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THE BIOCHEMICAL COMPOSITION AND THE FEED VALUE OF FODDERS FROM *Cicer arietinum* L. PLANTS

Victor ŢÎŢEI

"Alexandru Ciubotaru" National Botanical Garden (Institute), 18 Padurii Str., MD 2002, Chişinău, Republic of Moldova

Corresponding author's email: vic.titei@gmail.com

Abstract

Chickpea, Cicer arietinum, is a multipurpose Fabaceae species, widely used around the world, notably as a source of protein, used to restore soil fertility, which can tolerate high temperatures and arid climate. This research was aimed at evaluating the nutritive value of fodder from the chickpea, local cultivar 'ICHEL', grown in monoculture in an experimental field of the National Botanical Garden (Institute), Chişinău, Republic of Moldova. The results revealed that the dry matter of the whole Cicer arietinum plant contained 19.7% CP, 20.5%CF, 12.6% ash, 24,0% ADF, 37.6% NDF, 4.6% ADL, 18.1% TSS, 19.4% Cel, 13.6% HC, with nutritive and energy value 815 g/kg DMD, 737 g/kg DOM, RFV=174, 11.25 MJ/kg ME and 7.26 MJ/kg NEl. The quality of the prepared hay was: 19.4% CP, 23.8% CF, 13.4% ash, 28.3% ADF, 43.8% NDF, 5.4% ADL, 8.9% TSS, 22.9% Cel, 15.5% HC, 748 g/kg DMD, 647 g/kg DOM, RFV=142, 10.76 MJ/kg ME and 6.77 MJ/kg NEl. The dry matter of the fermented fodder contained 22.2% CP, 15.0% CF, 14.6% ash, 18.1% ADF, 31.3% NDF, 2.0% ADL, 19.8% TSS, 16.1% Cel, 13.2% HC, 59.62 mg/kg carotene, 890 g/kg DMD, 810 g/kg DOM, RFV=222, 13.2 MJ/kg ME, 7.48 MJ/kg NEl. The harvested biomass of the chickpea cultivar 'Ichel' can be used as alternative fodder for farm animals.

Key words*: Cicer arietinum, green mass, hay, nutritive value*, *silage.*

INTRODUCTION

Fabaceae species are widespread in all climatic zones, growing under the most diverse ecological conditions. The importance of *Fabaceae* species in people's life cannot be underestimated, since they are used as food, fodder, technical, medicinal, honey and ornamental crops, play an essential economic and ecological role in the development of sustainable agriculture by fixing atmospheric nitrogen and mobilizing phosphorus, have positive impact on the physical and chemical properties of soil, help reducing soil erosion processes, besides, they are an important food source for wild and domestic animals, provide nectar and pollen for bees and other useful insects (Kulkarni et al., 2018).

The genus *Cicer* L. of the *Fabaceae* family includes about 10 annual species and 36 perennial species, occurring in the Mediterranean Basin and southwest Asia, among the annual species only *Cicer arietinum* L., is domesticated and widely cultivated in more than 50 countries from different regions of the Earth, being the second legume pulse crop in the world. In the flora of Bessarabia, only one species, *Cicer arietinum* L., known by the common name chickpea, occurs sporadically, having been cultivated as a food plant for grains for hundreds of years. Chickpea is an annual plant, with a solid, erect, 4-angled, glandular-pubescent, branched stem, 30-70 cm tall; with falsely imparipinnate, short-petiolate leaves, with 4-8 pairs of elliptic or oblong-ovate leaflets, with finely serrate-toothed margins, 6-15 cm long; with small, toothed stipels. The inflorescences are raceme with solitary flowers, 10-20 mm long, with white, yellow, pink or blue-purple corolla; vexil with red or brown veins. It blooms in June and July. Fruit – an elliptical pod, yellow or reddish-yellowish, swollen, glandular, 2-3 cm long and 1-1.3 cm wide, on a curved pedicel, with 1-3 globular, variously colored seeds (yellow to blackish), 5-13 mm long. There are two main types of chickpea, which differ in seed size, shape and color. The first type of chickpea called *'desi'* produces small, angular, dark colored seeds, grown in the semi-arid tropical areas, and the other type *'kabuli'* produces large, round, light colored seeds and is grown

in areas with temperate climate. The root system consists of a thick taproot with several lateral roots, the epidermis is hairy, the exodermis is absent, and the endodermis is thin. The presence of nodules on the roots indicates a symbiotic relationship between chickpea and *Mesorhizobium ciceri* bacteria leading to biological nitrogen fixation of 120-150 kg/ha. The root system is so robust that it reaches more than 3 m deep into the soil, making it easier for the plant to survive under conditions of insufficient moisture. Of all the leguminous plants, the chickpea tolerates drought conditions the most easily. The minimum temperature for seed germination is 3-4°C, and at 6-8°C, and the plants emerge evenly at the soil surface within no more than 10 days after sowing. In the spring, chickpea seedlings withstand frost up to -6°C. It grows well in sandy soils and slightly salinized soils, but it is not recommended to plant chickpea in heavy, excessively wet, poorly aerated soils. (Maessen, 1972; Balashov et al., 2012; Izverscaia, 2020; Voshedsky et al., 2020). The cultivation of chickpea is a possible method of adaptation to climate change (Vargas-Blandino et al., 2021). In our country, chickpea has been researched and, as a result, cultivation technologies have been developed, plant resources have been mobilized and new high-productivity varieties have been created **(**Arseni, 1974; Celac & Machedon, 2010). Currently, 4 chickpea varieties are registered in the Catalog of Plant Varieties of the Republic of Moldova.

The main objective of this research was to evaluate the quality of green mass, hay and silage prepared from chickpea, *Cicer arietinum*.

MATERIALS AND METHODS

The local cultivar *'Ichel'* of chickpea, *Cicer arietinum* L., created at the Institute of Genetics, Physiology and Plant Protection by professor Valentin Celac, and grown in monoculture on the experimental land of National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subject of the research, the common sainfoin, *Onobrychis viciifolia,* cultivar '*Anamaria*' and the low-cumarin local ecotype of yellow sweet clover, *Melilotus officinalis*, were used as control variants. The chickpea samples were collected in the flowering - early pod stage, yellow clover - in the flowering stage, common sainfoin - in the budding-flowering stage. The leaf/stem ratio was determined by separating the leaves from the stem, weighing them separately and establishing the ratios for these quantities (leaves/stems). The prepared hay was dried directly in the field. The chickpea and yellow clover silages were prepared from directly harvested green mass, but common sainfoin 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 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 and some assessments of the main biochemical parameters: crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM), digestible organic matter (DOM) have been determined by near infrared spectroscopy (NIRS) technique PERTEN DA 7200. The concentration of hemicellulose (HC), cellulose (Cel), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl) and relative feed value (RFV) were calculated according to standard procedures.

RESULTS AND DISCUSSIONS

Analysing the results of the assessment of biomorphological peculiarities of the local cultivar *'Ichel'* of chickpea, *Cicer arietinum*, it can be noted that seedlings emerged uniformly at the soil surface at the end of April, the development of shoots was observed in the middle of May, the budding-flowering stage - at the end of May, the flowering - early pod stage - in the middle of June. At the time when the green mass was harvested, the chickpea plants reached 49.7 cm in height, common sainfoin 99.2 cm and yellow clover - 111.6 cm. The

chickpea yield was 2.42 kg/m^2 fresh mass or 0.71 kg/m^2 dry matter, yellow sweet clover - .3.78 kg/m^2 fresh mass or 1.17 kg/m^2 dry matter and common sainfoin-4.23 kg/m^2 fresh mass or 1.01 kg/m^2 dry matter According to Petrov (2004) the productivity of single-species chickpea was 2.8 t/ha dry matter, 290 kg/ha digestible protein, 23.8 GJ/ha metabolizable energy and 175 g digestible protein/fodder unit, but chickpea mixed with barley produced 2.2-2.6 t/ha DM, 200-230 kg/ha digestible protein, 18.1-21.2 GJ/ha ME and 160-168 g digestible protein/fodder unit, respectively. Makenova (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. Lingorski & Kertikov (2014) mentioned that under the conditions of Troyan, Bulgaria, the productivity of forage chickpea reached 12.82 t/ha green mass and 3.27 t/ha dry mass, the structural elements of the forage were 23.13% leaves, 28.53% inflorescences and 52.64% stems. Kertikov & Kertikova (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 mass and 774 kg/ha crude protein.

The biochemical composition, nutritive and energy value of the harvested green mass from the studied *Fabaceae* species are presented in Table 1. Analysing the results of the biochemical composition of green mass, we found that the dry matter of the studied species differs essentially in the concentration of crude protein, structural carbohydrates and energy. The chickpea fodder is characterized by high amount of crude protein, minerals, total soluble sugars, but lower amount of crude fibre, hemicellulose and cellulose. The content of acid detergent lignin in chickpea fodder was lower than in common sainfoin fodder, but higher than in yellow sweet clover fodder. The chickpea fodder is characterized by very high digestibility, which has a positive effect on relative feed value and energy concentration as compared with the forage produced from yellow clover and common sainfoin.

Table 1. The biochemical composition and nutritive value of harvested mass of the studied *Fabaceae* species

Indices	Chickpea	Common sainfoin	Yellow sweet clover
Crude protein, % DM	19.7	17.7	17.9
Crude fibre, % DM	20.5	29.3	33.0
Minerals, % DM	12.6	9.6	11.8
Acid detergent fibre, % DM	24.0	30.9	33.1
Neutral detergent fibre, % DM	37.6	44.7	47.3
Acid detergent lignin, % DM	4.6	4.9	4.4
Total soluble sugars, % DM	18.1	11.4	7.2
Cellulose, % DM	19.4	26.0	28.7
Hemicellulose, % DM	13.6	13.8	14.2
Digestible dry matter, g/kg DM	815	669	651
Digestible organic matter, g/kg DM	737	615	543
Relative feed value	174	135	124
Digestible energy, MJ/ kg	13.70	12.73	12.42
Metabolizable energy, MJ/ kg	11.25	10.45	10.20
Net energy for lactation, MJ/ kg	7.26	6.48	6.22

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

Indices	Chickpea	Common sainfoin	Yellow sweet clover
Crude protein, % DM	19.4	16.3	15.0
Crude fibre, % DM	23.8	33.8	37.4
Minerals, % DM	13.4	9.9	8.3
Acid detergent fibre, % DM	28.3	35.0	38.5
Neutral detergent fibre, % DM	43.8	49.6	49.3
Acid detergent lignin, % DM	5.4	5.2	5.6
Total soluble sugars, % DM	8.9	6.3	8.0
Cellulose, % DM	22.9	29.8	31.7
Hemicellulose, % DM	15.5	14.6	16.3
Digestible dry matter, g/kg DM	748	625	562

Digestible organic matter, g/kg DM	647	560	493
Relative feed value	142	115	103
Digestible energy, MJ/ kg	13.11	12.17	11.80
Metabolizable energy, MJ/ kg	10.76	9.99	9.69
Net energy for lactation, MJ/ kg	6.77	6.01	5.70

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

Indices	Chickpea	Common sainfoin	Yellow sweet clover
pH index	4.40	4.68	4.52
Organic acids, g/kg DM	44.8	23.40	40.50
Free acetic acid, g/kg DM	2.20	1.10	1.90
Free butyric acid, g/kg DM	0	0	0
Free lactic acid, g/kg DM	11.80	4.40	9.00
Fixed acetic acid, g/kg DM	2.80	2.20	3.20
Fixed butyric acid, g/kg DM	0.40	0	0
Fixed lactic acid, g/kg DM	27.60	15.70	26.40
Total acetic acid, g/kg DM	5.00	3.30	5.10
Total butyric acid, g/kg DM	0.40	0	0
Total lactic acid, g/kg DM	39.40	20.10	35.40
Acetic acid, % of organic acids	11.16	14.10	12.59
Butyric acid, % of organic acids	0.89	0	0
Lactic acid, % of organic acids	87.95	85.90	87.41
Crude protein, % DM	22.2	14.2	17.8
Crude fibre, % DM	15.0	31.2	34.8
Minerals, % DM	14.6	11.8	10.3
Acid detergent fibre, % DM	18.1	31.7	33.3
Neutral detergent fibre, % DM	31.3	47.0	46.2
Acid detergent lignin, % DM	2.0	4.0	3.8
Total soluble sugars, % DM	19.8	13.5	7.0
Cellulose, % DM	16.1	27.7	28.5
Hemicellulose, % DM	13.2	15.3	12.9
Digestible dry matter, g/kg DM	890	653	632
Digestible organic matter, g/kg DM	810	582	566
Relative feed value	222	127	129
Digestible energy, MJ/ kg	13.20	12.63	12.41
Metabolizable energy, MJ/ kg	10.84	10.37	10.19
Net energy for lactation, MJ/ kg	7.48	6.38	6.20

In the literature sources, there is little information regarding the chemical composition and nutritional value of whole plants of *Cicer* species. According to Larin et al. (1952), *Cicer macracanthum* green fodder contained in dry matter 14.8% CP, 3.5% EE, 21.6% CF and 53.8% NFE. Maessen (1972) remarked that *Cicer arietinum* forage contained 10.8-11.3% CP, 2.1-2.2% EE, 27.2-33.1% CF, 444.9-48.0% NFE, 9.1-11.4% ash. Kirilov 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 % CP, 3.44% EE, 27.14 % CF, 44.04% NFE and 11.32% ash; *Onobrychis viciifolia,* in turn, contained 17.53% CP, 3.12% EE, 20.08% CF, 51.17% NFE and 8.1% ash; *Medicago sativa* 17.36% CP, 2.32% EE, 27.84% CF, 42.63% NFE and 9.85% ash; *Lotus corniculatus* 17.14% CP, 3.14% EE, 25.63% CF, 45.32% NFE and 8.77% ash; *Pisum sativum* 13.04% CP, 2.14% EE, 25.06% CF, 58.30% NFE and 8.01% ash; *Glycine max* 13.13% CP, 2.48% EE, 29.87% CF, 45.50% NFE and 9.02% ash. Tedeeva (2018) reported that chickpea leaves contained 2.16-3.48% N, 0.31-0.49% P_2O_5, 2.09-2.36% K_2O and chickpea stems respectively 1.57-2.40% N, 0.28-0.36% P_2O_5, 1.71-2.01% K_2O. Semina & Telic (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 et al. (2020) found that the chemical composition of *Cicer arietinum* plants

harvested in the flowering period was 2.41-4.19% N, 0.84-1.24% P_2O_5, 3.22-4.12% K_2O.

The conservation of fodder and crop residues is a traditional way of reducing seasonal variations in feed availability. 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, fibres and other nutrients they need to maintain good health and be productive. We would like to mention that in the haymaking process, we noticed an increase in the concentration of structural carbohydrates, lignin and a decrease in the content of crude protein, total soluble sugars, digestibility, relative feed value and energy concentration as compared with the harvested green mass. The results regarding the forage quality of hay prepared from the studied *Fabaceae* species are shown in Table 2. The prepared hays contained 15.0-19.4% CP, 23.8-37.4% CF, 8.3-13.4% ash, 28.2-38.5% ADF, 43.8-49.6% NDF, 5.2-5.6% ADL, 6.3-8.9% TSS, 22.9-31.7% Cel and 14.6-16.3% HC. The digestibility, nutritive value and the energy concentration of prepared hays were 562-748 g/kg DMD, 493-647 g/kg DOM, RFV=103-142, 11.80-13.11 MJ/kg DE 9.69-10.76 MJ/kg ME and 5.70-6.77 MJ/kg NEl. The hay prepared from *Cicer arietinum* is characterized by very high content of crude protein and minerals, optimal content of soluble sugars and hemicellulose, but lower content of structural carbohydrates, which have a good effect on digestibility, nutritive and energy value. According to Maessen (1972) the chemical composition of chickpea hay was 12.9% CP, 1.5% EE, 36.3% CF, 38.1% NFE and 11.2% ash. Sainz-Ramírez et al. (2022) found that the dry matter content, the chemical composition and nutritive value sunflower-chickpea hay were 694.07 g/kg DM, 17.34% CP, 17.12% EE, 42.52% NDF, 27.03% ADF, 11.00% ash and 67.84% IVDOM, but alfalfa hay contained 880.14 g/kg DM, 18.05% CP, 2.25% EE, 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, silage is an important source of nutrients for the dairy production sector in the autumn - middle spring period. When opening the glass containers with chickpea silage, 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 yellow clover silage consisted of olive stems with dark green leaves and had a peculiar smell, similar to pickled apples, the sainfoin 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 *Fabaceae* 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, lower than sainfoin haylage and yellow clover silage. The concentration of organic acids in the chickpea silage is very high in comparison with sainfoin 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 corresponds to the first class quality. In chickpea silage butyric acid was detected in fixed form, in very small quantity (0.4 g/kg). Analysing the biochemical composition of fermented fodders, it has been determined that the concentrations of nutrients in the dry matter varied: 14.2-22.2% CP, 15.0- 34.8% CF, 18.1-33.3% ADF, 31.3-46.2% NDF, 2.0-4.0% ADL, 7.0-19.8% TSS, 16.1-28.5% Cel, 12.9-15.3% HC and 10.3-14.6% ash. The nutritive and energy values of the fermented fodders were 632-890 g/kg DMD, 566-810 g/kg DOM, RFV=127-222, 12.41-13.20 MJ/kg DE, 10.19-10.84 MJ/kg ME and 6.20-7.48 MJ/kg NEl. We would like to mention that chickpea silage was characterised by very high content of crude protein, minerals and total soluble sugars, but 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.

CONCLUSIONS

The dry matter of the harvested in flowering - early pod stage of *Cicer arietinum* plants contained 19.7% CP, 20.5%CF, 12.6% ash, 24,0% ADF, 37.6%NDF, 4.6% ADL, 18.1% TSS, 19.4% Cel, 13.6% HC, with nutritive and energy value 815 g/kg DMD, 737 g/kg DOM, RFV=174, 11.25 MJ/kg ME and 7.26 MJ/kg NEl.

The quality of the chickpea hay was: 19.4% CP, 23.8% CF, 13.4 % ash, 28.3% ADF, 43.8% NDF, 5.4% ADL, 8.9% TSS, 22.9% Cel, 15.5% HC, 748 g/kg DMD, 647 g/kg DOM, RFV=142, 10.76 MJ/kg ME and 6.77 MJ/kg NEl.

The chickpea silage was characterized by pH = 4.40, 5.0 g/kg acetic acid, 0.4 g/kg butyric acid, 39.4 g/kg lactic acid, 22.2% CP, 15.0% CF, 14.6% ash, 18.1% ADF, 31.3% NDF, 2.0% ADL, 19.8% TSS, 16.1% Cel, 13.2% HC, 59.62 mg/kg carotene, 890 g/kg DMD, 810 g/kg DOM, RFV=222, 13.2 MJ/kg ME, 7.48 MJ/kg NEl. The harvested biomass of the chickpea cultivar *'Ichel'* can be used as alternative fodder for farm animals.

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