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THE BIOCHEMICAL COMPOSITION AND THE FODDER VALUE OF SAND SAINFOIN, *ONOBRYCHIS ARENARIA* (KIT.) DC. IN MOLDOVA

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Abstract

Forage legumes are an essential component of agricultural systems in temperate regions of the world. Sainfoins (Onobrychis Mill.) are Eurasian legume perennial herbs, characterized by the highest condensed tannin content, provide beneficial effects and protect animals against bloat and increase protein absorption. In comparison with other species of fodder legumes, it is less demanding to the soil and if there is enough moisture in the soil, it produces high yields even in the poorest soils. We studied some biological peculiarities, the biochemical composition and the fodder value of a local ecotype of sand sainfoin, Onobrychis arenaria, grown in an experimental field of the National Botanical Garden (Institute), Chişinău. In the second growing season, the sand sainfoin was characterized by optimal growth rate and regenerative capacity after mowing, making it possible to cut it three times per season. It was established that the harvested green mass contained 169.6-264.5 g/kg dry matter. The concentration of nutrients in green mass dry matter was: crude protein 169.6-183.9 g/kg, crude fats 22.0-31.8 g/kg, crude cellulose 273.9-297.7 g/kg, nitrogen free extract 412.8 -447.2 g/kg, soluble sugars 34.4-73.2 g/kg, starch 15.9-23.3 g/kg, ash 74.1-83.6 g/kg, calcium 7.3-11.3 g/kg, phosphorus 2.5-2.7 g/kg, carotene 42.00-45.45 mg/kg. The hay prepared after the first and second cuts contained 163.8-167.9 g/kg crude protein, 16.5-17.0 g/kg crude fats, 315.2-366.7 g/kg crude cellulose, 377.1-413.7 g/kg nitrogen free extract, 75.5-83.6 g/kg ash, 7.7-9.9 g/kg calcium and 2.3-2.9 g/kg phosphorus, 7.86-8.66 MJ/kg metabolizable energy. The biochemical and the fodder value of the prepared haylages were: pH 4.75-5.16, lactic acid 51.5-53.0 g/kg, acetic acid 2.4-4.6 g/kg, butyric acid 0.3-0.4 g/kg, crude protein 164.9-174.9 g/kg, crude fats 26.1-27.4 g/kg, crude cellulose 278.2-300.3 g/kg, nitrogen free extract 428.9-439.3 g/kg, sugars 14.6-25.8 g/kg, starch 16.7-20.7 g/kg, calcium 9.3-9.9 g/kg, phosphorus 2.6-3.0 g/kg and 7.72-7.78 MJ/kg metabolizable energy.

***Key words**: biochemical composition, fodder value, green mass, hay, haylage, Onobrychis arenaria.*

INTRODUCTION

Forages are the major part of the diet of ruminant animals and provide energy, proteins and minerals. When feeding highly productive cows, the most common problem is meeting the protein need of animals. According to some scientists, due to the existing protein deficiency, agricultural enterprises lose about 30-35 % of their profits. This problem can be solved by increasing the production of high-protein fodder crops. Forage legumes are an essential component of agricultural systems in temperate regions of the world. Thanks to their nitrogen-fixing capabilities, they absorb nitrogen from the air, which reduces the need for nitrogen fertilizers.

Significant efforts to reduce the risk of bloat caused in ruminants by *Medicago* and *Trifolium* species have had limited success. One solution is to introduce other forage legume species that have the same beneficial qualities as alfalfa and clover, but without causing bloat. Forage legumes that contain moderate levels of secondary compounds such as condensed tannins and flavonoids offer some advantages to livestock nutrition. They increase nitrogen utilization efficiency within the digestive tract, reduce pasture bloat, provide resilience to resist parasites and reduce methane emissions into the environment from enteric fermentation (Mueller-Harvey et al., 2019).

Sainfoins (*Onobrychis* Mill.) are legume herbs, with 150 species distributed in many parts of the world, including West Asia, Europe, the western part of the United States and Canada. In comparison with other legumes species, the

Onobrychis species are less demanding to the soil and if there is enough moisture in the soil, it produces high yields even in the poorest soils, it is highly resistant to cold and drought, the fodder is characterized by high protein level and palatability, high condensed tannin content, provides beneficial effects to protect animals against bloat and increases protein absorption (Heckendorn et al., 2006; Hoste et al., 2014; Heuzé et al., 2020).

In Republic of Moldova the genus *Onobrychis* is represented by 4 species: *Onobrychis alba* (Waldst. & Kit.) Desv., *Onobrychis arenaria* Kit. D.C., *Onobrychis gracilis* Besser, *Onobrychis viciifolia* Scop.

Sand or Hungarian sainfoin, *Onobrychis arenaria* Kit. D.C. synonym *Onobrychis tanaitica* Spreng., *Onobrychis sibirica* (Besser) P.W. Ball is native to Eurasia and it has been cultivated in Ukraine since the beginning of the XX century. It has been used to create interspecies hybrids with common sainfoin, *Onobrychis viciifolia.* It is a perennial herb. Stems erect, branching, 40-90 cm high, with rare hairs or glabrous. Leaves pinnate with 6-15 pairs of elliptical or linear-lanceolate leaflets, 10-30 mm long, 2-5 mm wide. Racemes 5-9 cm long, multi-flowered. Florets purple-pink, 8-10 mm long. The pods are semi-pubescent, ovate, 5 mm long with short teeth on thorns and on the disk. The pods are flattened, indehiscent; each pod contains a single kidney-shaped seed, 4-6 mm in length. The plants bloom in May-June; seeds ripen in July. Due to its high drought resistance and nitrogen fixing ability, this species is suitable for fertilizing sandy, podzolic and calcareous soils, and for increasing the yields of subsequent crops on arable land.

The aim of this study was to evaluate some biological peculiarities, the biochemical composition and the fodder value of green mass, hay and haylage from sand sainfoin, *Onobrychis arenaria*.

MATERIALS AND METHODS

The local ecotype of sand sainfoin, *Onobrychis arenaria* that was cultivated in the experimental plot of the National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subject of the research.

The green mass in the second growing year was harvested manually at 10 cm stubble height. The samples were harvested for the first time in early flowering period - in May, the second harvest was done on July 7, and the third harvest - on October 2. The green mass productivity was determined by weighing the yield obtained from a harvested area of 10 m^2. The leaves/stems ratio was determined by separating leaves and flowers from the stem, weighing them separately and establishing the ratios for these quantities, samples of 1.0 kg harvested plants were taken. For chemical analyses, the samples were dried at 65 ± 5ºC. The dry matter content was detected by drying samples up to constant weight at 105ºC. The prepared hay was dried directly in the field. The haylage was prepared from wilted green mass, shredded and compressed in well-sealed glass containers. After 45 days, the containers were opened, and the organoleptic assessment and biochemical composition of the haylage were determined in accordance with the Moldavian standard SM 108. The content of crude protein, crude fats, crude cellulose, calcium, phosphorus, soluble sugars, starch, ash, lactic, acetic and butyric acids was appreciated in accordance with standard laboratory procedures in Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, Maximovca.

RESULTS AND DISCUSSIONS

Analyzing the agro-biological peculiarities of the local ecotype of sand sainfoin, *Onobrychis arenaria*, in the second growing season, it was established that the revival of plants was uniform, generative shoots developed in middle of April; they were characterized by moderate growth and development rates. At the end of May, the sand sainfoin plants reached 96 cm, the yield was 39.5 t/ha green mass or 6.56 t/ha dry matter, characterized by high content of leaves and flowers in the harvested mass (Table 1). Because of unfavorable meteorological conditions, high air temperatures and deficit moisture content of soil in May and early June, the revival of plants not was uniform. It was established that developed shoots grew about

60-68 cm, and the plants were cut for the second time, obtaining 19.23 t/ha green mass or 5.08 t/ha dry matter. The unfavorable meteorological conditions, the lack of rainfall and the very high air temperatures (38-41ºC) during the July-August affected the revival of sand sainfoin plants. A better growth and development rate was observed after the rain that fell at the middle of September, the formed shoots were erect and thicker, and reached 79 cm. The yield at the third harvest decreased in comparison with the previous harvests, and reached 10.03 t/ha green mass or 2.47 t/ha dry matter with optimal proportion of leaves (53%). The annual productivity of sand sainfoin, *Onobrychis arenaria*, in the second growing season, reached 68.76 t/ha green mass or 14.11 t/ha dry matter.

As a result of a research conducted by Matolinets & Voloshin (2016) in Perm region of Russia, it has been revealed that the three years' period average yield was 36.9 t/ha green mass or 7.53 t/ha of dry mass.

Table 1. Some biological peculiarities and the structure of the harvested mass depending on the harvest time of sand sainfoin, *Onobrychis arenaria*

Harvest time	Plant height, cm	Stem, g		Leaf + flower, g		Productivity, t/ha		Content of leaves and flowers in fodder, %
		green mass	dry matter	green mass	dry matter	green mass	dry matter	
First cut	96	6.28	0.88	9.00	1.62	39.50	6.56	64.8
Second cut	64	2.80	0.88	4.80	1.28	19.23	5.08	59.3
Third cut	79	3.72	1.27	5.31	1.43	10.03	2.47	53.0

Table 2. The biochemical composition and the fodder value of the green mass of sand sainfoin, *Onobrychis arenaria*

Indices	First cut	Second cut	Third cut
Crude protein, % DM	16.96	18.39	16.96
Crude fats, % DM	3.18	2.20	2.62
Crude cellulose, % DM	28.72	29.77	27.39
Nitrogen free extract, % DM	43.74	41.28	44.72
Soluble sugars, % DM	7.32	3.44	4.75
Starch, % DM	1.59	2.32	2.33
Ash, % DM	7.41	8.36	8.30
Nutritive units/ kg GM	0.17	0.20	0.26
Metabolizable energy, MJ/kg GM	1.73	2.47	2.53
Calcium, %	0.73	1.13	0.99
Phosphorus, %	0.25	0.25	0.27
Carotene, mg/ kg GM	45.45	43.45	42.00

The optimum use of forage resources in animal diets depends on the availability of detailed information on their chemical composition, biological properties and nutritional value, which may vary among plant species, cultivars, depending on age, growth stage and environmental conditions. The quality of the harvested green mass of sand sainfoin, *Onobrychis arenaria*, is presented in Table 2. It was found that in dry matter the crude protein varied from 169.6 to 183.9 g/kg, crude fats - from 22.0 to 31.8 g/kg, crude cellulose - from 273.9 to 297.7 g/kg, nitrogen free extract - from 412.8 to 447.2 g/kg, soluble sugars - from 34.4 to 73.2 g/kg, starch - from 15.9 to 23.3 g/kg, ash - from 74.1 to 83.6 g/kg, calcium - from 7.3 to 11.3 g/kg, phosphorus - from 2.5 to 2.7 g/kg. There was a significantly higher content of crude protein, crude cellulose and calcium in the green mass obtained after the second cut. The concentrations of crude fats and soluble sugars were high in the green mass at the first harvest and very low - in the green mass at the second harvest. The level of starch increased substantially in green mass at the second and third harvests.

Carotenoids, as part of the nutrients in the feed, support animal health and the quality of animal products. Animals cannot synthesize carotenoids. Plant carotenoids are precursors of vitamin A, together with vitamin E and polyphenols, which are natural antioxidants in ruminant diets. It was found that the concentrations of carotene decreased from 45.45 mg/kg fodder at the first haevers to 42.00 mg/kg fodder at the third harvest.

The content of dry matter, the concentration of nutrients and their digestibility influence the

feed and energy value of natural fodder. Therefore, 100 kg of green mass obtained at the first harvest contained 17 nutritive units and 173 MJ metabolizable energy, at the second harvest - 20 nutritive units and 247 MJ metabolizable energy and at the third harvest - 26 nutritive units and 253 MJ metabolizable energy for cattle. The estimated second season annual fodder productivity achieved 7600 nutritive units/ha, 1800 kg/ha digestible protein and 141.2 GJ/ha metabolizable energy.

Several literature sources describe the biochemical composition and nutritional performance of sainfoin whole plants. Gryazeva (2005), reported that *Onobrychis arenaria* green mass contained 238.4- 244.6 g/kg dry matter with 18.57-19.31% crude protein, 2.29-2.36% crude fats, 29.18-29.41% crude cellulose, 41.93-44.02% nitrogen free extract, 5.95-6.90% ash, but *Medicago sativa* green mass contained 248.9-269.6 g/kg dry matter with 18.62-20.66% crude protein, 2.49-2.52% crude fats, 31.18-32.60% crude cellulose, 37.20-39.17% nitrogen free extract, 7.02-9.09% ash. According to Pankov (2013), *Onobrychis arenaria* green mass harvest in flowering period contained 18.4% crude protein, 3.1% crude fats, 27.8% crude cellulose, 41.9% nitrogen free extract, 8.8% ash, 11.7 g/kg calcium and 1.7 g/kg phosphorus. Voloshin et al. (2015), found that the concentrations of nutrients and energy in the dry matter of tested cultivars of *Onobrychis arenaria*, at the first harvest, were 14.51-17.70% crude protein, 2.47-2.72% crude fats, 27.13-28.82% crude cellulose, 6.13-6.79% minerals, 6.09-6.44% sugars 92.25-137.11 mg/% carotene, 0.78-0.83 nutritive units/kg, 9.81-10.12 MJ/kg metabolizable energy and 144 g digestible protein per nutritive unit, but in the green mass at the second harvest, respectively, 15.42-15.92% crude protein, 2.45-2.60% crude fats, 21.24-24.38% crude cellulose, 3.00-4.20% minerals, 5.34-5.61% sugars, 142.90-152.43 mg/% carotene, 0.92-1.01 nutritive unit/kg, 10.61-11.17 MJ/kg metabolizable energy. Demydas et al. (2019) compared the forage quality of green mass from different species of sainfoin and found that the chemical composition of *Onobrychis arenaria* was 20.5-20.6% crude protein, 4.16-4.22% crude fats, 21.5-21.9% crude cellulose, 8.09-8.15% ash, 46.00% nitrogen free extract, 13.2-13.3 g/kg calcium and 6.2-6.5 g/kg phosphorus; *Onobrychis viciifolia* contained, respectively, 19.3-19.4% crude protein, 3.48-3.62% crude fats, 21.2-21.6% crude cellulose, 7.80-7.98% ash, 48.00% nitrogen free extract, 13.4-13.5 g/kg calcium and 5.2-5.6 g/kg phosphorus; *Onobrychis transcaucasica* - 20.1-20.3% crude protein, 4.07-4.20% crude fats, 21.5-21.6% crude cellulose, 8.06-8.16% ash, 46.00% nitrogen free extract, 12.6- 13.3 g/kg calcium and 6.4-6.6 g/kg phosphorus.

The use of forage conservation methods to supply roughage to herbivores at critical times of production is an excellent strategy in animal production. Giving that the main ones are hay, silage and haylage, they require peculiar characteristics to be conserved. The nutrition provided by hay is vital to keep the animal healthy and to protect their digestive health. The biochemical composition and fodder value of the hay prepared from sand sainfoin, *Onobrychis arenaria,* is presented in Table 3. The dry matter of prepared hay contained 163.8-167.9 g/kg crude protein, 16.5-17.0 g/kg crude fats, 315.2-366.7 g/kg crude cellulose, 377.1-413.7 g/kg nitrogen free extract, 75.5-83.6 g/kg ash, 7.7-9.9 g/kg calcium and 2.3-2.9 g/kg phosphorus. It is known that the digestibility of nutrients in hay is lower. Therefore, the nutritive value of 100 kg of hay from sand sainfoin was 46-62 nutritive units and 786-866 MJ metabolizable energy.

Table 3. The biochemical composition and the fodder value of the hay from sand sainfoin, *Onobrychis arenaria*

Indices	First cut	Second cut
Crude protein, % DM	16.38	16.79
Crude fats, % DM	1.70	1.65
Crude cellulose, % DM	36.67	31.52
Nitrogen free extract, % DM	37.71	41.37
Soluble sugars, % DM	3.36	2.10
Starch, % DM	1.24	1.39
Ash, % DM	7.55	8.36
Nutritive units/kg DM	0.46	0.62
Metabolizable energy, MJ/kg DM	7.86	8.66
Calcium, % DM	0.77	0.99
Phosphorus, % DM	0.23	0.29

Some authors mentioned various findings about the quality of the hay from *Onobrychis* species. Medvedev & Smetannikova (1981) remarked that sand sainfoin hay contained: 11.2-11.8% digestible protein, 1.8-2.9% crude fats, 5.6-

6.1% ash, 19.0-27.7% crude cellulose, 32.9-43.8% nitrogen free extract and 0.58 nutritive units/kg. Ryabinina (1998) reported that *Onobrychis arenaria* hay contained: 17.7% crude protein, 4.45% ash, 22.8% crude cellulose, 45.6% nitrogen free extract, 0.79% calcium, 0.21% phosphorus, 0.61 nutritive units/kg and 10.1 MJ/kg metabolizable energy. Dzyubenko & Abdushaeva (2012) reported that *Onobrychis arenaria* hay contained: 15.4% crude protein, 3.2% crude fats, 6.2% ash, 24.9% crude cellulose, 34.0% nitrogen free extract and 0.54 nutritive units/ kg.

It is advisable to feed lactating cows, in winter, with haylage, because its properties are close to those of the green mass of grasses, and the nutritional value of dry matter - to grass flour. As for the organoleptic properties, the haylages prepared from *Onobrychis arenaria* consists of green-olive 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 quality of sand sainfoin haylage prepared from green mass obtained at the second and third cuts is shown in Table 3. It has been determined that the pH index was 4.75-5.16, the concentrations of organic acids reached 60.5-62.8 g/kg, and most amounts of organic acids were in fixed form. The butyric acid was detected in fixed form - 0.3-0.4 g/kg.

Table 4. The quality of the haylage from sand sainfoin, *Onobrychis arenaria*

Indices	Second cut	Third cut
pH index	5.16	4.75
Content of organic acids, g/kg	60.5	62.8
Free acetic acid, g/kg	0.6	1.7
Free butyric acid, g/kg	0	0
Free lactic acid, g/kg	4.1	4.7
Fixed acetic acid, g/kg	2.4	4.6
Fixed butyric acid, g/kg	0.4	0.3
Fixed lactic acid, g/kg	53.0	51.5
Total acetic acid, g/kg	3.0	6.3
Total butyric acid, g/kg	0.4	0.3
Total lactic acid, g/kg	57.1	56.2
Acetic acid, % of organic acids	4.96	10.03
Butyric acid, % of organic acids	0.66	0.48
Lactic acid, % of organic acids	94.38	89.49
Crude protein, % DM	16.49	17.49
Crude fats, % DM	2.61	2.74
Crude cellulose, % DM	30.03	27.82
Nitrogen free extract, % DM	42.89	43.93
Soluble sugars, % DM	2.58	1.46
Starch, % DM	1.67	2.07
Ash, % DM	7.99	7.71
Metabolizable energy, MJ/kg DM	7.72	7.78
Calcium, % DM	0.99	0.93
Phosphorus, % DM	0.30	0.26

The haylage prepared from green mass obtained at the second harvest was characterized by optimal content of lactic acid and low content of acetic acid, in comparison with the haylage prepared from the green mass obtained at the third harvest. The dry matter in haylages prepared from sand sainfoin, contained 16.49-17.49% crude protein, 2.61-2.74% crude fats, 27.82-30.03% crude cellulose, 42.89-43.93% nitrogen free extract, 1.46-2.58% soluble sugars and 1.67-2.07% starch, 7.71-7.99% ash, 0.93-0.99% calcium and 0.26-0.30% phosphorus, 7.72-7.78 MJ/kg metabolizable energy. There was a significantly higher content of crude protein, nitrogen free extract and starch in the haylage obtained from green mass after the third cut.

Shitov (2008) found that pure haylage from sainfoin was characterized by pH 4.6, concentrations of lactic acid 1.31%, acetic acid 0.81%, butyric acid 0.24%, but sainfoin haylage conserved with *Lactobacillus* - pH 4.2, lactic acid 1.25%, acetic acid 0.47% and butyric acid 0 %. Morozkov & Maysak (2020) reported that *Onobrychis arenaria* haylage contained: 16.96% crude protein, 2.59% crude fats, 26.15% crude cellulose, 4.86% sugars, 10.63 g/kg calcium, 2.79 g/kg phosphorus, 22.90 mg/kg carotene, 9.50 MJ/kg metabolizable energy. Sainfoin haylage had positive effect on immuno-biochemical parameters of blood of cows and their reproductive functions.

CONCLUSIONS

The local ecotype of sand sainfoin, *Onobrychis arenaria*, in the second growing season, was characterized by optimal growth rate and regenerative capacity after mowing, making it possible to cut it three times per season, reaching a productivity of 68.76 t/ha green mass or 14.11 t/ha dry matter.

The biochemical composition of the green mass varied depending on the harvest time: crude protein 169.6-183.9 g/kg, crude fats 22.0-31.8 g/kg, crude cellulose 273.9 - 297.7 g/kg, nitrogen free extract 412.8 - 447.2 g/kg, soluble sugars 34.4-73.2 g/kg, starch 15.9-23.3 g/kg, ash 74.1-83.6 g/kg, calcium 7.3-11.3 g/kg, phosphorus 2.5-2.7 g/kg, carotene 42.00-45.45 mg/kg.

The estimated fodder productivity achieved 7600 nutritive units/ha, 1800 kg/ha digestible protein and 141.2 GJ/ha metabolizable energy.
The hay prepared after the first and second harvests contained 163.8-167.9 g/kg crude protein, 16.5-17.0 g/kg crude fats, 315.2-366.7 g/kg crude cellulose, 377.1-413.7 g/kg nitrogen free extract, 75.5-83.6 g/kg ash, 7.7-9.9 g/kg calcium and 2.3-2.9 g/kg phosphorus, 7.86-8.66 MJ/kg metabolizable energy.
The biochemical and the fodder value of the prepared haylages were: pH 4.75-5.16, lactic acid 51.5-53.0 g/kg, acetic acid 2.4-4.6 g/kg, butyric acid 0.3-0.4 g/kg, crude protein 164.9-174.9 g/kg, crude fats 26.1-27.4 g/kg, crude cellulose 278.2-300.3 g/kg, nitrogen free extract 428.9-439.3 g/kg, sugars 14.6-25.8 g/kg, starch 16.7-20.7 g/kg, calcium 9.3-9.9 g/kg, phosphorus 2.6-3.0 g/kg and 7.72-7.78 MJ/kg metabolizable energy.
The green mass, hay and haylage obtained from sand sainfoin, *Onobrychis arenaria*, contain a lot of nutrients, which make them suitable to be used as a part of diverse livestock diets.

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