SOME AGROBIOLOGICAL FEATURES AND THE ECONOMIC VALUE OF THE SPECIES *Onobrychis arenaria* AND *Onobrychis viciifolia*

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Abstract. The aim of this study was to evaluate some agrobiological features, the quality of fresh mass, hay and residual phytomass after harvesting the seeds of the leguminous species *Onobrychis arenaria* (Kit.) DC. and *Onobrychis viciifolia* Scop., grown in an experimental field of the National Botanical Garden (Institute), Chişinău, Republic of Moldova. In the first year of life, *Onobrychis arenaria* and *Onobrychis viciifolia* were characterized by optimal growth rate and regenerative capacity after being cut, making mowing possible twice per growing season. The productivity reached 2.71-3.15 kg/m^2 green mass or 0.69-0.78 kg/m^2 dry matter. It was determined that the dry matter content and its biochemical composition varied depending on the species and harvest time: 153-177g/kg CP, 196-231 g/kg CF,112-125 g/kg ash, 248-278 g/kg ADF, 372-412 g/kg NDF, 50-6 g/kg ADL,131-155 g/kg TSS, 192-219 g/kg Cel and 124-140 g/kg HC. The nutritive and energy values of fresh mass fodder: 67.32-69.68 % DDM, RFV=152-184, 10.81-11.16 MJ/kg ME and 6.83-7.15 MJ/kg NEl. The hay prepared from *Onobrychis arenaria* contained 176-179g/kg CP, 266-272 g/kg CF,116-126 g/kg ash, 284-285g/kg ADF, 381-387 g/kg NDF, 45-48 g/kg ADL, 108-109 g/kg TSS, 237-239 g/kg Cel and 97-102 g/kg HC with 66.70-66.78 % DDM, RFV=160-163, 10.7 MJ/kg ME and 6.8 MJ/kg NEl. We found that the fresh mass substrates for anaerobic digestion had C/N=17-20 and optimal amount of lignin and hemicelluloses, the biochemical methane potential of the studied substrates varied from 265 to 289 l/kg ODM. The sainfoin phytomass that remained after harvesting the seeds was characterised by moderate gross calorific values (18.0 MJ/kg) and ash content (3.98%), it could be processed into briquettes and used for the production of renewable energy. The local ecotype of sand sainfoin, *Onobrychis arenaria*, had optimal productivity and nutrient concentration, can serve as starting material in improving and implementing new varieties in the production of protein rich forage, as well feedstock for renewable energy.

Keywords: biochemical composition, feed value, *Onobrychis arenaria*, *Onobrychis viciifolia*, renewable energy.

Rezumat. Unele particularități agrobiologice și valoarea economică a speciilor *Onobrychis arenaria* și *Onobrychis viciifolia*. Scopul prezentului studiu a constatat în evaluarea unor particularități agrobiologice, a calității masei proaspete recoltate, a fânului preparat și a reziduurilor rămase după recoltarea semințelor la speciile de leguminoase sparceta de nisip, *Onobrychis arenaria*, și sparceta comună, *Onobrychis viciifolia*, cultivate în câmpul experimental din Grădina Botanică Națională (Institut), Chișinău, Republica Moldova. În anul fondării experiențelor, plantele de *Onobrychis arenaria* și *Onobrychis viciifolia* s-au caracterizat print-un ritm optim de creștere și regenerare după cosire, ce permite obținerea a două coase pe sezon și atingerea productivității de 2.71-3.15 kg/m^2 masă proaspătă sau 0.69-0.78 kg/m^2 substanță uscată. S-a determinat că conținutul de substanță uscată și compoziția ei biochimică variază în dependență de specie și perioada recoltării: 153-177 g/kg proteină brută (CP), 196-231 g/kg celuloză brută (CF),112-125 g/kg cenușă, 248-278 g/kg fibre solubile în detergent acid (ADF), 372-412 g/kg fibre solubile în detergent neutru (NDF), 50-61 g/kg lignină sulfurică (ADL), 131-155 g/kg total zaharuri solubile (TSS), 192-219 g/kg celuloză (Cel) și 124-140 g/kg hemiceluloză (HC). Valoarea nutritivă și energetică a substanțelor uscate din masa proaspătă recoltată: 63.34-69.68 % substanță uscată digestibilă (DDM), valoare relativă furajeră RFV=152-184, 10.81-11.16 MJ/kg energie metabolizantă (ME) și 6.83-7.15 MJ/kg energie netă pentru lactație. Fânul preparat din sparceta de nisip, *Onobrychis arenaria*, conține 176-179 g/kg CP, 266-272 g/kg CF, 116-126 g/kg cenușă, 284-285 g/kg ADF, 381-387 g/kg NDF, 45-48 g/kg ADL, 108-109 g/kg TSS, 237-239 g/kg Cel și 97-102 g/kg HC cu 66.70-66.78 % DDM, RFV=160-163, 10.7 MJ/kg ME și 6.8 MJ/kg NEl. S-a stabilit că substraturile de masă proaspătă recoltată pentru digestia anaerobă se caracterizează printr-un raport de carbon și azot de C/N=17-20, concentrație optimală de lignină sulfurică și hemiceluloză, potențialul biochimic de obținere a metanului variază de la 265 la 289 l/kg materie organică. Reziduurile după recoltarea semințelor de sparcetă au o valoarea calorifică (18.0 MJ/kg) și conținut de cenușă (3.98%) moderat, pot fi brichetate și utilizate la producerea energiei regenerabile. Ecotipul local de sparcetă de nisip, *Onobrychis arenaria* și *Onobrychis viciifolia* are o productivitate și concentrație optimală de substanțe nutritive, poate servi ca material inițial de ameliorare și implementate a soiurilor noi la producerea furajului bogat în proteine și a materie primă pentru producere de energie regenerabilă.

Cuvinte cheie: Compoziția biochimică, energie regenerabilă, *Onobrychis arenaria*, *Onobrychis viciifolia*, valoare nutritivă.

INTRODUCTION

Against the background of climate change and the expansion of areas with degraded and salinized soils, plant species must be mobilized that would be able to produce the necessary amounts of food and forage under these harsh conditions. In recent years, there has been a renewed interest in *Onobrychis* species. In comparison with other legume species, sainfoins are less demanding to the soil and if there is enough moisture in the soil, they produce high yields even in the poorest soils, they are highly resistant to cold and drought. Due to its high drought resistance and nitrogen fixing ability, the *Onobrychis* species is suitable for fertilizing sandy, podzolic and calcareous soils and for increasing the yields of subsequent crops on arable land. In addition, sainfoin has good leaf retention and high frost tolerance. This cool-season legume, alone or in grass mixtures, can be hayed, ensiled or grazed. The fodder is characterized by high protein amounts and palatability, high condensed tannin content, provides beneficial effects to protect animals against bloat and increases protein absorption. Pollination occurs via honey bees, and sainfoin has been credited as one of the most important sources of honey on the European continent, it has been estimated 400 kg/ha honey per annum. The

Onobrychis species are currently investigated and implemented in different regions of the Earth (HECKENDORN et al., 2006; ISTRATE & SAVATTI, 2008; ASAADI &YAZDI, 2011; CARBONERO et al., 2011; HOSTE et al., 2014; OKCU & ŞENGÜL, 2014; MORA-ORTIZ & SMITH, 2015; HUYEN, 2016; MATOLINETS & VOLOSHIN, 2016; 6; RUFINO-MOYA et al., 2019; HEUZÉ et al., 2020).

The genus *Onobrychis* Mill. belongs to the Hedysareae tribe of the Papilionoideae subfamily of the Fabaceae family (syn. *Leguminosae*), with 150 species distributed in many parts of the world, including West Asia, Europe, the western part of the United States and Canada. *Onobrychis transcaucasica* Grossh. is the most ancient sainfoin species with more than a thousand-year history of cultivation in Transcaucasia. Common sainfoin, *Onobrychis viciifolia* Scop. has been used in Russia as a forage crop for over 1000 years and there are records that it was cultivated in France in the 14th century, in Germany in the 17th century and in Italy in the 18th century. Sand sainfoin, *Onobrychis arenaria* Kit. D.C. has been cultivated in Ukraine since the beginning of the 20th century, it has been used to create interspecific hybrids with common sainfoin, *Onobrychis viciifolia.* According to NEGRU (2007) the genus *Onobrychis* Mill., in Republic of Moldova is represented by 4 species: *Onobrychis alba* (Waldst. & Kit.) Desv., *Onobrychis arenaria* Kit. D.C., *Onobrychis gracilis* Besser and *Onobrychis viciifolia* Scop.

Sand or Hungarian sainfoin, *Onobrychis arenaria* Kit. D.C., syn. *Onobrychis tanaitica* Spreng., *Onobrychis sibirica* (Besser) P.W.Ball, is a perennial herb. The stems are erect, branching, 40-90 cm tall, with sparse hairs or glabrous. Leaves are pinnate with 6-15 pairs of elliptical or linear-lanceolate leaflets, 10-30 mm long, 2-5 mm wide. Racemes are 5-9 cm long, multi-flowered. Florets are purple-pink, 8-10 mm long. The plants bloom in May-June; the seeds ripen in July. 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 weight of 1000 fruits is 15-20 g. The seeds are kidney-shaped, brown-green or yellow-gray, slightly shiny. The weight of 1000 seeds is 9-11 g.

Common sainfoin *Onobrychis viciifolia* Scop., syn. *Hedysarum onobrychis* L., *Onobrychis sativa* Lam., *Onobrychis viciaefolia* Scop. is a perennial herb, with dense stems, erect or slightly arched, whitish, hairy, 35-125 cm tall. The green leaves are 6-17 cm long, with 5-12 pairs leaflets attached to short peduncles, elongated obovate or elliptical, obviously ribbed, hairy on the underside. The stipules are long and acuminate, usually free, reddish brown, with slightly hairy edges. The flowers are arranged in terminal ovoid racemes, 16-23 cm long and 15-20 mm wide, at first dense, then loose, the bract 3.5-4.2 mm, the hairy peduncle 1 mm, the calyx 5.5-6.6 mm, the corolla pink-purple 10-13 mm, the banner petal equal or sometimes longer than the keel, the wings reach 2-3 mm. The fruit is a laterally compressed pod with 4-8 short thorns on the suture, gray or brown, 3-7 mm long and 2-4.5 mm wide, monosperm, indehiscent, the weight of 1000 fruits is 17-22 g.

The aim of this study was to evaluate some agrobiological features, the quality of fresh mass, hay and residual phytomass remained after harvesting the seeds from the leguminous species *Onobrychis arenaria* (Kit.) DC. and *Onobrychis viciifolia* Scop. and the possibility to use them as feed for ruminant animals and feedstock for the production of renewable energy.

MATERIAL AND METHODS

The common sainfoin, *Onobrychis viciifolia* Scop., and sand sainfoin, *Onobrychis arenaria* Kit. D.C., that were 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 subjects of the research. The seeds of the tested species were sown on March 27, at a spacing of 15 cm at a depth of 3-4 cm, 400 pods/m^2.

The sainfoin green mass, in first growing season, was harvested manually, at 10 cm stubble height. The first cut samples were collected in the flowering stage, July 1, the second cut – in the flower bud stage, August 8. The green mass productivity was determined by weighing the yield obtained from a harvested area of 10 m^2. The leaf/stem ratio was determined by separating the leaves and panicles from the stem, weighing them separately and establishing the ratios for these quantities, samples of 1.0 kg of harvested plants were used. For chemical analyses, the samples were dried at 65 ± 5°C. The dry matter content was detected by drying samples up to constant weight at 105 °C. The prepared hay was dried directly in the field. Some assessments of the main biochemical parameters: crude protein (CP), crude fibre (CF), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL) and total soluble sugars (TSS) have been determined by near infrared spectroscopy (NIRS) technique, using the PERTEN DA 7200 at the Research and Development Institute for Grassland Braşov, Romania. The concentration of hemicellulose (HC) and cellulose (Cel), the digestible dry matter (DDM), the relative feed value (RFV), the digestible energy (DE), the metabolizable energy (ME) and the net energy for lactation (NEl) were calculated according to standard procedures. The carbon content of the substrates was obtained using an empirical equation according to BADGER et al., (1979). The biochemical biogas potential (Yb) and the methane potential (Ym) were calculated according to the equations of DANDIKAS et al., (2014) based on the chemical compounds – acid detergent lignin (ADL) and hemicellulose (HC):

$$Yb = 727 + 0.25\ HC - 3.93\ ADL$$

$$Ym = 371 + 0.13HC - 2.00ADL$$

For the production of solid biofuel, the residual phytomass after seed harvesting was chopped using a stationary forage chopping unit. The chopped phytomass was milled in a beater mill equipped with a sieve with the diameter of openings of 10 mm. The physical and mechanical properties of dry biomass were determined according to

the Standards, at the State Agrarian University of Moldova: the moisture content of the plant material was determined by SM EN ISO 18134 in an automatic hot air oven MEMMERT100-800; the content of ash was determined at 550 ºC in a muffle furnace HT40AL according to SM EN ISO 18122; automatic calorimeter LAGET MS-10A with accessories was used for the determination of the calorific value, according to SM EN ISO 18125; the cylindrical containers were used for the determination of the biomass bulk density, calculated by dividing the mass over the container volume according to SM EN ISO 17828, SM EN ISO 18847. The briquetting was carried out by hydraulic piston briquetting press BrikStar model 50-12 (Briklis). The mean compressed (specific) density of the briquettes was determined immediately after removal from the mould as a ratio of measured mass over calculated volume.

RESULTS AND DISCUSSIONS

As a result of the phenological observations, it has been found that, in the first growing season, the studied *Onobrychis* species were characterised by similar growth and development rates. Thus, it has been determined that the seedlings emerged uniformly at the soil surface in the middle of April, 18 days after sowing. The development of shoots was observed in the second half of May, and their intensive growth – in June. At the time of the harvest, in the flowering stage, *Onobrychis arenaria* plants (80 cm) were shorter than *Onobrychis viciifolia* plants (84 cm), but the stems were thicker. The green mass productivity of *Onobrychis arenaria* reached 1.84 kg/m^2 with 26.1% dry matter content and 53.1 % foliage content, but the yield of *Onobrychis viciifolia* was 1.62 kg/m^2 with 25.6 % dry matter and 58.2 % foliage content. After the first cut, the regrowth of the plants was optimal; the formed shoots were erect, thin, over 68-71 cm in height. The sainfoin plants were cut for the second time in early August. *Onobrychis viciifolia* produced 1.09 kg/m^2 green mass or 0.28 kg/m^2 dry matter, but the productivity of *Onobrychis arenaria* reached 1.35 kg/m^2 green mass or 0.30 kg/m^2 dry matter.

Several literature sources have described the productivity of *Onobrychis* species. According to SLEPETYS et al., (2012), *Onobrychis viciifolia* produced 5.21 t/ha dry matter and *Medicago sativa* – 6.16 t/ha in the first year. VOLOSHIN (2017) found that in first year the perennial legume crop *Onobrychis arenaria*, developed according to the spring type, since by the middle of September the plant height reached 76-96 cm and the green mass productivity was 1.52-2.40 kg/m^2. CHERNIAVSKIH et al., (2020) reported that, in the first growing season, the dry matter productivity of *Onobrychis arenaria* reached 750.6 g/m^2 at the first cut and 467.9 g/m^2 at the second cut. LOHWASSER et al., (2021), evaluating the *Onobrychis* species, found that the yield ranged between 0 and 124 dt/ha in the first, 4 and 312 dt/ha in the second and 9 and 531 dt/ha in the third year, respectively.

The quality of the fresh mass depends on the species and the harvest time. It has been found that the concentration of nutrients in the first cut dry mater of *Onobrychis* was: 153-155 g/kg CP, 199-231 g/kg CF, 113-125 g/kg ash, 248-278 332 g/kg ADF, 372-405 g/kg NDF, 56-61 g/kg ADL, 143-191 g/kg TSS, 124-127 g/kg HC, 192-217 g/kg Cel (Table 1). Thus, the fresh mass of *Onobrychis arenaria* contained a low amount of crude fibre, structural carbohydrates, lignin and a higher amount of total soluble sugars than *Onobrychis viciifolia*, which had a positive impact on the digestibility, relative feed value and the energy concentration of the feed. The fodder from *Onobrychis arenaria* reached 69.58 % DMD and RFV=174 with 13.59 MJ/kg DE, 11.16 MJ/kg ME and 7.17 MJ/kg NEl, while the one from *Onobrychis viciifolia* – 67.61 % DMD and RFV=154 with 13.17 MJ/kg DE, 10.81 MJ/kg ME and 6.83 MJ/kg NEl. Analysing the quality of the second cut fresh mass, we would like to mention that the dry matter contained 155-177 g/kg CP, 196-232 g/kg CF, 114-125 g/kg ash, 250-277 g/kg ADF, 390-412 g/kg NDF, 50-58 g/kg ADL; the fodder and energy values were 67.32- 69.42% DMD, RFV=152-166, 13.19-13.56 MJ/kg ME and 6.84- 7.15 MJ/kg NEl. The concentrations of crude protein and ash were high in the second cut *Onobrychis arenaria* fodder. The amounts of hemicellulose increased, but total soluble sugars and lignin decreased substantially in the second cut fodder. The biochemical composition and the fodder quality of second cut *Onobrychis viciifolia* did not differ significantly in comparison with first cut fresh mass (Table 1).

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

Indices	*Onobrychis arenaria*		*Onobrychis viciifolia*	
	I cut	II cut	I cut	II cut
Crude protein, g/kg DM	153	177	155	158
Crude fibre, g/kg DM	199	196	231	231
Ash, g/kg DM	113	125	112	114
Acid detergent fibre, g/kg DM	248	250	278	277
Neutral detergent fibre, g/kg DM	372	390	405	412
Acid detergent lignin, g/kg DM	56	50	61	58
Total soluble sugars, g/kg DM	191	155	143	131
Cellulose, g/kg DM	192	200	217	219
Hemicellulose, g/kg DM	124	140	127	135
Dry matter digestibility, %	69.58	69.42	67.61	67.32
Digestible energy, MJ/kg DM	13.59	13.56	13.17	13.19
Metabolizable energy, MJ/kg DM	11.16	11.13	10.81	10.82
Net energy for lactation, MJ/kg DM	7.17	7.15	6.83	6.84
Relative feed value	174	166	154	152

Literature sources indicate considerable variation in the chemical composition and nutritional value of whole sainfoins plants. GRYAZEVA (2005), reported that the green mass of sand sainfoin 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. AUFRERE et al., (2008) mentioned that, in the early flowering stage, the green mass of *Onobrychis viciifolia* contained 12.4 % CP, 33.0 % ADF, 44.8 % NDF, 9.4 % ADL, 2.5 % condensed tannins, 65.1 % DMD, but *Medicago sativa* – 17.5 % CP, 31.9 % ADF, 47.8 % NDF, 8.24 % ADL, 61.1 % DMD. IGNATIEV et al., (2010), evaluating the chemical composition of *Onobrychis arenaria* cv. 'Veles', reported that the green mass contained 19.8 % crude protein, 2.47 % crude fats, 27.1 % crude cellulose, 7.0 % ash, 43.7 % nitrogen free extract. ASAADI & YAZDI (2011) found that in the dry rangelands of Iran, the chemical composition and the energy value of *Onobrychis radiata* harvested in the flowering stage were 13.65 % CP, 43.46 % ADF, 53.41 % DMD, 7.08 MJ/kg metabolizable energy, while *Onobrychis transcaspica* – 14.82 % CP, 41.48 % ADF, 55.63 % DMD and 7.46 MJ/kg metabolizable energy. According to PANKOV (2013), the green mass of *Onobrychis arenaria* harvested in the flowering stage 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. OKCU & ŞENGÜL (2014) compared the feed quality *Onobrychis* species native to East Anatolia, Turkey remarked the of *Onobrychis viciifolia* contained 14.87% CP, 9.15 % ash, 30.78 % ADF, 39.80 % NDF, but *Onobrychis stenostcahya* subs. *sosnowskyi, Onobrychis hajastana Onobrychis* huetiana subs. *bornmuelleri* 14.65-15.79% CP, 10.12-11.16 % ash, 23.93-3365 % ADF, 40.48-45.36 % NDF. VOLOSHIN (2015) found that the concentrations of nutrients and energy in the first cut dry matter of the tested cultivars of *Onobrychis arenaria* 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 unit/kg, 9.81-10.12 MJ/kg metabolizable energy and 144 g digestible protein per nutritive unit, but in the second cut green mass – 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 and 10.61-11.17 MJ/kg metabolizable energy, respectively. DRONOVA et al., (2016) remarked that *Onobrychis arenaria* grown in irrigated lands contained 17.7 % crude protein, 3.55 % crude fats, 25.0 % crude cellulose, 35.6 % nitrogen free extract and *Onobrychis viciifolia* contained 20.8 % crude protein, 3.13 % crude fats, 23.2 % crude cellulose, 33.9 % nitrogen free extract. DEMYDAS et al., (2019) compared the forage quality of the 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* – 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. HETMAN & VEKLENKO (2019) mentioned that the feed productivity of *Onobrychis arenaria* under the conditions of the right-bank Forest-Steppe Ukraine averaged 45.9-49.6 t/ha green mass, 1.58-1.73 t/ha crude protein, 89.6-89.9 GJ/ha metabolizable energy. According to HEUZE et al., (2020), the average feed value of *Onobrychis viciifolia* fresh aerial part was: 22.3 % dry matter, 16.9 % CP, 4.1 % crude fats, 25.8 % crude fibre, 35.4 % NDF, 30.1 % ADF, 9.4 % lignin, 8.0 % ash, 14.1 g/kg calcium, 4.6 g/kg phosphorus, 30.0 g/kg condensed tannins, 69.4 % digestible organic matter, 19.0 MJ/kg gross energy, 12.6 MJ/kg digestible energy and 10.1 MJ/kg metabolizable energy. According to AZUHNWI et al., (2012) after 42 days of regrowth, the nutritive value of sainfoin was similar to the first growth vegetative stage, with CP ranging from 148 to 186 g/kg, and NDF and ADF concentration averaging 365-454 g/kg and 337-397 g/kg, respectively (Table 2).

Table 2. The biochemical composition and the feed value of *Onobrychis arenaria* hay.

Indices	***Onobrychis arenaria***	
	I cut	II cut
Crude protein, g/kg DM	179	176
Crude fibre, g/kg DM	272	266
Ash, g/kg DM	116	126
Acid detergent fibre, g/kg DM	284	285
Neutral detergent fibre, g/kg DM	381	387
Acid detergent lignin, g/kg DM	45	48
Total soluble sugars, g/kg DM	108	109
Cellulose, g/kg DM	239	237
Hemicellulose, g/kg DM	97	102
Dry matter digestibility, %	66.78	66.70
Digestible energy, MJ/kg DM	13.08	13.07
Metabolizable energy, MJ/kg DM	10.74	10.73
Net energy for lactation, MJ/kg DM	6.76	6.75
Relative feed value	163	160

Hay is a valuable type of feed for farm animals, a rich source of protein, vitamins and minerals, both in winter and throughout the year. The quality of *Onobrychis arenaria* hay is presented in Table 2. The biochemical composition and the fodder quality of prepared hay did not differ significantly in dependence on the harvest time. We would like to mention that hay contained high amounts of crude protein and minerals, but optimal concentration of cell wall components and ash, which had a positive impact on the feed and energy values. The energy concentration reached 13.1 MJ/kg DE, 10.8 MJ/kg ME and 6.8 MJ/kg NEl. The Relative feed value was 160-163 units, which correspond to the premium class quality of hay.

Some authors mentioned various findings about the quality of the hay obtained 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, 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. BAL et al., (2006) showed that the hay produced from sainfoin plants cut in the flowering stage was characterized by 145 g/kg CP, 68.8 g/kg ash, 372.1 g/kg ADF, 492.7 g/kg NDF, 82 g/kg ADL. AUFRERE et al., (2008) remarked that the hay made from *Onobrychis viciifolia* plants cut in the early flowering stage and contained 9.0 % CP, 38.2 % ADF, 50.5 % NDF, 8.4 % ADL, 0.6 % condensed tannins, 59.6 % DMD, but *Medicago sativa* hay – 12.8 % CP, 36.2 % ADF, 50.5 % NDF, 7.6 % ADL, 59.6 % DMD. KAPLAN (2011) found that the chemical composition and the nutritive value of sainfoin hay were 11.39-17.79 % CP, 43.31-47.59 % NDF, 34.34-43.30 % ADF, 5.21-7.30 % ash, 46.60-53.17 % OMD and 6.86-7.79 MJ/kg metabolizable energy. DZYUBENKO & ABDUSHAEVA (2012) reported that *Onobrychis arenaria* hay contained 15.4 % crude protein, 3.2 % crude fat, 6.2 % ash, 24.9 % crude cellulose, 34.0 % nitrogen free extract and 0.54 nutritive units/kg. NIDERKORN et al., (2012) mentioned that *Onobrychis viciifolia* hay had 924 g/kg organic matter, 157 g/kg CP, 346 g/kg NDF, 249 g/kg ADF, 98 g/kg ADL. ÜLGER & KAPLAN (2016) indicated that the chemical composition and the nutritive value of sainfoin hay were 12.73-15.90 % CP, 5.95-7.63 % ash, 2.07-4.70 % condensed tannins, 42.57-53.89 % NDF, 32.01- 41.790 % ADF, 0.69-2.07 % crude fats, 60.05-72.58 % OMD and 8.31-10.19 MJ/kg metabolizable energy. HEUZE et al., (2020) mentioned that the average quality of sainfoin hay was 89.7 % dry matter, 15.2 % CP, 2.1 % crude fats, 26.6 % crude fibre 47.7 % NDF, 35.7 % ADF, 9.0 % lignin, 7.9 % ash, 13.7 g/kg calcium, 3.1 g/kg phosphorus, 54.6 g/kg condensed tannins, 63.2 % digestible organic matter, 18.5 MJ/kg gross energy, 11.0 MJ/kg digestible energy and 8.9 MJ/kg metabolizable energy.

Anaerobic digestion is a versatile process owing to the wide range of input materials that can be used as well as the various utilization options for the produced gas and the accumulated digestate. Biogas is the most flexible and controllable form of energy compared to wind and sun. The advantage of biogas is its better manageability compared to wind and solar power, as it is independent from weather conditions and thus can be produced continuously. Anaerobic digestion using lignocellulosic material as the substrate is a cost-effective strategy for biomethane production, which provides great potential to convert biomass. Lignocellulosic biomass is mainly composed of cellulose, hemicellulose and lignin, which vary a lot based on the types of plants, the conditions of growth and maturation, both in quantity and in quality, into renewable energy. The quality of feedstock for biogas production depends on the nutrient composition and on how accessible it is to enzymes and microbes (VINTILĂ & NEO, 2011; DANDIKAS et al., 2014). Sainfoin is a promising co-substrate for biogas production, playing an important role in the reduction of foam formation, which is considered one of the most frequent disturbances in biogas reactors. It also offers the possibility of partial substitution of maize in biogas systems with beneficial effect on methane yield and environmental protection (AHRENS, 2017; LOHWASSER et al., 2021).

The results regarding the quality of the substrate and the potential for obtaining biogas and biomethane from the freshly harvested mass of the studied *Onobrychis* species are shown in Table 3. We found that in the researched substrates, according to the C/N ratio, which constituted 17-20, the amount of acid detergent lignin (50-61 g/kg) and hemicellulose (124-140 g/kg) met the established standards; the biochemical methane potential of studied substrates varied from 265 to 289 l/kg ODM. The first cut fresh mass substrates contained high amounts of cellulose, hemicellulose and lignin, which had negative effect on degradation and biochemical methane yield. Methane productivity ranged from 1655 to 1830 m^3/ha. *Onobrychis arenaria* was characterised by higher indices due to a higher yield of biomass and substrate quality (Table 3).

Table 3. The biochemical composition and the biomethane production potential of the studied *Onobrychis* species.

Indices	***Onobrychis arenaria***		***Onobrychis viciifolia***	
	I cut	II cut	I cut	II cut
Crude protein, g/kg DM	153	177	155	158
Nitrogen, g/kg DM	24.48	28.32	24.80	25.58
Carbon, g/kg DM	492.78	486.11	493.33	492.22
Ratio carbon/nitrogen	20.13	17.16	19.89	19.24
Acid detergent lignin, g/kg DM	56	50	61	58
Hemicellulose, g/kg DM	124	140	127	135
Biogas potential, L/kg VS	536	565	519	533
Biomethane potential, L/kg VS	275	289	265	273

According to SLEPETYS et al., (2012) the *Onobrychis viciifolia* energy biomass was characterized by 2.59 % Nitrogen, 47.1 % Carbon, 0.17 % Sulphur, C/N=18.2, 57.9 % NDF, 48.3 % ADF, 8.07 % ash, 19.2 % lignin, 4.62 % water soluble carbohydrates and *Medicago sativa* contained 2.365 % Nitrogen, 47.0% Carbon, 0.088% Sulphur, C/N=20.2, 57.5% NDF, 49.1% ADF, 7.67% ash, 16.2% lignin, 5.18% water soluble carbohydrates. In our previous study, we found that the biogas production potential of the fermentable (digestible) organic matter from *Onobrychis arenaria* reached 542 l/kg, *Onobrychis viciifolia* – 526 l/kg and *Medicago sativa* – 514 l/kg, the methane yield was 288 l/kg, 276 l/kg and 270 l/kg, respectively (TELEUŢĂ & ŢÎŢEI, 2016). AMALEVICIUTE-VOLUNGE et al., (2020) reported that the best yields of methane were obtained from *Onobrychis viciifolia* 277.7 L/kg.

The residual phytomass after harvesting the seeds can be processed into briquettes and used for the production of renewable energy. Some physical and mechanical proprieties of residual phytomass after harvesting the seeds are presented in Table 4. It was determined that the moisture content of milled chaff biomass of *Onobrychis* species was 10.2 %, the bulk density of the milled chaffs – 283 kg/m^3, the ash content – 3.98 %, the gross calorific value – 18.01 MJ/kg, the specific density of briquettes – 725.1 kg/m^3. According to XIONG et al., (2008), *Onobrychis viciifolia* biomass has 16.73 MJ/kg net calorific value and 4.43 % ash, but *Phalaris arundinacea* biomass – 16.33 MJ/kg and 9.81 %, respectively (Table 4).

Table 4. Some physical and mechanical properties of residual phytomass after harvesting the seeds.

Indices	***Onobrychis* phytomass**	***Zea mays* stalks (control)**
Moisture content, %	10.2	7.9
Ash content of biomass, %	3.98	4.42
Gross calorific value of biomass, MJ/kg	18.01	17.83
Bulk density of chopped chaffs, kg/m^3	187	87
Bulk density of milled chaffs, kg/m^3	283	100
Specific density of briquettes, kg/m^3	725.1	923.0

CONCLUSIONS

In the first growing year, *Onobrychis arenaria* and *Onobrychis viciifolia* were characterized by an optimal growth rate and regenerative capacity after being cut, making mowing possible twice per season, the productivity reached 2.71-3.15 kg/m^2 green mass or 0.69-0.78 kg/m^2 dry matter.

The dry matter content and its biochemical composition varied depending on the species and harvest time: 153-177g/kg CP, 196-231 g/kg CF,112-125 g/kg ash, 248-278 g/kg ADF, 372-412 g/kg NDF, 50-6 g/kg ADL, 131-155 g/kg TSS, 192-219 g/kg Cel and 124-140 g/kg HC.

The nutritive and energy values of sainfoins fresh mass fodder: 67.32-69.68 % DDM, RFV=152-184, 10.81-11.16 MJ/kg ME and 6.83-7.15 MJ/kg NEl.

The hay prepared from *Onobrychis arenaria* contained 176-179 g/kg CP, 266-272 g/kg CF,116-126 g/kg ash, 284-285g/kg ADF, 381-387 g/kg NDF, 45-48 g/kg ADL, 108-109 g/kg TSS, 237-239 g/kg Cel and 97-102 g/kg HC with 66.70-66.78 % DDM, RFV=160-163, 10.7 MJ/kg ME and 6.8 MJ/kg NEl.

The sainfoins fresh mass substrates for anaerobic digestion had C/N=17-20, the optimal amount of lignin and hemicelluloses, the biochemical methane potential of the studied substrates varied from 265 to 289 l/kg ODM.

The sainfoins phytomass that remained after harvesting the seeds was characterised by moderate gross calorific values (18.0 MJ/kg) and ash content (3.98%), it could be processed into briquettes and used for the production of renewable energy.

The local ecotype of sand sainfoin, *Onobrychis arenaria*, had optimal productivity and nutrient concentration, and can serve as starting material in breeding, improving and implementing new varieties in the production of protein rich forage, as well feedstock for renewable energy.

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