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# SOME BIOLOGICAL PECULIARITIES AND THE BIOMASS QUALITY OF COMMON BUCKWHEAT, *Fagopyrum esculentum*, GROWING UNDER THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

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***Abstract***

*Common buckwheat - Fagopyrum esculentum Moench, Polygonaceae family, is a short-season crop, cultivated for its grain-like seeds and as a melliferous and cover crop, enabling more complete adaption to its environment than other traditional crops. The goal of this research was to evaluate some biological peculiarities and the biomass quality of common buckwheat Fagopyrum esculentum cultivated in the experimental sector of the "Alexandru Ciubotaru" National Botanical Garden (Institute), Chisinau, Republic of Moldova. The prospects of using harvested biomass as forage and substrates for biomethane production were assessed. We found that whole-plant dry matter, cut in the early flowering stage, contained 15.4% CP, 9.4% ash, 37.5%CF, 39.1% ADF, 57.7% NDF, 6.6% ADL, 32.5% Cel, 18.1% HC, 6.9% TSS, with nutritive and energy values: 584 g/kg DDM, RFV= 95, 11.74 MJ/kg DE, 9.51 MJ/kg ME and 5.54 MJ/kg NEl, but in seed formation stage - 10.8% CP, 8.0% ash, 36.2% CF, 38.3% ADF, 58.9% NDF, 6.9% ADL, 31.4% Cel, 21.6% HC, 10.1% TSS, with nutritive and energy values: 591 g/kg DDM, RFV= 93, 11.88 MJ/kg DE, 9.62 MJ/kg ME and 5.62 MJ/kg NEl. The quality of the silage prepared from whole plants cut in the seed formation stage was: pH = 3.76, 39.9 g/kg lactic acid, 0.2 g/kg butyric acid, 10.9 g/kg acetic acid, 226/kg DM with 9.6% CP, 7.7% ash, 35.5% CF, 36.2% ADF, 55.5% NDF, 5.5% ADL, 30.7% Cel, 24.5% HC, 8.4% TSS, with nutritive and energy values: 607 g/kg DDM, RFV = 102, 12.00 MJ/kg DE, 9.85 MJ/kg ME and 5.87 MJ/kg NEl. It has been estimated that the green mass substrates for anaerobic digestion, have C/N=20.5-29.5, optimal amount of lignin and hemicelluloses, the biochemical methane potential reaches 292-305 l/kg ODM, but in ensiled substrate - C/N=33.3 and biochemical methane potential 314 l/kg ODM.*

***Key words****: biochemical composition, biological peculiarities, biomass, biomethane, Fagopyrum esculentum, green mass, silage.*

## INTRODUCTION

The continuous global population growth has resulted in the intensification of food and energy production, which has been necessary in order to cover the rising demands to maintain the standards of living.

The family *Polygonaceae*, as mentioned by "The Plant List", includes 59 plant genera, with 5,385 scientific plant names, 1,384 are accepted species names. The representatives of this family are present worldwide, but are most diverse in the North Temperate Zone. It consists mostly of herbs and some trees, shrubs and vines. Several species are cultivated for seeds and vegetables, forage, medicinal plant, energy biomass, also as ornamentals and cover crop. The genus *Fagopyrum* Mill. is composed of 26 diploid/tetraploid species of which common buckwheat, *Fagopyrum esculentum* Moench. and tartary buckwheat, *Fagopyrum tataricum* Gaertn. are the most cultivated species, their edible gluten-free seeds are eaten as groats or used sometimes in flour, particularly for buckwheat pancakes, and portions of the plant are frequently included in animal feed. Common buckwheat, *Fagopyrum esculentum* Moench., is one of the oldest domesticated food crops from Asia. It is native to south-central China and Tibet and has been introduced into suitable climates across Eurasia, Africa and the Americas. It is an annual herbaceous plant, stems – ascending or erect, ribbed, reddish, with internodes, branched above, glabrous or papillate on one side, reaching up to the height of 1.5 m. Leaves petiolate, petiole 0.5-2 cm long, grooved lower leaves with long petiole, upper ones subsessile; lamina triangular or sagittate, cordate, basal lobes rounded to acuminate, 1.5-10 x 1-8 cm,

ochrea 2-3 (5) mm long, hyaline, pubescent near the base. The inflorescence is composed of numerous clusters of flowers (panicles in long axillary spikes) containing 5-6 flowers attached to the nodes of the stem, flowers white or cream, pink or red. The indeterminate growth habit whereby ripened seeds coexist with green seeds and few flowers in the same plant. The fruits are achenes - about 5-7 mm with 3 prominent sharp angles, flat surfaces, pale brown. *Fagopyrum esculentum* has deep rooted, branched, taproot system. It tolerates a wide range of soil types and fertility levels, but performs best when the climate is cool and moist. Common buckwheat is low fertiliser requirements, the seeding rate depends on the purpose of cultivating the crop, thus, 30-40 kg/ha are needed when used as a grain crop or about 50 kg/ha when used as a cover/fodder crop; a low seeding rate has the potential to increase weed competition because of the low density of the plant population and hence results in low yield; sowing depth depends on the type of soil and climatic conditions. The *Fagopyrum esculentum* has a wide range of agronomic and health benefits that make it a promising crop for sustainable agricultural production. The achenes are gluten free, have high nutritional quality of proteins and are rich in minerals; the levels of fibre and starch with reduced speed of digestion and rutin made buckwheat products favourable for healthy nutrition, patients with diabetes and coeliac disease. Young plantlets can be consumed in salads it is rich in amino acids, minerals and fibres, more valuable than seeds from a nutritional point of view, with higher concentration of lysine and vitamin C (Campbell, 1997; Ohnishi, 1998; Treadwell & Huang, 2008; Jacquemart et al., 2012; Mariotti et al., 2015; Farooq et al., 2016; Arduni et al., 2016; Arduni & Mariotti, 2018; Heuzé et al., 2019; Ohsako & Li, 2020).

*Fagopyrum esculentum* is of interest to beekeepers because flowering lasts generally until the first frosts, a period when there are few other melliferous plants. Buckwheat honey has dark colour and strong taste. Best common buckwheat cultivars produce from 150 to 300 kg/ha (Campbell, 1997; Cawoy et al., 2008; Alekseyeva & Bureyko, 2000; Ion et al., 2018; Liszewski & Chorbiński, 2021).

The goal of this research was to evaluate some biological peculiarities and the quality of fresh and ensiled biomass of common buckwheat *Fagopyrum esculentum,* as fodder for ruminant animals, as well as substrate for the production of biomethane by anaerobic digestion.

## MATERIALS AND METHODS

The common buckwheat *Fagopyrum esculentum,* which was cultivated in the experimental plot of the National Botanical Garden (Institute) of Moldova, Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″, served as subject of research and the traditional crop alfalfa, *Medicago sativa* and corn, *Zea mays*, were used as control variants. The experimental design was a randomised complete block design with four replications, and the experimental plots measured 10 $m^2$. *Fagopyrum esculentum* was sown in the middle of May, at 25-cm row spacing and a rate of 5 $g/m^2$. The green mass was harvested manually at 5 cm cutting height, in the flowering and seed formation period. The leaf/stem ratio was determined by separating the leaves from the stem, weighing them separately and establishing the ratios for these quantities (leaves/stems). The common buckwheat silage was prepared from green mass harvested in the seed formation period, cut into small pieces and compressed in glass containers. The containers were stored for 45 days, and then, they were opened and the organoleptic assessment and the determination of the organic acid composition of the persevered forage were done in accordance with the Moldavian standard SM 108. The dry matter content was detected by drying samples to constant weight at 105°C. For biochemical analysis, the plant samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with mesh diameter of 1 mm and some of the main biochemical parameters, such as crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM), digestible organic matter (DOM) were determined by near infrared spectroscopy (NIRS) using PERTEN DA 7200 with standardized methods at the RDI for Grassland Brasov, in Romania. The concentration of hemicellulose (HC), cellulose (Cel), digestible

energy (DE), metabolizable energy (ME), net energy for lactation (NEl) and relative feed value (RFV) were calculated according to standard procedures.

The carbon content of substrates was obtained using an empirical equation according to Badger et al. (1979). The biochemical methane potential was calculated according to the equations of Dandikas et al. (2015).

## RESULTS AND DISCUSSIONS

As a result of the study on the biological peculiarities of studied taxa of common buckwheat *Fagopyrum esculentum*, the emergence of the seedlings was observed on the 4$^{th}$-6$^{th}$ days after sowing, the development of the stem - in 7-8 days after seedling emergence, the formation of the flower buds occurred at the end of June and the flowering period during July-August, the seed formation period in middle July, the seed ripening August-September.

The structure of the common buckwheat harvested aerial plant biomass and its yield are shown in Table 1. At the flowering stage, the height of *Fagopyrum esculentum* plants was 116.1 cm, while in seed formation stage it reached 126.4 cm, *Medicago sativa* plants, at first cut, were 84.5 cm tall, but at the third cut - 53.8 cm. The green mass productivity of *Fagopyrum esculentum* plants cut in flowering stage reached 29.2 t/ha green mass or 3.8 t/ha dry matter with 44.5% leaves and flowers, while those cut in seed formation stage produced 12.8 t/ha green mass or 3.8 t/ha dry matter with 61.8% leaves, but the leguminous forage crop *Medicago sativa* at the first cut yielded 27.7 t/ha green mass, 7.2 t/ha dry matter with 52.9 % leaves and flowers, while at the third cut - 9.6 t/ha green mass, 2.2 t/ha dry matter with 62.5% leaves, respectively.

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

| Plant species | Plant height cm | Stem, g | | Leaf + flower, g | | Yield, t/ha | |
|---|---|---|---|---|---|---|---|
| | | fresh mass | dry matter | fresh mass | dry matter | fresh mass | dry matter |
| *Fagopyrum esculentum,* flowering stage | 106.9 | 28.10 | 2.84 | 11.40 | 2.28 | 29.20 | 3.80 |
| *Fagopyrum esculentum,* seed formation stage | 126.4 | 20.75 | 4.92 | 16.30 | 3.67 | 30.60 | 7.11 |
| *Medicago sativa*, first cut | 84.5 | 6.21 | 1.63 | 6.92 | 1.81 | 27.70 | 7.20 |
| *Medicago sativa*, third cut | 53.8 | 5.93 | 0.92 | 5.81 | 1.53 | 9.60 | 2.01 |

Analysing the results of the common buckwheat fresh mass quality (Table 2), we concluded that the dry matter of the whole plants harvested in the flowering stage contained of 15.4% CP, 9.4% ash, 37.5% CF, 39.1% ADF, 57.7% NDF, 6.6% ADL, 32.5% Cel, 18.1% HC, 6.9% TSS, with nutritive and energy values: 584 g/kg DDM, RFV = 95, 11.74 MJ/kg DE, 9.51 MJ/kg ME and 5.54 MJ/kg NEl, but the harvested whole plants in seed formation stage - 10.8% CP, 8.0% ash, 36.2% CF, 38.3% ADF, 58.9% NDF, 6.9% ADL, 31.4 % Cel, 21.6% HC, 10.1% TSS, with nutritive and energy values: 591 g/kg DDM, RFV= 93, 11.88 MJ/kg DE, 9.62 MJ/kg ME and 5.62 MJ/kg NEl, respectively. The common buckwheat natural forage contained optimal amount of crude protein, structural carbohydrates, lignin and energy concentration, as compared with the *Medicago sativa* natural forage. As compared with green corn forage, the buckwheat forage stands out due to its higher concentration of crude protein, minerals, cell wall fractions and low level of total soluble sugars, digestibility, relative feed value and energy concentration.

Literature sources indicate considerable variation in the chemical composition and nutritional value of *Fagopyrum* whole plants. According to Larin (1952), buckwheat green fodder contained in dry matter - 10.7% CP, 2.8% EE, 28.2% CF, 48.7% NFE, hay - 12.2% CP, 2.4 % EE, 31.5%CF, 41.4% NFE, straw 6.0% CP, 1.9% EE, 40.0% CF, 44.5% NFE. Campbell (1997) showed that buckwheat green fodder is characterised by 36.6% DM, including 4.6% CP, 0.9% EE, 8.0% CF, 19.5% NFE, 3.6% minerals. Amelchanka et al. (2010) mentioned that the use of fresh buckwheat reduced ruminal ammonia concentrations and enhanced estimated microbial nitrogen growth efficiency, the contents of net energy for lactation in fresh mass was 4.3 MJ/kg, but in ensiled mass 4.9 MJ/kg. Kälber et al. (2011) compared the forage quality of green mass

from flowering catch crops and remarked that buckwheat green forage contained 160 g/kg DM, 13.8% CP, 1.97 % EE, 50.2% NDF, 38.3% ADF, 8.26% ADL, 11.2 % ash; phacelia forage - 120 g/kg DM, 14.9% CP, 2.44% EE, 46.9% NDF, 34.9% ADF, 8.35% ADL, 15.0% ash; berseem clover forage –117 g/kg DM, 17.1% CP, 2.59% EE, 43.2% NDF, 33.9% ADF, 7.03% ADL, 12.8% ash; chicory forage - 104 g/kg DM, 19.1% CP, 3.46% EE, 40.1% NDF, 29.4% ADF, 7.46% ADL, 19.0% ash, but ryegrass forage -131 g/kg DM, 19.0% CP, 3.23% EE, 56.0% NDF, 33.1% ADF, 4.92% ADL, 12.9% ash. Kara (2014) reported that the mineral nutrient content in harvested buckwheat biomass was 1.42-3.29% N, 1.99-3.43% Ca, 0.204-0.294% P, 1.93-5.76% K, 0.314-0.643% Mg. Mariotti et al. (2015) remarked that herbage quality of buckwheat plant in the green achene stage was 12.0 % ash, 14.4 % CP, 2.2 % EE, 45.2 % NDF, 27.9 % ADF, 6.2 % ADL, 30.3 % NFC, 15.6 % HC, 23.5 % Cel, 53.3 % TDN and RFV=135.7, but in the brown achene stage: 9.6% ash, 10.3% CP, 1.7 % EE, 41.8% NDF, 26.7% ADF, 6.8% ADL, 34.9% NFC, 15.1% HC, 19.9% Cel, 58.5% TDN and RFV = 152.2, respectively. Görgen et al. (2016) found that *Fagopyrum esculentum* forage contained 95-142 g/kg DM with 14.3-23.8% CP, 41.2-57.6 % NDF, 31.3-33.4% ADF**,** 10.1-15.2% ash, but *Pennisetum glaucum* forage contained 127-172 g/kg DM with 20.2-24.2% CP, 52.1-55.1% NDF, 25.1-27.5% ADF**,** 10.6-12.2% ash. Leiber et al. (2018) reported that the chemical composition of the experimental dietary components from total aerial part of buckwheat plants was 917 g/kg OM, 11.0% CP, 1.5% EE, 46.0% NDF, 28.4% non-NDF carbohydrates, 4.8% total extractable phenols, but the ryegrass fodder contained 910 g/kg OM, 16.6% CP, 3.8% EE, 52.6% NDF, 17.2 % non-NDF carbohydrates, 0.82% total extractable phenols. Heuze et al. (2019) remarked that the average dry matter content and fodder value of common buckwheat fresh mass was: 159.8 g/kg DM, 14.6% CP, 0.9% EE, 28.4% CF, 46.3% NDF, 33.9% ADF, 7.7% lignin, 11.4% ash, 25.6 g/kg Ca, 2.4 g/kg P, 60.2% DOM, 17.6 MJ/kg GE, 10.6 MJ/kg DE and 8.5 MJ/kg ME. Bhardwaj & Hamama (2020) remarked that *Fagopyrum esculentum* forages contained 20.8 % CP, 5.6 % EE, 38.4% NDF and 31.4% ADF. Omokanye et al. (2021) mentioned that the content of dry matter and concentration nutrients in *Fagopyrum esculentum* biomass was 227 g/kg DM, 12.2% CP, 57.0% NDF, 38.8% ADF, 14.0 g/kg Ca, 2.5 g/kg P, with 57.0 % TDN, 1.40 Mcal/kg net energy of maintenance and RFV=96. Erol et al. (2022) reported that buckwheat forage harvested in the flowering stage consisted of 30.49-48.30% leaf rate, the dry matter contained 19.39-22.66% CP, 19.89-27.58% ADF, 30.86-40.14% NDF and RFV=158.92-221.40, but the forage harvested in the milk stage contained 20.00-44.54% leaves, 12.80-16.17% CP, 26.59-30.30% ADF, 36.60-45.04% NDF and RFV = 115.39-175.48. Zhou et al. (2022) compared the forage quality of eight Tartary buckwheat cultivars harvested in different growth stages mentioned that nutritional contents were 3.15-7.08% CP, 3.39-5.39% EE, 6.00-20.20% CF, 29.92-50.04% NDF, 24.72-42.02% ADF, 52.25-68.35% NFE, 7.38-17.49% ash, 0.20-0.34% Ca, 0.16-0.40% P, 50.83-64.07% TDN, RFV = 121.31-217.39 and RFQ = 124.90-224.54.

Ensiled fodder is a key element for productive and efficient ruminant livestock farms, which provides a uniform level of high-quality feed for ruminants, particularly in the autumn - middle spring period, but also throughout the year. The prepared silage from common buckwheat cut in seed formation stage was distinguished by light olive leaves and yellow stems with pleasant smell specific to pickled vegetables, but corn silage - by homogeneous yellow colour with pleasant smell like pickled fruits; the consistency was retained, in comparison with the initial plant green mass, without mould and mucus. As a result of the performed analysis (Table 3), it was determined that the silage fermentation profile of prepared silages was pH = 3.76-3.77, 5.60-17.00 g/kg free lactic acid, 5.10-5.50 g/kg free acetic acid, 21.10-39.00 g/kg fixed lactic acid, 5.20-5.40 g/kg fixed acetic acid, 0.20 g/kg fixed butyric acid. In buckwheat silage, the concentration of total organic acids is higher, and fixed lactic acid predominates, as compared with corn silage.

Table 2. The biochemical composition and the nutritive value of the harvested green mass of the studied species

| Indices | *Fagopyrum esculentum* | | *Medicago sativa* | | *Zea mays* |
|---|---|---|---|---|---|
| | flowering stage | seed formation stage | first cut | third cut | |
| Crude protein, g/kg DM | 154 | 108 | 170 | 141 | 84 |
| Minerals, g/kg DM | 94 | 80 | 90 | 90 | 52 |
| Crude fibre, g/kg DM | 375 | 362 | 341 | 383 | 248 |
| Acid detergent fibre, g/kg DM , | 391 | 383 | 365 | 393 | 271 |
| Neutral detergent fibre, g/kg DM | 577 | 589 | 558 | 579 | 474 |
| Acid detergent lignin, g/kg DM | 66 | 69 | 63 | 66 | 48 |
| Total soluble sugars, g/kg DM | 69 | 101 | 63 | 69 | 336 |
| Cellulose, g/kg DM | 325 | 314 | 302 | 327 | 223 |
| Hemicellulose, g/kg DM | 181 | 216 | 193 | 186 | 203 |
| Digestible dry matter, g/kg DM | 584 | 591 | 605 | 583 | 678 |
| Relative feed value | 95 | 93 | 101 | 94 | 133 |
| Digestible energy, MJ/ kg | 11.74 | 11.88 | 11.96 | 11.57 | 13.28 |
| Metabolizable energy, MJ/ kg | 9.51 | 9.62 | 9.82 | 9.50 | 10.90 |
| Net energy for lactation, MJ/ kg | 5.54 | 5.62 | 5.83 | 5.51 | 6.91 |

Table 3. The fermentation profile, the nutrient composition of the silage prepared from the studied species

| Indices | *Fagopyrum esculentum* | *Zea mays* |
|---|---|---|
| pH index | 3.76 | 3.77 |
| Content of organic acids, g/kg DM | 51.00 | 48.60 |
| Free acetic acid, g/kg DM | 5.50 | 5.10 |
| Free butyric acid, g/kg DM | 0 | 0 |
| Free lactic acid, g/kg DM | 5.60 | 17.00 |
| Fixed acetic acid, g/kg DM | 5.40 | 5.20 |
| Fixed butyric acid, g/kg DM | 0.20 | 0.20 |
| Fixed lactic acid, g/kg DM | 39.90 | 21.10 |
| Total acetic acid, g/kg DM | 10.90 | 10.30 |
| Total butyric acid, g/kg DM | 0.20 | 0.20 |
| Total lactic acid, g/kg DM | 39.9 | 38.10 |
| Acetic acid, % of organic acids | 21.37 | 21.19 |
| Butyric acid, % of organic acids | 0.38 | 0.41 |
| Lactic acid, % of organic acids | 78.24 | 78.40 |
| Crude protein, g/kg DM | 96.00 | 80.00 |
| Crude fibre, g/kg DM | 355.00 | 245.00 |
| Minerals, g/kg DM | 77.00 | 59.00 |
| Acid detergent fibre, g/kg DM | 362.00 | 258.00 |
| Neutral detergent fibre, g/kg DM | 555.00 | 469.00 |
| Acid detergent lignin, g/kg DM | 55.00 | 37.00 |
| Total soluble sugars, g/kg DM | 84.00 | 326.00 |
| Cellulose, g/kg DM | 307.00 | 221.00 |
| Hemicellulose, g/kg DM | 245.00 | 211.00 |
| Digestible dry matter, g/kg DM | 607.00 | 688.00 |
| Relative feed value | 102 | 136 |
| Digestible energy, MJ/ kg | 12.00 | 13.45 |
| Metabolizable energy, MJ/ kg | 9.85 | 11.04 |
| Net energy for lactation, MJ/ kg | 5.87 | 7.06 |
| Carbon, g/kg DM | 513.00 | 522.78 |
| Nitrogen, g/kg DM | 7.10 | 12.80 |
| Ratio carbon/nitrogen | 72 | 41 |
| Biomethane potential, L/kg VS | 303 | 338 |

As compared with the initial fresh mass, the *Fagopyrum esculentum* silage (Table 3), had optimal concentration of crude protein, total soluble sugars and minerals, reduced content of neutral detergent fibre and acid detergent lignin, which had a positive impact on dry matter digestibility, relative feed value and net energy for lactation. It has been found that the concentration of crude protein, acid detergent lignin and minerals in buckwheat silage is higher, but the concentration of carbohydrates and energy is lower than in corn silage.

Different results are presented in the literature regarding the biochemical composition and feed value of buckwheat silage. Kälber et al. (2012) found that the ensilability was optimal for buckwheat sward, and the buckwheat silage contained 135 g/kg CP, 15.8 g/kg EE, 445 g/kg ADF and 75.7 g/kg ADL. Mariotti et al. (2015) remarked that the quality of ensiled forage of buckwheat in the green achene stage was pH = 3.8, 1.4% lactic acid, 12.1% ash, 14.2% CP, 1.3% EE, 49.1 % NDF, 35.2% ADF, 8.9% ADL, 26.0% NFC, 13.9% HC, 26.3% Cel, 50.1% TDN and RFV = 117.2, but in the brown achene stage, respectively, pH = 4.1, 1.4% lactic acid, 10.1% ash, 10.1% CP, 1.8% EE, 44.2% NDF, 32.0% ADF, 8.7% ADL, 35.7% NFC, 12.2% HC, 23.3% Cel, 55.5% TDN and RFV = 135.3. Herrmann et al. (2016) studied the biochemical composition of silages made of various crops in Germany and remarked that buckwheat silage contained 231 g/kg dry matter with 89.9 % organic matter, pH = 5.0, 4.5% lactic acid, 1.3% acetic acid, 0.6% butyric acid, 11.4% CP, 1.7% EE, 44.4% NFE, 52.2% NDF, 42.6% ADF and 13.4% ADL; the silage made from buckwheat/phacelia mixtures - 256 g/kg dry matter with 91.5% organic matter, pH = 4.0, 3.9% lactic acid, 2.1% acetic acid, 0.3% butyric acid, 9.4% CP, 2.7% EE, 52.3% NFE, 42.9% NDF, 37.8% ADF, 8.5% ADL, but maize silage - 302 g/kg dry matter with 95.8 % organic matter, pH= 3.7, 5.1 % lactic acid, 1.6 % acetic acid, 0 % butyric acid, 7.8 % CP, 2.6 % EE, 64.7 % NFE, 41.2 % NDF, 24.0 % ADF and 2.9 % ADL. Keles et al. (2016) reported that buckwheat silages contained 89.8% OM, 2.9% EE, 12.7% CP, 47.2% NDF, 38.1% ADF, 9.5% ADL, 71.9% DOM, 1.92 Mcal/kg ME, but maize silage - 94.1% OM, 2.6% EE, 7.5% CP, 50.9% NDF, 27.3% ADF, 3.9% ADL, 71.9% DOM and 2.18 Mcal/kg ME.

A developing society needs energy to sustain its growth. Renewable energy has become the core element of sustainable development nowadays. Versatile energy sources such as biomass, are used for various purposes, including biogas production. The product of this process is combustible methane, carbon dioxide, some hydrogen and digested effluent can be used as fertilizer. Plant biomass may be used for biogas production directly after harvest and as ensiled substrates. The results regarding the quality of the *Fagopyrum esculentum* substrates and the potential for obtaining biomethane are shown in Table 4. Methanogenic bacteria need a suitable ratio of carbon to nitrogen for their metabolic processes. The nitrogen content in the investigated buckwheat substrates ranged from 15.36 g/kg to 24.64 g/kg, the estimated content of carbon - from 503.33 g/kg to 512.78 g/kg, the C/N ratio varied from 20.42 to 33.38; the alfalfa substrates contained 22.56-27.20 g/kg nitrogen, 500.0 g/kg carbon and C/N = 18.38-22.16; the corn substrates contained 12.80-13.44 g/kg nitrogen, 511.11-527.00 g/kg carbon and C/N = 39.00-39.93. Essential differences were observed between the acid detergent lignin and hemicellulose contents. The buckwheat green mass substrates contained lower amounts of hemicellulose and higher amounts of lignin than buckwheat silage substrate, the biochemical methane potential varied from 292-305 l/kg VS in green mass substrates to 314 l/kg VS in silage substrate. The biochemical methane potential of buckwheat substrates, as compared with alfalfa substrates, does not differ essentially, but as compared with corn substrates, it is lower. According to Pabón Pereira (2009) *Fagopyrum esculentum* substrate contained 170 g/kg DM, 90% OM, 44 % total fibre, 5% lignin, 26% Cel, 12% HC, 4% starch, 14% protein, with biochemical methane potential 320 l/kg, but *Hordeum vulgare* substrate contained 380 g/kg DM, 95% OM, 65 % total fiber, 2% lignin, 23 % Cel, 40 % HC, 22 % starch, 9% protein, with biochemical methane potential 300 l/kg. Herrmann et al. (2016) mentioned that buckwheat silage substrates had C/N = 26.4, biochemical methane potential 210.4 l/kg VS; buckwheat/phacelia mixture silage - C/N=29 and biochemical methane potential 232.9 l/kg VS, but maize silage C/N = 37 and biochemical methane potential 328.2 l/kg VS. Elsayed et al. (2019) reported that buckwheat husk substrate had 97.60% volatile solids, 47.50% total carbon, 2.30% total nitrogen, C/N = 20.65 and cumulative methane yields achieved 200 mL/g VS, but wheat straw substrate contained 95.64% volatile solids, 47.62% total carbon, 0.30% total nitrogen, C/N = 158.73 and 230 mL/g VS methane yields.

Table 4. The biochemical biomethane production potential of the researched substrates

| Indices | *Fagopyrum esculentum* | | | *Medicago sativa* | | *Zea mays* | |
|---|---|---|---|---|---|---|---|
| | green mass, flowering stage | green mass, seed formation stage | silage | green mass, first cut | green mass, third cut | green mass | silage |
| Crude protein, g/kg DM | 154.00 | 108.00 | 96.00 | 170.00 | 141.00 | 84.00 | 80.00 |
| Minerals, g/kg DM | 94.00 | 80.00 | 77.00 | 90.00 | 90.00 | 52.00 | 59.00 |
| Nitrogen, g/kg DM | 24.64 | 17.28 | 15.36 | 27.20 | 22.56 | 13.44 | 12.80 |
| Carbon, g/kg DM | 503.33 | 511.11 | 512.78 | 500.00 | 500.00 | 527.00 | 511.1 |
| Ratio carbon/nitrogen | 20.42 | 29.58 | 33.38 | 18.38 | 22.16 | 39.00 | 39.93 |
| Hemicellulose, g/kg DM | 181.00 | 216.00 | 245.00 | 193.00 | 186.00 | 203.00 | 221.0 |
| Acid detergent lignin, g/kg DM | 66.00 | 69.00 | 55.00 | 63.00 | 69.00 | 48.00 | 37.00 |
| Biomethane potential, L/kg VS | 305 | 292 | 314 | 314 | 298 | 321 | 338 |

## CONCLUSIONS

The *Fagopyrum esculentum* whole plants cut in the early flowering stage contained 15.4% CP, 9.4% ash, 37.5% CF, 39.1% ADF, 57.7% NDF, 6.6% ADL, 32.5% Cel, 18.1% HC, 6.9% TSS, with nutritive and energy values: 584 g/kg DDM, RFV= 95, 11.74 MJ/kg DE, 9.51 MJ/kg ME and 5.54 MJ/kg NEl, but in the seed formation stage - 10.8% CP, 8.0% ash, 36.2% CF, 38.3% ADF, 58.9% NDF, 6.9% ADL, 31.4% Cel, 21.6% HC, 10.1% TSS, with nutritive and energy values: 591 g/kg DDM, RFV= 93, 11.88 MJ/kg DE, 9.62 MJ/kg ME and 5.62 MJ/kg NEl.

The quality of the silage prepared from *Fagopyrum esculentum* whole plants cut in the seed formation stage was: pH= 3.76, 39.9 g/kg lactic acid, 0.2 g/kg butyric acid, 10.9 g/kg acetic acid, 226 g/kg DM with 9.6 % CP, 7.7 % ash, 35.5 % CF, 36.2 % ADF, 55.5 % NDF, 5.5 % ADL, 30.7 % Cel, 24.5 % HC, 8.4 % TSS, with nutritive and energy values: 607 g/kg DDM, RFV= 102, 12.00 MJ/kg DE, 9.85 MJ/kg ME and 5.87 MJ/kg NEl.

The *Fagopyrum esculentum* green mass substrates for anaerobic digestion, have C/N = 20.42-29.58 and the biochemical methane potential reaches 292-305 l/kg ODM, but in ensiled substrate - C/N = 33.38 and biochemical methane potential was 314 l/kg ODM.

The *Fagopyrum esculentum* plants develop well under the climatic conditions of Moldova, and green mass and silage have optimal feeding value, and also may be used as feedstock for biomethane production.


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