trefoil, the first cut, in early flowering periods. The prepared hay was dried directly in the field. The chickpea silage was prepared from directly harvested green mass, but haylage was produced from wilted green mass, cut into small pieces. The chopped green mass or wilted green mass was compressed in well-sealed glass containers, stored at ambient temperature (18-20 C) for 45 days, to allow complete fermentation to occur. Following the 45-day fermentation period, each glass container was opened and the content was visually examined, the colour and the aroma were recorded. The dry matter content was detected by drying samples up to constant weight at 105°C. For biochemical analysis, the plant samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with diameter of openings of 1 mm. The pH of the samples of silage and haylages was measured immediately after removal from the containers. At the same time, samples were taken to determine the content of organic acids (lactic, acetic and butyric) in free and fixed state. The evaluation of chemical composition: crude protein (CP), crude fat (EE), crude cellulose (CF), nitrogen-free extract (NFE), ash, calcium (Ca), phosphorus (P), content of organic acids in silage were carried out in the Laboratory of Nutrition and Forage Technology of the Scientific-Practical Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, in accordance with the methodological indications. The gross energy (GE), metabolizable energy (ME), net energy for lactation (NEl) were calculated according to standard procedures.

The carbon content of the substrates was determined using an empirical equation according to Badger C.M. *et al*, (1979). The biochemical methane potential was calculated according to Baserga U. (1998) corrected with the digestibility index of nutrients.

RESULTS AND DISCUSSIONS

Forages are a major source of nutrients for herbivores. Sometimes the balance of nutrients or the presence of some constituents in the forage will have positive or negative effects on animal health and productivity. The biochemical composition nutritive and energy value of the green mass from chickpea, *Cicer arietinum*, is presented in *table 1.* We would like to mention that chickpea green fodder was characterised by higher content of crude protein, crude fats, but low level of crude cellulose, as compared with the green forage produced from the traditional forage legume crops – alfalfa, sainfoin and bird's-foot-trefoil. The concentration of nitrogen free extract in chickpea green fodder is optimal (43.57 %), about the same level as in sainfoin, but much higher as compared with alfalfa and bird's-foot-trefoil forage. The content of mineral substances in chickpea green reaches 10.26 %, exceeding essentially sainfoin and alfalfa fodders. Besides, the amount of phosphorus and calcium is much higher than in the traditional forage legume crops. The chickpea fodder is characterized by very high digestibility, which has a positive effect on the concentration of metabolizable energy (9.83 MJ/kg) and net energy for lactation (5.74 MJ/kg).

In the specialized literature, there is little information regarding the nutrient content of green mass from the genus *Cicer*. Larin I.V. *et al* (1952), reported that the harvested *Cicer macracanthum* plants contained in dry matter 14.8 % crude protein, 3.5 % crude fats, 21.6 % crude cellulose and 53.8 % nitrogen free extract. Maessen L.J.G.V (1972) remarked that *Cicer arietinum* forage contained 10.8-11.3 % crude protein, 2.1-2.2 % crude fats, 27.2-33.1 % crude cellulose, 444.9-48.0 % nitrogen free extract, 9.1-11.4 % ash. Kirilov A. *et al* (2016) compared the quality of green mass of whole plants of perennial and annual legumes harvested in the flowering-pod formation stage, and reported that the chemical composition of *Cicer arietinum* was 14.06 % crude protein, 3.44 % crude fats, 27.14 % crude cellulose, 44.04 % nitrogen free extract and 11.32 % ash; *Onobrychis viciifolia*, in turn, contained 17.53 % crude protein, 3.12 % crude fats, 20.08 % crude cellulose, 51.17 % nitrogen free extract and 8.1 % ash; *Medicago sativa*: 17.36 % crude protein, 2.32 % crude fats, 27.84 % crude cellulose, 42.63 % nitrogen free extract and 9.85 % ash; *Lotus corniculatus*: 17.14 % crude protein, 3.14 % crude fats, 25.63 % crude cellulose, 45.32 % nitrogen free extract and 8.77 % ash; *Pisum sativum* 13.04 % crude protein, 2.14 % crude fats, 25.06 % crude cellulose, 58.30 % nitrogen free extract and 8.01 % ash; *Glycine max* 13.13 % crude protein, 2.48 % crude fats, 29.87 % crude cellulose, 45.50 % nitrogen free extract and 9.02 % ash. Nasiyev B. N. *et al* (2017) mentioned that the protein content of fodder units for green forage at chickpea reached 213.4 g, in barley green forage – 99.94 g, but the combination of barley and chickpea green forage contained 197.71 g, respectively. Tedeeva V.V. (2018) reported that chickpea leaves contained 2.16-3.48 % N, 0.31-0.49 % P_2O5, 2.09-2.36 % K_2O and chickpea stems – 1.57-2.40 % N, 0.28-0.36 % P_2O_5, 1.71-2.01 % K_2O, respectively. Semina A. Yu., Telic K.M., (2020) evaluating the quality of 15 collection samples of *Cicer arietinum* of various ecological and geographical origin, mentioned that the protein content in the green mass varied from 10.64 % to 15.06 %. Voshedsky N.N. *et al* (2020) found that the chemical composition of plants of the chickpea cultivar 'Donplaza' harvested in the flowering period was 2.41-4.19 % N, 0.84-1.24 % P_2O_5, 3.22-4.12 % K_2O.

Hay is the oldest, and still the most important conserved fodder, despite its dependence on suitable weather at harvest time. Hay is an essential part of livestock diet, providing them, during winter, with the necessary protein, fibers and other nutrients they need to maintain good health and be productive. The results regarding the forage quality of hay prepared from the studied forage legume species are shown in *table 2*. We would like to mention that the hay prepared from *Cicer arietinum* is characterized by high content of crude protein (19.77%) and minerals (11.37%), optimal nitrogen free extract content (43.57%), but lower content of crude cellulose. The concentration of crude fats in chickpea hay is optimal (2.64%) about the same level as bird's-foot-trefoil hay. It was found that the levels of phosphorus and calcium in chickpea hay were significantly higher as compared with sand sainfoin and bird's-foot-trefoil hays.

Table 1

The biochemical composition and the fodder value of the green mass from the studied leguminous species

Indices	*Cicer arietinum*	*Medicago sativa*	*Onobrychis arenaria*	*Onobrychis vicifolia*	*Lotus corniculatus*
Crude protein, % DM	19.31	16.28	16.96	15.29	16.35
Crude fats, % DM	4.23	2.75	3.18	3.03	3.91
Crude cellulose, % DM	22.62	33.25	27.72	29.03	35.70
Nitrogen free extract, % DM	43.57	39.58	43.74	45.58	33.83
Ash, % DM	10.26	8.22	7.32	6.97	10.21
Calcium, % DM	1.45	1.43	0.73	0.82	1.06
Phosphorus, %	0.32	0.22	0.25	0.22	0.26
Gross energy, MJ/ kg	18.46	18.59	18.54	18.68	18.57
Metabolizable energy, MJ/ kg	9.83	8.25	9.11	9.07	8.13
Net energy for lactation, MJ/ kg	5.74	4.56	5.15	5.12	4.40

Table 2

The biochemical composition and the fodder value of the hay from the studied leguminous species

Indices	*Cicer arietinum*	*Onobrychis arenaria*	*Lotus corniculatus*
Crude protein, % DM	19.77	16.38	18.19
Crude fats, % DM	2.64	1.70	2.56
Crude cellulose, % DM	27.01	36.67	32.42
Nitrogen free extract, % DM	39.21	37.71	36.33
Ash, % DM	11.37	7.55	10.49
Calcium, % DM	1.46	0.77	1.16
Phosphorus, %	0.31	0.23	0.29
Gross energy, MJ/ kg	18.07	18.56	18.25
Metabolizable energy, MJ/ kg	8.1	7.50	8.11
Net energy for lactation, MJ/ kg	4.98	4.12	4.49

Table 3

The fermentation quality and biochemical composition of the investigated ensiled forage

Indices	*Cicer arietinum*		*Onobrychis arenaria* haylage	*Lotus corniculatus* haylage
	silage	haylage		
pH index	4.50	4.47	5.16	4.70
Total organic acids, g/kg	45.3	49.8	60.5	37.1
Free acetic acid, g/kg	2.1	2.2	0.6	1.7
Free butyric acid, g/kg	0.0	0.0	0.0	0.2
Free lactic acid, g/kg	10.8	10.3	4.1	7.6
Fixed acetic acid, g/kg	2.2	2.5	2.4	4.0
Fixed butyric acid, g/kg	0.4	0.3	0.4	0.0
Fixed lactic acid, g/kg	29.8	34.5	53.0	23.6
Total acetic acid, g/kg	4.3	4.7	3.0	5.7
Total butyric acid, g/kg	0.4	0.3	0.4	0.2
Total lactic acid, g/kg	40.6	44.8	57.1	31.2
Acetic acid, % total acids	9.49	9.43	4.96	15.36
Butyric acid, % total acids	0.89	0.62	0.66	0.54
Lactic acid, % total acids	89.63	89.95	94.38	84.10
Crude protein, % DM	19.64	20.61	16.49	17.09
Crude fats, % DM	5.67	6.15	2.61	4.16
Crude cellulose, % DM	24.57	25.37	30.03	33.22
Nitrogen free extract, % DM	39.20	36.77	42.89	35.75
Ash, % DM	10.92	11.15	7.99	9.78
Calcium, % DM	1.41	1.39	0.99	1.00
Phosphorus, %	0.35	0.39	0.30	0.27
Gross energy, MJ/ kg	18.75	18.90	18.58	18.68
Metabolizable energy, MJ/ kg	9.81	9.70	8.69	8.55
Net energy for lactation, MJ/ kg	5.55	5.47	4.89	4.64

Table 4

Biochemical methane production potential of green and ensiled mass substrates from leguminous species

Indices	*Cicer arietinum*			*Medicago sativa*	*Onobrychis arenaria*		*Onobrychis vicifolia*	*Lotus corniculatus*	
	green mass	silage	haylage	green mass	green mass	haylage	green mass	green mass	haylage
Organic dry matter, g/kg	897.4	890.8	888.5	917.8	926.8	920.1	930.3	897.9	902.2
Digestible matter, g/kg	640.8	631.3	628.0	580.9	603.4	603.4	609.5	621.6	625.9
Digestible proteins, g/kg	142.9	145.3	152.5	122.1	127.2	123.6	114.6	119.4	124.8
Digestible fats, g/kg	24.1	32.3	35.1	13.7	17.5	14.4	16.7	23.1	24.5
Digestible carbohydrates, g/kg	473.8	453.7	440.4	445.1	458.7	465.4	478.8	479.1	476.6
Carbon, g/kg	498.6	497.9	493.6	509.9	514.9	511.2	516.8	498.8	501.2
Nitrogen, g/kg	30.9	31.4	33.0	26.0	27.1	26.4	24.5	26.2	27.3
Ratio carbon/nitrogen	16.2	15.8	15.0	19.6	19.0	19.4	21.1	19.0	18.4
Biochemical methane potential, L/kg DM	289	278	279	247	258	257	260	267	270
Biochemical methane potential, L/kg OM	322	312	314	269	278	279	279	297	299

The energy supply of the chickpea hay reached 8.81MJ/kg metabolizable energy and 4.98 MJ/kg net energy for lactation, exceeding the hay produced from sand sainfoin and bird's-foot-trefoil.

According to Karpova O.S. *et al* (1964), the concentration of nutrients in chickpea hay was 21.9 % crude protein, 2.4 % crude fats, 34.2 % crude cellulose, 29.4 % nitrogen free extract. Maessen L.J.G.V (1972) found that the chemical composition of *Cicer arietinum* hay was 12.9 % crude protein, 1.5 % crude fats, 36.3 % crude cellulose, 38.1 % nitrogen free extract and 11.2 % ash. Sainz-Ramírez A. *et al* (2022) reported that the dry matter content, the chemical composition and nutritive value sunflower-chickpea hay consisted of 694.07 g/kg DM, 17.34 % crude protein, 17.12 % crude fats, 42.52 % NDF, 27.03 % ADF, 11.00 % ash and 67.84 % IVDOM, but alfalfa hay contained 880.14 g/kg DM, 18.05 % crude protein, 2.25 % crude fats, 36.06 % NDF, 28.05 % ADF, 10.00 % ash and 67.04 % IVDOM, respectively.

Ensiling, a fermentation process, is now a major conservation method for large-scale enterprises. The production of fermented fodder, silage and haylage, minimizes the risk associated with field losses, which can be incurred under rainy conditions during hay making. Besides, fermented fodders are an important source of nutrients for the dairy production sector in the autumn - middle spring period. When opening the glass containers with silage and haylage from *Cicer arietinum*, there was no gas or juice leakage from the preserved mass. The chickpea fermented mass had homogeneous, agreeable olive colour with pleasant smell, similar to the smell of green pea, the texture was preserved, in comparison with the initial green mass, without mould and mucus. The haylage prepared from *Lotus corniculatus* consists of green leaves and yellowish-green stems, has a pleasant smell of pickled vegetables; the texture of the plants stored as haylage was preserved well, without mold and mucus. The *Onobrychis arenaria* haylage had yellowish-green leaves and yellow-green stems with pleasant smell like pickled vegetables. The results regarding the quality of the fermented fodder from studied forage legume species are illustrated in *table 3*. It was determined that the pH values of the fermented fodder depended on the species, thus, chickpea silage had pH=4.4 and haylage pH=4.47, lower than sand sainfoin and bird's-foot-trefoil haylages. The concentration of organic acids in the chickpea ensiled forage is high in comparison with sainfoin haylage, but lower than bird's-foot-trefoil haylage. Most organic acids in the investigated fermented fodders were in fixed form. According to the Moldavian standard SM 108, the ratio of acetic acid and lactic acid of the studied fermented fodders correspond to the first class quality. In chickpea fermented fodders, butyric acid was detected in fixed form, in very small quantity (0.3-0.4 g/kg). Analyzing the biochemical composition of fermented fodders, it has been determined that the concentrations of nutrients in the dry matter varied. We would like to mention that chickpea fermented forage contained high content of crude protein (19.64-20.61%) and crude fats (5.67-6.15%), but low concentration of crude cellulose (24.57-25.37%) which had a positive effect on the energy supply 9.70-9.81MJ/kg metabolizable energy and 5.47-5.55 MJ/kg net energy for lactation, being higher than in the haylage produced from sand sainfoin and bird's-foot-trefoil. The concentration of phosphorus and calcium in chickpea fermented forage was significantly higher as compared with sand sainfoin and bird's-foot-trefoil haylages. We would like to mention that chickpea haylage contains higher amounts of crude protein, crude fats, crude cellulose, ash and phosphorus, but lower amount of nitrogen free extract, as compared with the chickpea silage.

Yücel C. *et al* (2020) found that chickpea silage had pH=5.66 and its dry mater contained 12.4% CP, 39.3% ADF, 42.5% NDF, 58.3% OMD and RFV=131.

Renewable bioenergy is an interesting alternative to meet the world's energy needs without extra economic burden and any significant environmental impacts. Biogas is a product of anaerobic fermentation of organic products. Among the fuels from plant biomass, biogas has a great importance and can successfully replace fossil fuels to obtain electric power and heat, also organic fertilizers. The quantities of biogas and the methane that can be produced from a substrate depend mainly on its content of carbohydrates, fats and proteins, its biodegradability and its carbon to nitrogen ratio. It is a commonly known fact that methanogenic bacteria need a suitable ratio of carbon to nitrogen for their metabolic processes, ratios higher than 30:1 were found to be unsuitable for optimal digestion, and ratios lower than 10:1 were found to be inhibitory, because of low pH, poor buffering capacity and high concentrations of ammonia in the substrate. The results of the determination of the quality of substrates from the studied forage legume species and their biochemical methane production potential are presented in *table 4*. The nitrogen content in the studied substrates ranged from 24.5 to 33.0 g/kg, the estimated content of carbon – from 497.9 to 516.8 g/kg, the C/N ratio varied from 15.0 to 21. It is well known that fats are a good source of energy. Carbohydrates supply most of the energy for maintaining vitality. The two carbohydrate fractions commonly used in evaluating the carbohydrate content of substrates are crude cellulose and nitrogen-free extract. The capability of biomass methanization is tightly associated with nutrient digestibility and plant species. When crude cellulose content increases, digestibility usually decreases. Nitrogen-free extract contains the most digestible portion of the carbohydrates. Digestible organic matter or fermentable organic matter represents the proportion of organic matter which can be biologically degraded under anaerobic conditions and, thus, can be potentially utilized in biogas facilities. The digestible organic matter concentration in the tested forage legume substrates ranged from 580.9 to 640.8 g/kg, the biochemical methane production potential varied from 247 to 289 l/kg DM or 269 to 322 l/kg OM. The best results were achieved in chickpea substrates with high level of digestible organic matter and low content of crude fiber.

CONCLUSIONS

The local chickpea cultivar *'Ichel'*, which has high content of crude protein and crude fats, can be used as an alternative forage source for farm animals or as co-substrate in biogas generators for renewable energy production.

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