SOME AGROBIOLOGICAL PECULIARITIES AND THE ECONOMIC VALUE OF WHITE SWEETCLOVER, *Melilotus albus*, AND YELLOW SWEET CLOVER, *Melilotus officinalis*, IN THE REPUBLIC OF MOLDOVA

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Abstract. The aim of this study was to evaluate some agrobiological peculiarities, the quality of harvested fresh mass, ensiled mass and prepared hay of the local ecotypes of white sweetclover, *Melilotus albus*, and yellow sweet clover, *Melilotus officinalis*, grown in pure culture in an experimental field of the National Botanical Garden (Institute), Chişinău, Republic of Moldova. Common sainfoin, *Onobrychis viciifolia*, was used as control. In the year when the experiments started, the plants of *Melilotus albus* and *Melilotus officinalis* were characterized by slower growth and development rates as compared with the control, and in the second year, the development rate was optimal, which allowed to reach a productivity of 3.78-4.31 kg/m^2 fresh mass or 1.17-1.20 kg/m^2 dry matter. It was found that the59utrientt content and fodder value were: 132-179 g/kg CP, 330-381 g/kg CF, 81-118 g/kg ash, 331-386 g/kg ADF, 473-567 g/kg NDF, 44-64 g/kg ADL, 72-86 g/kg TSS, 287-322 g/kg Cel, 142-181g/kg HC, 58.8-63.1 % % DDM, RFV=97-124, 11.66-12.42 MJ/kg DE, 9.57-10.20 MJ/kg ME, 5.59-6.22 MJ/kg Nel. The ensiled mass had specific smell, pH=4.42-4.52, 24.0-40.5 g/kg organic acids, 3.4-5.1 g/kg acetic acid, 20.0-35.4 g/kg lactic acid, it contained 127-178 g/kg CP, 348-414 g/kg CF, 99-103 g/kg ash, 333-407 g/kg ADF, 462-581 g/kg NDF, 38-58 g/kg ADL, 62-70 g/kg TSS, 285-349 g/kg Cel, 129-174 g/kg HC, 57.2-63.0 % DDM, RFV=92-129, 9.34-10.19 MJ/kg ME and 5.30-6.20 MJ/kg Nel. The hay prepared from yellow sweet clover, *Melilotus officinalis,* contained 150 g/kg CP, 34 g/kg CF, 83 g/kg ash, 385 g/kg ADF, 493 g/kg NDF, 56 g/kg ADL, 80 g/kg TSS, 317 g/kg Cel and 163 g/kg HC with 59.6 % DDM, RFV=103, 9.69 MJ/kg ME and 5.70 MJ/kg Nel. We found that the fresh and ensiled mass substrates for anaerobic digestion had C/N=17-25 and optimal amount of lignin and hemicelluloses, the biochemical methane potential of the studied substrates varied from 267 to 353 l/kg ODM, but in the control it was about 291-311 l/kg ODM. The local ecotypes white sweetclover, *Melilotus albus*, and yellow sweet clover, *Melilotus officinalis*, have optimal productivity and nutrient concentration, can be serve as alternative fodder crops, as well feedstock in biogas generators for the production of renewable energy.

Keywords: biochemical composition, biomethane, fodder value, *Melilotus albus*, *Melilotus officinalis*.

Rezumat. Unele particularităţi agrobiologice şi valoarea economică a speciilor de sulfină albă *Melilotus albus* şi sulfină galbenă *Melilotus officinalis* în Republica Moldova. Scopul prezentului studiu a constatat în evaluarea unor particularităţi agrobiologice, a calităţii masei proaspete recoltate, a masei însilozate şi fânului preparat din ecotipurile locale de sulfină albă – *Melilotus albus* şi sulfină galbenă *Melilotus officinalis* cultivate în cultură pură pe câmpul experimental din Grădina Botanică Naţională (Institut), Chişinău, Republica Moldova, iar ca martor a servit sparceta comună, *Onobrychis viciifolia*. În anul fondării experienţelor, plantele de *Melilotus albus* şi *Melilotus officinalis* s-au caracterizat print-un ritm mai lent de creştere şi dezvoltare comparativ cu martorul, iar în următorul an ritmul de dezvoltare a fost optimal, fapt ce a permis atingerea productivităţii de 3.78-431 kg/m^2 masă proaspătă sau 1.17-1.20 kg/m^2 substanţă uscată. S-a stabilit că conţinutul de nutrienţi în substanţă uscată a furajului natural şi valoarea lor nutritivă în speciile de sulfină este de 132-179 g/kg proteină brută (CP), 330-381 g/kg celuloză brută (CF), 81-118 g/kg cenuşă, 331-386 g/kg fibre solubile în detergent acid (ADF), 473-567 g/kg fibre solubile în detergent neutru (NDF), 44-64 g/kg lignină sulfurică (ADL), 72-86 g/kg total zaharuri solubile (TSS), 287-322 g/kg celuloză (Cel) şi 142-181 g/kg hemiceluloză (HC), 58.8-63.1 % substanţă uscată digestibilă (DDM), valoare relativă furajeră RFV=97-124, 11.66-12.42 MJ/kg energie digestibilă (DE), 9.57-10.20 MJ/kg energie metabolizantă (ME) şi 5.59-6.22 MJ/kg energie netă pentru lactaţie. Masa însilozată are un miros specific, ph=4.42-4.52, 24.0-40.5 g/kg acizi organici, 3.4-5.1 g/kg acid acetic, 20.0-35.4 g/kg acid lactic, conţine 127-178 g/kg CP, 348-414 g/kg CF, 99-103 g/kg cenuşă, 333-407 g/kg ADF, 462-581 g/kg NDF, 38-58 g/kg ADL, 62-70 g/kg TSS, 285-349 g/kg Cel, 129-174 g/kg HC cu 57.2-63.0 % DDM, RFV=92-129, 9.34-10.19 MJ/kg ME şi 5.30-6.20 MJ/kg Nel. Fânul preparat din sulfină galbenă, *Melilotus officinalis*, conţine 150 g/kg CP, 34 g/kg CF, 83 g/kg cenuşă, 385 g/kg ADF, 493 g/kg NDF, 56 g/kg ADL, 80 g/kg TSS, 317 g/kg Cel şi 163 g/kg HC cu 59.6 % DDM, RFV=103, 9.69 MJ/kg ME şi 5.70 MJ/kg NEl. S-a stabilit că substraturile de masă proaspătă şi de siloz pentru digestia anaerobă se caracterizează printr-un raport de carbon şi azot de C/N=17-25, concentraţie optimală de lignină sulfurică şi hemiceluloză, potenţialul biochimic de obţinere a metanului variază de la 267 la 353 l/kg materie organică, comparativ cu 291-311 l/kg materie organică la martor. Ecotipurile locale de sulfină albă, *Melilotus albus*, şi sulfină galbenă, *Melilotus officinalis*, au o productivitate şi concentraţie optimală de substanţe nutritive, ar putea servi ca culturi alternative leguminoase pentru furajarea animalelor de fermă, dar şi ca substrat pentru staţiile de biogaz pentru producerea energiei renovabile.

Cuvinte cheie: compoziţia biochimică, biometan, valoare nutritivă, *Melilotus albus, Melilotus officinalis*.

INTRODUCTION

Legumes have world-wide importance as a source of food, fodder, feedstock for biorefineries and as a source of nitrogen for natural grasslands and agro-ecosystems. Land deterioration seriously restricts the regional development of society and economy and, in some cases, even threatens the survival of humans. *Fabaceae* plants have gained a lot of attention recently due to their potential uses in ecological restoration of various types saline-alkali land, barren land and mining land. The interest in systems based on legumes has increased significantly over the recent years due to their importance for

sustainable and organic farming. In the European Union, the interest in forage legumes has increased for several economic and environmental reasons (***. The resolution of the European Parliament, 2018; ***. ECPGR, 2021).

The diversification of legume forage production has to be achieved by mobilization, acclimatization and implementation of new species and non-traditional crops from the local flora and from other floristic regions. The efficient use of the biological potential of the native *Fabaceae* species that have adapted to the local climatic conditions becomes more and more relevant (TELEUŢĂ & ŢÎŢEI, 2016; ŢÎŢEI, 2020).

The Plant List (2013) includes 205 scientific plant names of species rank for the genus *Melilotus*, 22 of them are accepted species names, distributed in the Mediterranean countries, Asia and North America, Central and Eastern Europe. There are 6 species of the genus *Melilotus* in Romania and 4 species in the Republic of Moldova. The most known and common species are white sweet clover – *Melilotus albus* Medik. and yellow sweet clover – *Melilotus officinalis* L. (STOIAN, 1987; IZVERSCAIA, 2020). In comparison with other legume species, sweetclover is less demanding to the soil and if there is enough moisture in the soil, it produces high yields even in the poorest soils. Besides, this species is highly resistant to cold and drought. It can extract from the soil and then release phosphorus, potassium and other micronutrients that are otherwise unavailable to crops. Due to its high nitrogen fixing ability, sweetclover is suitable for fertilizing sandy and calcareous soils and for increasing the yields of subsequent crops on arable land. As feedstuff, sweetclover is mainly grown to produce hay, silage, green-chop, pasture and standover feed grazed directly. MARUSCA (2019), using the method of evaluating the productivity of grasslands based on flora relevés, mentioned that *Melilotus albus* was characterized by a high forage value, *Melilotus officinalis* – by average forage value and *Onobrychis viciifolia* – by a very high forage value, the indices for useful green mass were appreciated with a grade of 7-8 points, as very good. It is commonly known that the optimal condensed tannin content provides beneficial effects to protect animals against bloat and increases protein absorption (KUMAR & SINGH, 1984). *Melilotus* species have been credited as one of the most important forage resources of honey plants on the European continent, the productivity has been estimated 200-400 kg/ha honey per year (GLUKHOV, 1974). Sweetclover is, therefore, a new source of fibres that can be cultivated on wet and saline soils, otherwise not suitable for agriculture (RIGAL et al., 2016).

The aim of this study was to evaluate some agrobiological peculiarities, the quality of harvested fresh mass, ensiled mass and prepared hay of the local ecotypes of white sweetclover, *Melilotus albus*, and yellow sweet clover, *Melilotus officinalis*, and the prospects of using them as feed for ruminant animals and as feedstock for the production of renewable energy.

MATERIALS AND METHODS

The local biennial ecotypes of white sweetclover, *Melilotus albus* Medik., and yellow sweetclover, *Melilotus officinalis* L., which were grown in pure culture in the experimental plot of the "Alexandru Ciubotaru" National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subjects of the research, and the traditional fodder crop – common sainfoin, *Onobrychis viciifolia* Scop., was used as control. The experimental design was a randomized complete block design with four replications, and the experimental plots measured 50 m^2. The *Melilotus* seeds were sown in late March, at a depth of 2.0 cm, at a distance of 15 cm between rows, the sowing density was 120 scarified seeds/m^2. The plant growth, development and productivity were assessed according to methodical indications. The sweetclover green mass samples were collected at the 1st cut, in the flowering stage, in the second growing season, while the common sainfoin – in the budding-flowering stage. The leaf/stem ratio was determined by separating leaves and flowers from the stem, weighing them separately and establishing the ratios for these quantities. For this purpose, samples of 1.0 kg harvested plants were taken. The sweetclover 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 fresh mass and fermented fodder samples were dehydrated in an oven with forced ventilation at a temperature of 60°C. At the end of the fixation, the biological material was finely ground in a laboratory ball mill. The quality of the biomass was evaluated by analysing such indices as: crude protein (CP), crude fibre (CF), crude ash (CA), total soluble sugars (TSS), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL) which have been determined by near infrared spectroscopy (NIRS) technique PERTEN DA 7200 of the Research and Development Institute for Grassland Braşov, Romania. The concentration of hemicellulose (HC) and cellulose (Cel), digestible dry matter (DDM), the digestible energy (DE), the metabolizable energy (ME), the net energy for lactation (NEl) and the relative feed value (RFV) were calculated according to standard procedures. The carbon content of the substrates was determined using an empirical equation according to BADGER et al., (1979). The biochemical methane potential was calculated according to DANDIKAS et al., (2015).

RESULTS AND DISCUSSIONS

Analysing the results of the assessment of agro-biological peculiarities, it has been found that the studied *Melilotus* species were characterised by similar growth and development rates, which were low in comparison with *Onobrychis viciifolia*. The *Melilotus* seedlings emerged unevenly at the soil surface at the end of April, 23-37 days after

sowing. *Melilotus* species developed the rosette and 1-3 erect shoots about 53-78 cm long and did not produce flower buds until the end of the first growing season. The green mass productivity of *Melilotus albus* reached 1.74 kg/m^2 with 23.0% dry matter content and *Melilotus officinalis* – 1.64 kg/m^2 with 28.9% dry matter content, but the yield of *Onobrychis viciifolia,* at two cuts, was 2.93 kg/m^2 with 23.9% dry matter content, respectively.

We noticed that, in the second growing season, the regrowth and development of the local ecotypes of sweetclovers plants began when the average temperature was above 5 °C, in the first days of April. It was established that the revival of *Melilotus* plants from dormant buds was uniform, characterized by faster growth and development rates. The development of shoots was observed at the end of April, and their intensive growth – in middle May. *Melilotus officinalis* produced more shoots than *Melilotus albus* plants, but they were shorter and thinner. In comparison with *Onobrychis viciifolia*, the development of flower buds occurred 9 days later in *Melilotus albus* and 16 days later in *Melilotus officinalis*. Some agrobiological peculiarities and the structure of the green mass of the *Fabaceae* species are presented in Table 1. At the time when the green mass was harvested, the *Onobrychis viciifolia* plants reached 99 cm in height, but *Melilotus* plants – 112-130 cm. The productivity of *Melilotus* species reached 3.78-4.31 kg/m^2 or 1.17-1.20 kg/m^2 dry matter, but the yield of *Onobrychis viciifolia* was 4.23 kg/m^2 or 1.01 kg/m^2 dry matter. The harvested green mass of *Melilotus officinalis* was characterized by a higher content of dry matter (31 %) and leaves (78.7%).

Table 1. Some agrobiological peculiarities and the structure of the green mass of the studied *Fabaceae* species.

Plant species	Plant height, cm	Stem, g		Leaf + flower, g		Productivity, kg/m^2	
		fresh mass	dry matter	fresh mass	dry matter	fresh mass	dry matter
Melilotus albus	129.7	10.2	3.0	30.6	8.4	4.31	1.20
Melilotus officinalis	111.6	6.5	1.6	17.7	5.9	3.78	1.17
Onobrychis viciifolia, first cut	99.2	10.1	2.5	12.5	2.9	4.23	1.01

Several literature sources have described the productivity of *Melilotus* species. According to GEIDEMAN (1962), the yield of white sweetclover *Melilotus albus* was 3.0 kg/m^2 green mass and 0.7 kg/m^2 hay, yellow sweetclover *Melilotus officinalis* – 3.5 kg/m^2 green mass and 0.5 kg/m^2 hay. MEDVEDEV & SMETANNIKOVA (1981) mentioned that the green mass productivity of *Melilotus albus* was 42.3-50.0 t/ha and *Melilotus officinalis* – 24.0 t/ha. STOIAN (1987) found that, under the conditions of the Danube Delta, Romania, *Melilotus alba* yielded 32 t/ha fresh mass or 6.4 t/ha dry matter. ANNAEVA et al., (2020) found that, in the saline areas of Uzbekistan, the productivity of *Melilotus albus* cv. Kibray ranged from 31.6 to 38.0 t/ha green mass at the first cut and 22.6-28.1 t/ha green mass at the second cut, but *Medicago sativa* cv. Tashkent yielded 17.5-22.5 t/ha and 17.4-20.9 t/ha, respectively. AVETISYAN et al., (2020) revealed that, under the forest-steppe conditions of the Krasnoyarsk territory, Russia, the productivity of *Melilotus albus* was 49.5 t/ha green mass, 11.3 t/ha dry matter, 122.0 GJ/ha metabolizable energy. KINTL et al., (2022) reported that the productivity of *Melilotus albus* reached 29.9 t/ha green mass or 9.5 t/ha dry matter. KOSOLAPOV et al., (2021) reported that the tested *Melilotus albus* varieties were characterized, in the first year of life, by a growing season of 106-110 days, 78.0-88.1 cm plant height, 14.48-16.39 t/ha green mass with 52.0-58.6 % leaf coverage, 2.88-23.51 t/ha dry matter, but in the second year of life – a growing season of 61-71 days, 145-182 cm plant height, 29.67-38.54 t/ha green mass with 53.9-66.9 % leaf coverage, 6.71-9.74 t/ha dry matter. LAHKIM BENNANI et al., (2021a) evaluated the agronomic performance of twenty ecotypes of yellow sweet clover in North-West of Morocco and showed that the yield of dry matter varied from 4.00 to 14.81 t/ha.

Analysing the results of the fresh mass quality of the local ecotypes of sweetclover, Table 2, we would like to mention that the nutrient content and fodder value were: 132-179 g/kg CP, 330-381 g/kg CF, 81-118 g/kg ash, 331-386 g/kg ADF, 473-567 g/kg NDF, 44-64 g/kg ADL, 72-86 g/kg TSS, 287-322 g/kg Cel, 142-181g/kg HC, 58.8-63.1 % % DDM, RFV=97-124, 11.66-12.42 MJ/kg DE, 9.57-10.20 MJ/kg ME, 5.59-6.22 MJ/kg NEl, but *Onobrychis viciifolia* fodder – 177 g/kg CP, 293 g/kg CF, 96g/kg ash, 309 g/kg ADF, 447 g/kg NDF, 49 g/kg ADL, 114 g/kg TSS, 260g/kg Cel, 135g/kg HC, 64.8 % DMD, RFV=135, 12.73MJ/kg DE, 10.45 MJ/kg ME, 6.48 MJ/kg NEl, respectively. The white sweetclover contained a low amount of crude protein and high amount of structural carbohydrates, lignin, which contributed to the reduction of digestibility, relative feed value and energy concentration as compared with the yellow sweetclover forage. The biochemical composition and the fodder quality of *Melilotus officinalis* did not differ significantly in comparison with *Onobrychis viciifolia* fodder.

Literature sources indicate considerable variation in the chemical composition and nutritional value of *Melilotus* species. According to GEIDEMAN (1962), the *Melilotus alba* herbage contained 13-20 % CP, 2-3% EE, 25-37 % CF, 40-47 % NFE, 0.14-1.41 % cumarin. MEDVEDEV & SMETANNIKOVA (1981) reported that *Melilotus albus* dry matter contained 16-22 % CP, 2-4 % EE, 24-34 % CF, 30-45 % NFE, 7-9 % ash. According to MEZHUNTS (2006), sweetclover fodder is characterized by 926 g/kg OM, 583 g/kg IVDOM, 151 g/kg CP, 18.7 MJ/kg GE and 10.9 MJ/kg DE, but sainfoin – 918 g/kg OM, 569 g/kg IVDOM, 172 g/kg CP, 18.4 MJ/kg GE and 10.5 MJ/kg DE, respectively. CANBOLAT & KARAMAN (2009) compared the feed quality of these species and mentioned that *Melilotus albus* contained 15.91% CP, 1.99 % EE, 6.98 % ash., 43.14% NDF, 33.23% ADF, 12.74% ADL with 72.1% OMD, RFV=135.9, 10.2 MJ/kg ME and 6.4 MJ/kg NEl, but in *Melilotus officinalis* forage there was 15.78% CP, 1.08 % EE, 7.24 % ash., 46.00% NDF, 37.79% ADF, 12.66% ADL with 68.3%OMD, RFV=120.3, 9.4 MJ/kg ME and

5.6 MJ/kg NEl. ÇAÇAN et al., (2015) compared the forage quality of the green mass from different *Fabaceae* species and reported that the *Melilotus alba* plants contained 23.24 % CP, 20.87 % ADF, 36.25 % NDF with 72.64 % OMD and RFV =186.4; *Melilotus officinalis* – 24.71 % CP, 22.11 % ADF, 38.41 % NDF with 71.68 % OMD and RFV=173.6. BOZHANSKA et al., (2016) mentioned that the chemical composition and energy nutritional value of *Melilotus albus* was: 11.76% CP, 3.16 % EE, 32.59% CF, 33.60% NDF, 24.15% ADF; 3.05 % ADL, 9.45% HC, 21.10% Cel, 5.28% ash, 1.84% Ca, 0.25%P, 17.11 MJ/kg GE, 7.48 MJ/kg ME, 0.69 feed unit of milk and 0.63 feed unit of growth. MAKAROV & ANDRUSOVA (2016) mentioned that *Melilotus albus* contained 17.8% CP, 1.9 % EE, 22 % CF, 48 % NFE, 10.6 % ash., 1.73% Ca, 0.26% P, 113g/kg DP, 0.76 feed unit/kg. ZINOVENKO et al., (2016) found that the concentrations of nutrients and energy in the dry matter of the *Melilotus albus* plants harvested in budding stage was 166.3g/kg DM with 18.67 % CP, 3.16 % EE, 25.28 % CF, 6.92 % ash, 0.46-0.68-0.87% coumarin, 1.01 nutritive unit/kg and 10.87 MJ/kg ME, but in the flowering period – 219.4 g/kg DM with 150.1 % CP, 3.42 % EE, 33.14 % CF, 6.83 % ash, 1.25% coumarin, 0.95 nutritive unit/kg and 10.2 MJ/kg ME. DASHKEVICH et al., (2018) found that the nutrient and energy concentrations in the dry matter of the tested ecotypes of *Melilotus albus* were 13.33-19.56 % CP, 1.90-2.26 % EE, 14.60-23.94 % CF, 46.19-56.80 % NFE, 7.43-10.12 % minerals, 0.46-0.90% coumarin and 9.81-10.83 MJ/kg ME, in *Melilotus officinalis* plants – 16.20-20.73 % CP, 2.02-2.28 % EE, 13.18-18.66 % CF, 49.57-57.80 % NFE, 7.73-11.09 % minerals, 0.28-1.13% coumarin and 10.57-11.29 MJ/kg ME. MÜLLER & HAHN (2020) remarked that *Melilotus officinalis* herbage contained 268.6 g/kg DM with 21.7 % CP, 24.29 % CF, 11.06% CF, 4.9 % NFE, 89.3 % ash. HUNADY et al., (2021) reported that *Melilotus alba* dry matter contained 87.23 % OM, 16.68% CP, 4.43 % EE, 19.89% CF, 35.16% NDF, 27.82% ADF. KARA (2021) evaluating of the quality of *Melilotus officinalis* herbages, they mentioned that nutrient matter in early flowering stage was 21.44 % CP, 40.87% $NDF_{OM,}$ 28.51% $ADF_{OM,}$ 25.40% NFC, 2.67%EE, 9.60% ash, 65.54%ODM, 9.29 MJ/kg ME, 5.75 MJ/kg NEl, but in full flowering stage – 16.85 % CP, 44.64% $NDF_{OM,}$ 31.11% $ADF_{OM,}$ 22.63% NFC, 3.07%EE, 8.68% ash, 61.09% ODM, 9.01 MJ/kg ME, 5.49 MJ/kg NEl. KOSOLAPOV et al., (2021) reported that the dry matter of the tested *Melilotus albus* plants, in their first year of life, contained 18.4-20.2 % CP and 22.10-24.20% CF, but in the second growing season – 19.10-23.0 % CP and 22.10-25.20% CF. LAHKIM BENNANI et al., (2021b) found that the average concentrations of nutrients in the dry matter of the *Melilotus officinalis* ecotypes were in the vegetative stage 19.43% CP, 5.76% EE, 14.01% ash and 3.5% ADL, in the budding period 17.91%c CP, 3.64%EE, 10.63% ash and 4.31% ADL, in the flowering period 14.51% CP, 3.01% EE, 8.60% ash and 6.65% ADL.

Table 2. The biochemical composition and the feed value of green mass of the studied *Fabaceae* species.

Indices	*Melilotus albus*	*Melilotus officinalis*	*Onobrychis viciifolia*
Crude protein, g/kg DM	132	179	177
Crude fibre, g/kg DM	381	330	293
Ash, g/kg DM	81	118	96
Acid detergent fibre, g/kg DM	386	331	309
Neutral detergent fibre, g/kg DM	567	473	447
Acid detergent lignin, g/kg DM	64	44	49
Total soluble sugars, g/kg DM	86	72	114
Cellulose, g/kg DM	322	287	260
Hemicellulose, g/kg DM	181	142	138
Digestible dry matter, g/kg DM	588	631	648
Relative feed value	97	124	135
Metabolizable energy, MJ/kg DM	11.66	12.42	12.73
Net energy for lactation, MJ/kg DM	9.57	10.20	10.45
Digestible energy, MJ/kg DM	5.59	6.22	6.48

Ensiling, a lactic acid fermentation process, is mainly used to preserve forage and has substantial effects on the nutritive value, which has a positive effect on the health of farm animals, particularly in autumn and winter. During the sensorial assessment it was found that the silage from sweetclovers consisted of olive stems with dark green leaves and has a peculiar smell, similar to pickled apples, while the haylage prepared from common sainfoin consisted of yellowish-green leaves and yellow-green stems and it had a pleasant smell like pickled vegetables. The texture of the plant mass stored as silage and haylage was preserved well, without mold and mucus. The results regarding the quality of the fermented fodder are shown in Table 3. It has been determined that the pH values of the fermented fodder depended on the species, thus, *Melilotus* silages had a pH=4.42-4.52, lower than *Onobrychis viciifolia* haylage. The content of organic acids in the fermented fodder from *Melilotus albus* did not vary essentially in comparison with *Onobrychis viciifolia* haylage, but was much lower than in *Melilotus officinalis*. Most organic acids were in fixed form, butyric acid not was detected. According to the Moldavian standard SM 108, the ratio of acetic acid and lactic acid of the studied fermented fodder corresponds to the 1st class quality. It was found that during the process of ensiling, the concentrations of crude protein and acid detergent lignin in *Melilotus albus* silage decreased, but the level of minerals, neutral detergent fibre increased in comparison with the harvested green mass. In white sweetclover silage, the amount of crude protein and energy concentrations were reduced as compared with sainfoin haylage. We would like to mention that the *Melilotus officinalis* silage was characterised by higher content of crude protein and 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.

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

Indices	*Melilotus albus*	*Melilotus officinalis*	*Onobrychis viciifolia*
pH index	4.42	4.52	4.68
Organic acids, g/kg DM	24.00	40.50	23.40
Free acetic acid, g/kg DM	0.30	1.90	1.10
Free butyric acid, g/kg DM	0	0	0
Free lactic acid, g/kg DM	2.30	9.0	4.40
Fixed acetic acid, g/kg DM	3.10	3.20	2.20
Fixed butyric acid, g/kg DM	0	0	0
Fixed lactic acid, g/kg DM	18.30	26.4	15.70
Total acetic acid, g/kg DM	3.40	5.10	3.30
Total butyric acid, g/kg DM	0	0	0
Total lactic acid, g/kg DM	20.60	35.40	20.10
Acetic acid, % of organic acids	14.20	12.59	14.10
Butyric acid, % of organic acids	0	0	0
Lactic acid, % of organic acids	85.80	87.41	85.90
Crude protein, g/kg DM	127	178	142
Crude fibre, g/kg DM	414	348	312
Ash, g/kg DM	99	103	118
Acid detergent fibre, g/kg DM	407	333	317
Neutral detergent fibre, g/kg DM	581	462	470
Acid detergent lignin, g/kg DM	58	38	40
Total soluble sugars, g/kg DM	62	70	135
Cellulose, g/kg DM	349	285	277
Hemicellulose, g/kg DM	174	129	153
Digestible dry matter, g/kg DM	572	630	642
Digestible energy, MJ/kg DM	92	129	127
Metabolizable energy, MJ/kg DM	11.38	12.41	12.63
Net energy for lactation, MJ/kg DM	9.34	10.19	10.37
Relative feed value	5.30	6.20	6.38

Several studies have evaluated the potential of *Melilotus* species for silage production. MEDVEDEV & SMETANNIKOVA (1981) mentioned that white sweetclover silage contained 23.1 % DM, including 3.4% CP, 1.6% EE, 9.4% CF, 7.2% NFE, 1.6 % ash, 2.2 g/kg Ca, 0.64 g/kg P and 84 mg/kg carotene. POPP et al., (2015) reported that sweetclover silage was characterized by 22.2 % DM, pH 4.5, lactic acid 0.1 g/kg fresh mass, acetic acid 1.3 g/kg fresh mass, butyric acid 0.32 g/kg fresh mass, 8.6% CP, 0.9% EE, 38.0% NFE, 41.0 % Cel, 31.0 % HC and 15.0% lignin. ZINOVENKO et al., (2016) found that the biochemical composition of the silage prepared from *Melilotus albus* plants harvested in the budding stage was 276.9/kg DM with pH = 4.2, 3.42% lactic acid, 0.56% acetic acid, 18.12 % CP, 2.96 % EE, 25.78 % CF, 6.59 % ash, 0.46-0.68-0.87% coumarin, 1.01 nutritive unit/kg and 10.87 MJ/kg ME, but in the silage prepared in the flowering stage, there was 305.9 g/kg DM with pH = 4.2, 3.26% lactic acid, 0.45% acetic acid, 117.24% CP, 3.05 % EE, 26.45 % CF, 7.25 % ash, 1.25% coumarin, 0.95 nutritive unit/kg and 10.2 MJ/kg ME. MÜLLER & HAHN (2020) reported that *Melilotus officinalis* ensiled feedstock after a storage period of 90 days had pH 4.61, 9.66 g/kg lactic acid, 0.03 g/kg propionic acid, 1.25 g/kg ethanol. KINTL et al., (2022) remarked that the quality of silage from pure white sweetclover was 332.5 g/kg DM, pH 4.2, 8.20 g/kg lactic acid, 2.51 g/kg acetic acid, 0.83 g/kg ethanol, butyric acid 0.32 g/kg fresh mass, 92.24% OM, 14.48% CP, 2.88%EE, 8.57 % starch, 37.00% ADF, 43.43% NDF, 5.6% ADL, 8.04 mg/kg coumarin. KARA (2021), evaluating of the quality of *Melilotus officinalis* silage, mentioned that when prepared from plants harvested in early flowering stage, it contained 230 g/kgDM, pH 3.88, 5.76 g/kg lactic acid, 0.712 g/kg acetic acid, 0.003 g/kg butyric acid, 22.78 % CP, 37.60% $NDF_{OM,}$ 25.95% $ADF_{OM,}$ 27.02% NFC, 2.80%EE, 9.79%ash, but – in full flowering stage – 250 g/kgDM, pH 4.25, 3.68 g/kg lactic acid, 0.727 g/kg acetic acid, 0.002 g/kg butyric acid, 16.48 % CP, 42.16% $NDF_{OM,}$ 29.36% $ADF_{OM,}$ 29.69% NFC, 2.90%EE, 8.75% ash, respectively.

Hay is a valuable type of feed for farm animals and the quality of hay depends on the plant species, on the age at which these plants have been harvested, on the morphological structure of the herbage, on the techniques and equipment used for hay preparation, on the conditions of its storage and on many other factors. Each factor and even combinations of them can have an impact on the nutritional value of hay. The results regarding the quality of hay prepared from the studied *Fabaceae* species are shown in Table 4. During the process of preparing hay, we observed an increase in the concentration of crude fibre, cellulose, hemicellulose, acid detergent lignin and a decrease in crude protein, soluble sugar, which had a negative effect on dry matter digestibility, relative feed value and energy concentration as compared with the initial green mass. A more substantial change in biochemical composition and nutritional value is probably attested in the morphological structure of the herbage. ZVEREVA (2016) in a comparative study on the loss of aerial organs and their parts during haymaking and the wilting intensity of cut shoots in perennial legume grasses in the forest-steppe of West Siberia, found that after cutting, more intense loss of vegetative and generative organs was observed in *Medicago* and *Melilotus* plant species (22-30% of the total weight); the process of

drying of shoots and leaves of legume grasses was uneven, *Medicago varia*, *Melilotus albus* and *Melilotus officinalis* plants had smaller leaves; the loss of their vegetative organs at drying was greater; their petioles dried out faster than the leaf blades. However, the hay prepared from local ecotype *Melilotus officinalis* was characterized by optimal content of crude protein, relative feed value, metabolizable energy and net energy for lactation and could be fed to livestock. HOSSEINKHANI et al., (2018) found that *Melilotus officinalis* hay contained 87.96 % DM, 7.09% ash, 13.28% CP, 7.48 % EE, 33.76% NDF, 23.55% ADF with 70.54 % DMD, 96.84% relative palatability and 9.99 MJ/kg ME; but *Medicago sativa* hay contained 87.52 % DM, 5.95% ash, 14.30% CP, 6.10 % EE, 35.48% NDF, 23.86% ADF with 70.30 % DMD, 100.00 % relative palatability and 9.95 MJ/kg ME.

Table 4. The biochemical composition and the feed value of hay from studied *Fabaceae* species.

Indices	***Melilotus officinalis***	***Onobrychis viciifolia***
Crude protein, g/kg DM	150	163
Crude fibre, g/kg DM	374	338
Ash, g/kg DM	83	99
Acid detergent fibre, g/kg DM	385	335
Neutral detergent fibre, g/kg DM	493	496
Acid detergent lignin, g/kg DM	56	52
Total soluble sugars, g/kg DM	80	60
Cellulose, g/kg DM	317	283
Hemicellulose, g/kg DM	163	161
Dry matter digestibility, %	596	628
Digestible energy, MJ/kg DM	11.80	12.38
Metabolizable energy, MJ/kg DM	9.69	10.16
Net energy for lactation, MJ/kg DM	5.70	6.18
Relative feed value	103	118

Table 5. The biochemical composition and the biomethane production potential of the studied *Fabaceae* species.

Indices	***Melilotus albus***		***Melilotus officinalis***		***Onobrychis viciifolia***	
	green mass	**silage**	**green mass**	**silage**	**green mass**	**haylage**
Crude protein, g/kg DM	132	127	179	178	177	142
Nitrogen, g/kg DM	21.12	20.32	28.64	28.48	28.30	22.70
Carbon, g/kg DM	510.60	500.60	490.00	498.22	502.20	490.00
Ratio carbon/nitrogen	24.2	24.6	17.1	17.5	17.7	21.6
Acid detergent lignin, g/kg DM	64.0	58.0	44.0	38.0	49.0	40.0
Hemicellulose , g/kg DM	181.0	174.0	142.0	129.0	138.0	153.0
Biomethane potential, L/kg VS	267	278	344	353	291	311

In the context of the current sharp rise in energy prices, diminishing supplies of fossil fuels, greenhouse gas emission and frequent weather anomalies caused by climate change, in order to ensure energy security, it is imperative to identify alternative resources and to develop new technological processes for renewable energy production. Biomass is an attractive and convenient energy resource that can be used in the processes of decarbonisation and energy transition. Anaerobic digestion using lignocellulosic material as the substrate is a cost-effective strategy for biomethane production, which provides great potential to convert biomass. The quality of feedstock for biogas production depends on the nutrient composition and on how accessible it is to enzymes and microbes. Coumarin rich plants are a promising co-substrate for biogas production, playing an important role in the activity of bacteria and 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 (KINTL et al., 2020). The carbon to nitrogen ratio is one of the basic factors governing the correct course of methane production by fermentation. Methanogenic bacteria need a suitable ratio of carbon to nitrogen for their metabolic processes, ratios higher than 30:1 were found to be unsuitable for optimal digestion, and ratios lower than 10:1 were found to be inhibitory, due to low pH, poor buffering capacity and high concentrations of ammonia in the substrate. The results regarding the quality of substrates and their biochemical methane potential are illustrated in Table 5. We found that in the tested *Melilotus* green mass substrates, according to the C/N ratio, which constituted 17.1-24.2, the amount of acid detergent lignin (44-64 g/kg) and hemicellulose (142-181g/kg) met the established standards; the biochemical methane potential of the studied substrates varied from 267 to 344 l/kg ODM, and 291 l/kg ODM in the control. As we have mentioned above, the process of ensiling reduced the concentration of acid detergent lignin, which had a positive effect on the activity of methanogenic bacteria. The biochemical biomethane potential of sweetclover silage substrates reached 278-353 L/kg. The best biomethane potential was achieved in *Melilotus officinalis* substrates. According to POPP et al., (2015) the cumulative methane yield of substrate co-digestion of sweetclover silage and cow manure was almost equal: 266 L/kg VS for the 2.5 % coumarin content substrate and 259 L/kg VS for the 5.0% coumarin substrate, respectively, and 265 L/kg VS for the coumarin-free control substrate. MÜLLER & HAHN (2020) reported that *Melilotus officinalis* substrates achieved 600 l/kg biogas or 315 l/kg specific methane yield, but maize substrates – 620 l/kg or 335 l/kg specific methane yield. KINTL et al., (2022) found that, in sweetclover silage, the average biogas yield was 0.4741 m^3/kg VS and the methane yield was 0.2741m^3/kg VS or 68.5 % methane content in biogas after 35 days of

the experiment. HUNADY et al., (2021) calculated the theoretical methane yield and revealed that the values of biomass from *Galega orientalis*, *Lathyrus pratensis*, *Trigonella foenum-graecum* and *Melilotus alba* ranged from 0.161 to 0.172 m^3/kg VS, the methane yield of the biomass of *Onobrychis viciifolia*, *Astragalus cicer*, *Dorycnium germanicum* and *Vicia sylvatica* ranged from 0.141 to 0.160 m^3/kg VS and the absolutely lowest value – 0.120-0.140 m^3/kg VS – was calculated for *Medicago sativa*.

CONCLUSIONS

The productivity of the local ecotypes of *Melilotus albus* and *Melilotus officinalis*, in the first year, reached 1.64-1.74 kg/m^2 green mass or 0.40-048 kg/m^2 dry matter, but in the second year, 3.78- 4.31 kg/m^2 green mass or 11.7-1.20 kg/m^2 dry matter. The dry matter of the harvested mass, in the second year, contained 132-179 g/kg CP, 330-381 g/kg CF, 81-118 g/kg ash, 331-386 g/kg ADF, 473-567 g/kg NDF, 44-64 g/kg ADL, 72-86 g/kg TSS, 287-322 g/kg Cel, 142-181g/kg HC, with 58.8-63.1 % % DDM, RFV=97-124, 11.66-12.42 MJ/kg DE, 9.57-10.20 MJ/kg ME and 5.59-6.22 MJ/kg NEl.

The silage prepared from *Melilotus albus* and *Melilotus officinalis* is characterized by specific smell, pH=4.42-4.52, 24.0-40.5 g/kg organic acids, 3.4-5.1 g/kg acetic acid, 20.0-35.4 g/kg lactic acid, it contained 127-178 g/kg CP, 348-414 g/kg CF, 99-103 g/kg ash, 333-407 g/kg ADF, 462-581 g/kg NDF, 38-58 g/kg ADL, 62-70 g/kg TSS, 285-349 g/kg Cel, 129-174 g/kg HC with nutritive and energy values: 57.2-63.0 % DDM, RFV=92-129, 9.34-10.19 MJ/kg ME and 5.30-6.20 MJ/kg NEl.

The hay prepared from yellow sweet clover, *Melilotus officinalis,* contained 150 g/kg CP, 34 g/kg CF, 83 g/kg ash, 385 g/kg ADF, 493 g/kg NDF, 56 g/kg ADL, 80 g/kg TSS, 317 g/kg Cel and 163 g/kg HC with 59.6 % DDM, RFV=103, 9.69 MJ/kg ME and 5.70 MJ/kg NEl.

The biochemical methane potential of sweetclovers green mass substrates reaches 267 to 344 L/kg organic matter and in silage substrates respectively 278-353 L/kg organic matter.

The local ecotype of yellow sweetclover, *Melilotus officinalis* is distinguished by a higher feed value and biochemical methane potential.

The local ecotype of sweetclovers can be used for the restoration of degraded lands, as a component of the mix of grasses and legumes for the creation of temporary grasslands. The harvested biomass can be used as alternative fodder for farm animals or as substrates in biogas generators for the production of renewable energy.

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