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# THE BIOCHEMICAL COMPOSITION AND THE NUTRITIVE VALUE OF FODDERS FROM SOYBEAN, *GLYCINE MAX*, IN MOLDOVA

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***Abstract***

*Soybean, Glycine max, is grown primarily for seed production and has a long history of being grown as a forage crop. The main objective of this research was to evaluate the quality of green mass, prepared hay and haylage from soybean Glycine max cv. 'CLAVERA', cultivated in the experimental plot of the National Botanical Garden (Institute) "Alexandru Ciubotaru", Chisinau, Republic of Moldova. The results revealed that the harvested soybean whole plants contained 26.5 % dry matter. The concentration of nutrients in the dry matter of green mass was: 178 g/kg CP, 286 g/kg CF, 94 g/kg ash, 310 g/kg ADF, 484 g/kg NDF, 49 g/kg ADL, 142 g/kg TSS, 261 g/kg Cel, 174 g/kg HC, with nutritive and energy value 68.6% DMD, 63.4% DOM, RFV=124, 12.73 MJ/kg DE, 10.48 MJ/kg ME and 6.46 MJ/kg NEl. The biochemical composition, nutritive and energy value of prepared hay: 173 g/kg CP, 303 g/kg CF, 105 g/kg ash, 331 g/kg ADF, 504 g/kg NDF, 53 g/kg ADL, 110 g/kg TSS, 278 g/kg Cel and 173 g/kg HC, 64.6% DMD, 57.8% DOM, RFV=116, 12.42 MJ/kg DE, 10.20 MJ/kg ME and 6.22 MJ/kg NEl. The haylage is characterized by pH = 4.69, 13.4 g/kg acetic acid, 69.3 g/kg lactic acid, 181 g/kg CP, 319 g/kg CF, 126 g/kg ash, 334 g/kg ADF, 510 g/kg NDF, 42 g/kg ADL, 71 g/kg TSS, 292 g/kg Cel, 176 g/kg HC, with nutritive and energy value 63.0% DMD, 55.8% DOM, RFV=115, 12.40 MJ/kg DE, 10.18 MJ/kg ME and 6.19 MJ/kg NEl. We consider that soybean forage may be used as multi-purpose feed for livestock.*

***Key words***: *biochemical composition, Glycine max, green mass, hay, haylage, nutritive value, soybean.*

## INTRODUCTION

The current global challenges in the agricultural and food sectors, regarding the shortage of natural protein in the human diet and animal feed, as well as the lower possibilities to supply local organic fertilizers and the rising prices of mineral fertilizers and pesticides are problems that can be partially solved by the introduction and large-scale cultivation of protein-rich crops and legumes. Legume plants play a major role in developing sustainable agriculture, both globally and on national level. Legume crops are known to have a positive influence on the physical and chemical properties of the soil and on the yield and quality of the plants cultivated after them on the same land, as well as providing fodder, which is one of the most important inputs of animal production.

Soybean *Glycine max* L. Merr. a member of the *Fabaceae* family, is an annual thermophyte, $C_3$ photosynthesis type plant, native to Asia. Soybean has been cultivated as a food crop in Asia since 2800 BC, however, in Europe, the first references to this species in literature date back to the 17th century, and only at the beginning of the 18th century soybean began to be sown in botanical gardens, thus becoming known to a wider audience. In 1898, the U.S. Department of Agriculture began to promote actively the cultivation of soybean. In Europe, however, the interest in soybeans began to grow only with the significant population growth in the 20th century. Last but not least, the intensification of livestock production after the World War II was one of the main reasons that contributed to the import of soybean into Europe from the USA and South America. These factors led to the first efforts to breed and grow soybean cultivars adapted to the climatic conditions of Europe, thus, in the late 1980s, the development of the large-scale cultivation of soybean in Europe began, Romania being the most important producer of soybean in Europe. Since 2000, Ukraine has

become the most important soybean growing country, accounting for almost half of the production of soybean grown in Europe. Soybean is one of the most important crops worldwide for producing oil and protein. The total world production of soybeans in 2020-2021 was 383 million metric tonnes, Brazil and the United States were the leading global producers of soybeans. Due to the sharp increase in the demand for soybeans from the industry producing concentrated feeds - which was caused, among other things, by the ban on the use of flour of animal origin as a feed component - Europe currently imports about 90% of soybean.

Soybean may also be grown to be used as forage for grazing, haying or ensiling, either alone or in mixtures, because of its high protein content. Compared to other forage legumes, soybean may reliably be included into crop rotations as a forage crop, since it can be sown as the first or second crop, it can enrich the organic matter content of soils and it is highly nutritious (Medvedev & Smetannikova, 1981; Undersander et al., 2017; Casper et al., 2013; Heuzé, et al., 2016; Kulkarni et al., 2018; Peiretti et al., 2018).

The soil and climate conditions, the temperature and photoperiod regimes, especially in the central and northern areas of the Republic of Moldova, are favourable for soybean cultivation. According to the data of the National Bureau of Statistics, in 2000-2020, in the Republic of Moldova, the highest yield – of 111 thousand tons of soybeans – was harvested in 2010, the area of land sown with soybeans being 59.1 thousand hectares or 4% of the total area cultivated with herbaceous crops. In the 80's of the last century, about 20 thousand ha were sown with soybean monoculture or mixed with maize, Sudan grass, the harvested crop being fed to animals fresh or used to produce flour fortified with vitamins. But, because of the socio-economic changes that affected agriculture, the livestock numbers considerably reduced over time, and the areas sown with fodder crops were also reduced. In recent years, agricultural producers have realized that animal husbandry cannot be efficiently organized without ensuring a sustainable and balanced supply of protein-rich feed, and lately we have noticed, fortunately, a growing interest of local farmers in this crop.

The main objective of this research was to evaluate the quality of green mass, prepared hay and haylage from soybean, *Glycine max*.

## MATERIALS AND METHODS

The local cultivar 'Clavera' of soybean, *Glycine max*, created at the Institute of Genetics, Physiology and Plant Protection 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 fodder crop - common sainfoin, *Onobrychis viciifolia* cv. 'Anamaria', was used as control variant. The experimental design was a randomised complete block design with four replications, and the experimental plots measured 10 $m^2$. Soybean was sown on 7 May at a depth of 4.0 cm on rows at a distance of 45 cm. The green mass was harvested manually. The soybean samples were collected in early pod stage, on 3 August. 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 haylage was prepared from wilted mass. For ensiling, the wilted mass was cut into 1.5-2.0 cm pieces by using a forage chopping unit, shredded and compressed in well-sealed glass containers. The dry matter content was detected by drying samples up to constant weight at 105°C. After 45 days, the containers were opened and the sensorial and fermented indices of conserved forage were determined in accordance with standard laboratory procedures - the Moldavian standard SM 108 for forage quality analysis. 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 bio-morphological peculiarities of the studied legume crops, it can be noted that the harvested soybean whole plants contained 26.5% dry matter, 57.8% leaves + pods, but common sainfoin - 23.7% dry matter and 53.5% leaves + flowers.

The biochemical composition, nutritive and energy value of the green mass and hay from the studied legume crops: soybean 'Clavera' and common sainfoin 'Anamaria' are presented in Table 1. Analysing the results of the biochemical composition of green mass, we found that the dry matter of the studied legume crops has similar concentration of crude protein, acid detergent fibre, acid detergent lignin, cellulose and energy. The soybean fodder is characterized by lower level of crude fibre, minerals, but high amount of total soluble sugars and hemicellulose which have a positive effect on digestibility.

Table 1. The biochemical composition and nutritive value of green mass and hay from studied legume crops

| Indices | *Glycine max* | | *Onobrychis viciifolia* | |
|---|---|---|---|---|
| | green mass | hay | green mass | hay |
| Crude protein, g/kg DM | 178 | 173 | 177 | 163 |
| Crude fibre, g/kg DM | 286 | 303 | 293 | 338 |
| Minerals, g/kg DM | 94 | 105 | 96 | 99 |
| Acid detergent fibre, g/kg DM | 310 | 331 | 309 | 350 |
| Neutral detergent fibre, g/kg DM | 484 | 504 | 447 | 496 |
| Acid detergent lignin, g/kg DM | 49 | 53 | 49 | 52 |
| Total soluble sugars, g/kg DM | 142 | 110 | 114 | 63 |
| Cellulose, g/kg DM | 261 | 278 | 260 | 298 |
| Hemicellulose, g/kg DM | 174 | 173 | 138 | 146 |
| Digestible dry matter, g/kg DM | 686 | 646 | 669 | 625 |
| Digestible organic matter, g/kg DM | 634 | 578 | 615 | 560 |
| Relative feed value | 124 | 116 | 135 | 115 |
| Digestible energy, MJ/kg | 12.73 | 12.42 | 12.73 | 12.17 |
| Metabolizable energy, MJ/kg | 10.45 | 10.20 | 10.45 | 9.99 |
| Net energy for lactation, MJ/kg | 6.46 | 6.22 | 6.48 | 6.01 |

Literature sources indicate considerable variation in the chemical composition and nutritional value of whole plants of soybean. Undersander et al. (2007) remarked that soybean forage contained 11.4-19.5% CP, 3.3-4.8% EE, 21.4-30.0% CF, 43.8-47.5% NFE, 59.6-64.1% NDF, 39.6% ADF, 3.8-4.7% ADL, 31.5-37.2% Cel 16.0% HC 18.3-18.4 MJ/kg GE. Blount et al. (2013) reported that the dry matter content and nutrients value of soybean forage harvested mass were: 240-560 g/kg DM, 167-246 g/kg CP, 21-92 g/kg EE, 419-567 g/kg NDF, 58.2-61.4% IVDOM. Heuze et al. (2016) remarked that the average feed value of soybean fresh mass was: 24.0% DM, 15.7% CP, 4.4% EE, 31.2% CF, 48.1% NDF, 31.2% ADF, 5.8% lignin, 9.3% ash, 14.8 g/kg Ca, 2.7 g/kg P, 64% DOM, 18.9 MJ/kg GE, 11.6 MJ/kg DE and 9.2 MJ/kg ME. Tabacco et al. (2018) found that whole soybean plants, depending on the stage of maturity, contained 22.0-37.4% DM, 16.7-25.0% CP, 3.1-6.8% fats, 35.4-47.0% NDF, 26.7-38.3% ADF, 5.7-9.1% ADL, 3.6-7.6% WSC, 1.2-8.1% starch, 8.0-11.6% ash. Peiretti et al. (2015) remarked that herbage quality of soybean plant in the vegetative stage was 185.1-190.5 g/kg DM, 14.26-14.77% ash, 25.77-30.11% CP, 1.29-1.58% EE, 45.32-50.80% NDF, 32.77-35.65% ADF, 5.80-6.47% ADL, 876.5-880.7 g/kg IVTD, 17.5-18.1 MJ/kg GE, but in the generative stage: 181.9-204.4 g/kg DM, 9.25-10.15% ash, 15.38-22.85% CP, 1.06-1.53% EE, 45.42-66.27% NDF, 37.18-42.54% ADF, 6.95-8.12% ADL, 775.9-842.1 g/kg IVTD, 18.0-18.5 MJ/kg GE. Zanine et al. (2020) reported that the harvested soybean genotypes contained 44.30-54.13% stems, 28.20-48.12% leaves; 0-25.6% pods, 156.9-180.8 g/kg DM and their biochemical composition was: 14.45-

16.09% CP, 8.30-14.00% ash, 48.44-59.79% NDF, 41.74-49.60% ADF, 3.18-2.64% HC. Iqbal et al. (2021) mentioned that the nutritional quality of forage soybean as influenced by different mineral and organic fertilization regimes, on irrigated land, under the climatic conditions of Faisalabad, Pakistan was 18.21-21.9% CP, 1.70-1.97% EE, 23.0-26.2% CF and 9.3-11.2% ash.

Hay plays an important role in the animal husbandry feeding system, representing a low-cost and abundant source of nutrients, it is vital to keep animals healthy and productive. We would like to mention that in the process of producing hay, in the studied legume crops, we noticed an increase in the concentration of neutral detergent fibre, acid detergent fibre, acid detergent lignin, cellulose, minerals and a decrease in the content of crude protein, total soluble sugars, matter digestibility, relative feed value and energy concentration as compared with the harvested green mass. The hay prepared from the studied legume crops (Table 1) contained 163-173 g/kg CP, 303-338 g/kg CF, 99-105 g/kg ash, 331-350 g/kg ADF, 496-504 g/kg NDF, 52-53 g/kg ADL, 63-110 g/kg TSS, 278-298g/kg Cel and 146-173 g/kg HC. The nutritive value and the energy value of prepared hays were 62.5-64.6% DMD, 56.0-57.8% DOM, RFV=115-116, 12.17-12.42 MJ/kg DE 9.99-10.20 MJ/kg ME and 6.01-6.22 MJ/kg NEl. The soybean hay is characterized by high amount of crude protein, total soluble sugars and hemicellulose, but lower level of crude fibre, cellulose, which have a positive effect on the nutritive and energy value.

Some authors mentioned various findings about the quality of soybean hay. According to Medvedev & Smetannikova (1981), the chemical composition of hay from soybean plants was 15.4% CP, 5.2% EE, 22.8% CF, 38.6 % NFE and 7.2% ash. Kökten et al. (2014), reported that the hay from the soybean variety tested in Bingol Province of Turkey contained: 7.16-10.13% ash, 10.8-13.2% CP, 48.5-54.9% NDF, 33.3-44.1% ADF with 54.6-62.9% DMD and RFV=96.6-118.2. Heuze et al. (2016) revealed that soybean hay contained 91.5% DM, 1.9% CP, 5.4% EE, 33.8% CF, 47.0% NDF, 4.9% ADF, 7.0% lignin, 7.6% ash, 0.86% Ca, 0.19%P, 59.0% ODM, 19.6 MJ/kg GE, 10.9 MJ/kg DE, 8.6 MJ/kg ME. Başaran et al. (2017) found that the chemical composition and nutritive value of pure soybean hay were 10.55-14.94% CP, 1.10-1.41% Ca, 0.25-0.27% P, 0.87-1.59% K, 0.28-0.40% Mg and RFV = 94.02-152.02, but the hays from binary mixtures with different seed ratio of sorghum-Sudan grass hybrid - 8.15-12.31% CP, 0.3-0.64% Ca, 0.25-0.34% P, 0.85-1.83% K, 0.13-0.34% Mg and RFV = 78.38-92.22, respectively. Sürmen & Kara (2017) reported that the hay prepared from pure soybean plants harvested in full flowering stage contained 19.74% CP, 38.19% NDF, 31.32% ADF, 3.59% ADL with 644.9 g/kg DDM and RFV = 157.14, but the hay from different seed ratio mixtures of buckwheat and soybean contained 14.18-16.20% CP, 40.68-43.78% NDF, 34.94-38.11.36% ADF, 2.55-3.10% ADL, 59.20-61.68 g/kg DDM and RFV = 125.80-141.00.

The production of fermented fodder minimizes the risk associated with field losses, which can be incurred under rainy conditions during hay making. Wilting herbage prior to ensiling has many advantages including reducing effluent production and fuel consumption, improved ensilibility characteristics and reduced quantities of forage for transport. Haylage is an important source of nutrients for the dairy production sector, it is a great way to preserve nutrients for the autumn - middle spring period. When opening the glass vessels with haylage prepared from *Glycine max*, there was no gas or juice leakage from the preserved mass. The prepared soybean haylage had agreeable colour, olive leaves and light-yellow stems with pleasant smell specific to pickled watermelon, the consistency was retained, in comparison with the initial green mass, without mould and mucus. The fermentation profile of the prepared soybean haylage was as follows: pH 4.69, content of organic acids 82.7 g/kg DM, including 4.7 g/kg free acetic acid, 3.5 g/kg free lactic acid, 8.7 g/kg fixed acetic acid, 65.8 g/kg fixed lactic acid, the butyric acid not was detected. It has been determined that the concentrations of nutrients in the dry matter of soybean haylage reached 181 g/kg CP, 319 g/kg CF, 334g/kg ADF, 510 g/kg NDF, 42 g/kg ADL, 71 g/kg TSS, 292 g/kg Cel, 176 g/kg HC, 126 g/kg ash, 12.6 g/kg Ca and 2.1 g/kg P. The

nutritive and energy values of the prepared soybean haylage were 63.0% DMD, 55.8% DOM, RFV=115, 12.40MJ/kg DE 10.18 MJ/kg ME and 6.19 MJ/kg NEl.

Several studies have evaluated the quality of soybean fermented fodder (silage, haylage) as feed for ruminants. Garcia (2006) reported that the nutrient composition of silage from direct-cut soybean ranged from 16.0 to 20.6% CP, 38.3 to 48.3% NDF, 27.3 to 37.3% ADF, 6.0-7.4% ADL, 1.36-1.49% Ca, 0.26-0.31% P. Mustafa et al. (2007) found that the dry matter content and the chemical composition of soybean silage, after 45 days of ensiling, were 527-542 g/kg DM, 14.9-20.8% CP, 44.4-49.0% NDF, 35.3-37.1% ADF, 6.4-8.1% ADL, 9.5-9.7% ash. Vargas-Bello-Pérez et al. (2008) reported that the dry matter content and the chemical composition of silages from soybean were 409 g/kg DM, pH=5.29, 18.4% CP, 12.6% ash, 1.5 % fats, 46.9% NDF, 37.7% ADF, 11% ADL, 1.1 Mcal/kg NEl., alfalfa silage contained 459 g/kg DM, pH=4.89, 24.4% CP, 10.0% ash, 2.6.5% fats, 42.5% NDF, 32.4% ADF, 7.6% ADL, 1.44 Mcal/kg Nel, respectively. According to Ayaşan (2011) the nutrient concentration soybean silage was 350 g/kg DM, 18.3% CP, 43.3% NDF, 32.3% ADF, 6.7% ADL. Casper et al. (2013) reported that the nutrient composition of 20 soybean haylage samples was as follows: pH = 3.48-5.10, 0.5-8.5% lactic acid, 0.8-0.6.1% acetic acid, 14.5-22.9% CP, 2.3-6.6% EE, 30.6-42.6% ADF, 30.6-42.6% NDF, 6.9-11.5% ADL, 17.0-32.0% NFC, 61.1-77.1% IVDMD, 4.6-10.3% ash, 0.67-1.39% Ca, 0.19-0.43% P, 0.25-0.44% Mg, 1.37-2.48% K, 0.12-0.24% S, 0.07-0.89% Cl. Tabacco et al. (2018) remarked the fermentative and chemical characteristics of silage prepared from soybean plants harvested at two stages of growth were: 22.0-37.4% DM, pH = 4.23-5.15, 1.47-11.63% lactic acid, 4.63-7.09% acetic acid, 0.38-1.13 % propionic acid, 0-3.87% butyric acid, 1.00-3.53% ethanol, 18.0-24.40% CP, 8.0-13.4% ash, 36.8-50.6% NDF, 31.3-41.9% ADF, 6.3-9.7% ADL. In their study conducted to determine the effect of wilting times of harvested mass on haylage quality, Sahar et al. (2020) found that soybean haylage had pH = 4.52-5.44 and contained 272.7-648.7 g/kg DM, 8.60-12.93% CP, 47.86-54.46% NDF, 38.00-47.07% ADF, 56.12-57.80% DDM with RFV = 92.58-111.04. Zanine et al. (2020) mentioned that the nutrient concentration and fermentation characteristics of soybean silages were 150.6-193.0 g/kg DM, 8.72-10.48% ash, 6.53-10.54% CP, 42.26-50.05% NDF, 3.78-5.01% WSC with 6I.78-64.48% IVDMD, pH=5.23-5.66, 0.02-3.71% lactic acid, 1.47-3.67% acetic acid, 0.10-5.47% butyric acid. Homan et al. (2021) revealed that pure soybean silage was characterized by 26.54% DM, pH 4.94, 1.04% lactic acid, 0.17% acetic acid, 1.85% propionic acid, 0.36% butyric acid 15.56% CP, 4.22% EE, 38.68% NDF, 33.3% ADF and 8.61% ash, but the silage made from mixtures of soybean and corn contained 27.51-29.03% DM, pH 4.22-4.35, 1.01-2.29% lactic acid, 0.17-0.44% acetic acid, 0.49-1.19% propionic acid, 0.18-0.39% butyric acid 10.20-11.76% CP, 3.96-4.73% EE, 41.05-44.73% NDF, 23.28-28.77% ADF and 5.46-5.91% ash.

## CONCLUSIONS

The concentration of nutrients in the dry matter of the green mass of *Glycine max* cv. 'CLAVERA' reached 178 g/kg CP, 286 g/kg CF, 94 g/kg ash, 310 g/kg ADF, 484 g/kg NDF, 49 g/kg ADL, 142 g/kg TSS, 261 g/kg Cel, 174 g/kg HC, with nutritive and energy value 68.6% DMD, 63.4% DOM, RFV = 124, 12.73 MJ/kg DE, 10.48 MJ/kg ME and 6.46 MJ/kg NEl.

The biochemical composition, nutritive and energy value of the prepared hay are characterized by the following indices: 173 g/kg CP, 303 g/kg CF, 105 g/kg ash, 331 g/kg ADF, 504 g/kg NDF, 53 g/kg ADL, 110 g/kg TSS, 278 g/kg Cel and 173 g/kg HC, 64.6% DMD, 57.8% DOM, RFV = 116, 12.42 MJ/kg DE, 10.20 MJ/kg ME and 6.22 MJ/kg NEl.

The haylage is characterized by pH = 4.69, 13.4 g/kg acetic acid, 69.3 g/kg lactic acid, 181 g/kg CP, 319 g/kg CF, 126 g/kg ash, 334 g/kg ADF, 510 g/kg NDF, 42 g/kg ADL, 71 g/kg TSS, 292 g/kg Cel, 176 g/kg HC, 126 g/kg ash, 12.6 g/kg Ca and 2.1 g/kg P, with nutritive and energy value 63.0% DMD, 55.8% DOM, RFV = 115, 12.40 MJ/kg DE, 10.18 MJ/kg ME and 6.19 MJ/kg NEl.

The plants of *Glycine max* cv. 'Clavera' may be used to prepare different types of feed for livestock.

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