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# THE QUALITY OF GREEN MASS AND THE SILAGE FROM PEARL MILLET, *PENNISETUM GLAUCUM,* GROWING UNDER THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

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***Abstract***

*Pearl millet, Pennisetum glaucum (L.) R. Br.] is a $C_4$ climate-resilient plant species, the sixth most important cereal crop of the world, has great potential as grain and multi-purpose forage for arid and semi-arid ecosystems. We studied some agrobiological peculiarities, the concentration of nutrients in green mass and silage prepared from pearl millet, Pennisetum glaucum, grown in an experimental field of the National Botanical Garden (Institute), Chişinău. It was established that the pearl millet plants harvested in the flowering period contained 200 g/kg dry matter, its biochemical composition was:10.19% crude protein, 3.11 % crude fats, 31.61% crude cellulose, 40.28% nitrogen free extract, 5.45% soluble sugars 1.79 g/kg starch, 14.80% ash, 6.0 g/kg calcium 3.9 g/kg phosphorus and 50.0 mg/kg carotene. The quality of the prepared silage was: pH= 4.08, 25.0 g/kg lactic acid, 7.3 g/kg acetic acid, butyric acid – not detected, 7.42 % crude protein, 3.87 % crude fats, 30.56% crude cellulose, 47.29% nitrogen free extract, 1.55% soluble sugars 1.19 g/kg starch, 10.86% ash, 4.2 g/kg calcium 2.7 g/kg phosphorus and 28.0 mg/kg carotene.*

***Key words**: biochemical composition, green mass, pearl millet, Pennisetum glaucum, silage.*

## INTRODUCTION

Demand for animal-source foods is increasing because of population growth, rising incomes and urbanization. The global human population is estimated to reach 9.6 billion in 2050, with about 70% living in urban areas, whereas incomes are expected to increase by 2% a year. As a consequence, the growth of the livestock sector is expected to continue in the coming decades. The global meat and milk production growth was possible due to significant increases in livestock numbers but also to productivity growths. Most of the meat and milk from domestic herbivores is produced by cattle, with 20% of meat and 83% of milk; buffaloes produce 1% of global meat production and 13% of milk; small ruminants have a smaller contribution, with 5% of meat and 4% of milk (Mottet et al., 2018). Forages are the major part of the diet of ruminant animals and provide energy, proteins, minerals, vitamins.

Climate change affects crop production by directly influencing biophysical factors such as plant and animal growth along with the various areas associated with food processing and distribution. Assessment of the effects of global climate changes on agriculture can be helpful to anticipate and adapt farming to maximize the agricultural production more effectively. The incorporation of neglected and underused crops, the domestication of new species would promote agricultural diversity and could provide a solution to many of the problems associated with food security, nutrition, healthcare, medicine and industrial needs. It has been well established that the plant species with $C_4$ photosynthesis type can easier face the adverse effects of high temperature, water insufficiency and salinity stress, besides such crops have the potential to maintain productivity, increase income and food security of farming communities in semiarid and arid regions. Millets are especially gaining popularity due to their high resilience to climate change effects and acceptable productivity and nutritional value (Jukanti et al., 2016).

Pearl millet, *Pennisetum glaucum* (L.) R. Br., *Poaceae* family (syn. *Pennisetum americanum, Pennisetum typhoides, Pennisetum typhoideum, Pennisetum spicatum, Setaria glauca*) is cultivated extensively in the Indian subcontinent and African semiarid regions since prehistoric times. Currently, Pearl millet is the sixth most important cereal crop after rice, wheat, maize, barley and sorghum in the world with over 33 million hectares, accounts for approximately 50 % of the total world production of millets and it is a crop of major importance in arid and semi-arid regions. Pearl millet or cattail millet is a robust, strongly tillering, annual, herbaceous, grass plant, usually 1-4 m tall, with basal and nodal tillering, producing an extensive and dense root system, which may reach a depth of 1.2-1.6 m, sometimes even of 3.5 m; sometimes the nodes near ground level produce thick, strong prop roots. The stem is slender, 1-3 cm in diameter, solid, often densely villous below the panicle, with prominent nodes. The leaf sheath is open and often hairy; the ligule is short, membranous, with a fringe of hairs; the leaf blade is linear to linear-lanceolate, up to 1.5 m × 5-8 cm, and has margins with small teeth, scaberulous and often pubescent. The inflorescence is cylindrical or ellipsoidal, contracted, with a stiff and compact panicle, similar to a spike, 15-200 cm long. The spikelet is 3-7 mm long, consisting of 2 glumes and usually 2 florets. The caryopsis is globose, subcylindrical or conical, 2.5-6.5 mm long, the colour varies from white, pearl, or yellow to grey-blueish and brown, occasionally purple (Oyen & Andrews, 1996; Marsalis et al., 2012; Sharma et al., 2021). Pearl millet is drought- and heat-tolerant and has a considerable ability to grow and yield in poor, sandy and saline soils under arid, hot, and dry climates; this is an advantage over other popular forage grasses in the region, such as fodder maize. It is also a hydrocyanic and prussic acid-free crop, which gives it nutritional superiority over sorghum species (Hassan et al., 2014; Jukanti et al., 2016).

The aim of this study was to evaluate some biological peculiarities, the biochemical composition and the fodder value of green mass and silage from pearl millet, *Pennisetum glaucum.*

## MATERIALS AND METHODS

The introduced ecotype of pearl millet, *Pennisetum glaucum*, which was cultivated in the experimental plot of the National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subject of the research, and the traditional fodder crops – corn, *Zea mays* and sudangrass, *Sorghum sudanense* were used as control variants. The pearl millet and sudangrass green mass samples were collected in full flowering period, while the corn – in the kernel milk-wax 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 dry matter content was detected by drying samples up to constant weight at 105 °C. For chemical analyses, the samples were dried at 65 ± 5 °C. For ensiling, the green mass was shredded and compressed in well-sealed containers. After 45 days, the containers were opened, the organoleptic assessment was carried out. The content of crude protein (CP), crude fats (EE), crude cellulose (CF), nitrogen free extract (NFE), soluble sugars (TSS), starch, ash, calcium (Ca), phosphorus (P), carotene, lactic, acetic and butyric acids, silage pH index, nutritive units and metabolizable energy were appreciated in accordance with standard laboratory procedures at the Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, Maximovca.

## RESULTS AND DISCUSSIONS

Analyzing the results of the assessment of agro-biological peculiarities, it can be noted that pearl millet, *Pennisetum glaucum* seedlings emerged on the soil surface 3-9 days after sowing. For uniform germination, pearl millet needs higher soil temperature, 14-15°C, than traditional fodder crops: corn and sudangrass. Compared to sudangrass, pearl millet has the potential to produce many effective tillers that may expand on large areas. The colour of the investigated pearl millet plants is deep purple. In the full flowering period, the *Pennisetum glaucum* plants were shorter than *Sorghum sudanense* plants, but the stems were four times thicker and thus had a positive impact on tiller mass. The yield of *Pennisetum glaucum* plants harvested in full flowering period reached 5.65 kg/m$^2$ green mass or 1.17 kg/m$^2$ dry matter, with 25.2 % leaves, 58.1 % stems and 16.7 % panicles, but the yield of *Sorghum sudanense* was 4.58 kg/m$^2$ green mass or 0.83 kg/m$^2$ dry matter with 26.3 % leaves, 64.4 % stems and 9.3 % panicles. The biomass productivity of *Zea mays* harvested in kernel milk-wax period was 5.88 kg/m$^2$ green mass or 1.81 kg/m$^2$ dry matter.

Several literature sources have described the productivity of *Pennisetum glaucum* plants. According to Medvedev& Smetannikova (1981), in the Kuban region of Russia, the green mass productivity of *Pennisetum glaucum* var. *aristatum* was 40.5-51.0 t/ha, but *Pennisetum glaucum* var, *inermis* yielded 34.0-43.0 t/ha. Shashikala et al. (2016) found that fodder yield potential of multicut pearl millet genotypes were 55.2-81.1 t/ha green mass, 13.3-27.7 t/ha dry matter and 1.39-3.04 t/ha crude protein. Toderich et al. (2016) reported that, in some marginal lands of Central Asia, the productivity of pearl millet ranged from 42.23 to 45.12 t/ha green mass at the first cut and 27.18-31.23 t/ha green mass at the second cut, respectively, the total annual aboveground dry matter varied from 27.18 to 31.23 t/ha. As a result of a research conducted by Gurinovich et al. (2020) in the Oryol region of Russia, it has been revealed that the three years' period average yield of pearl millet cultivar *'Gurso'* was 65.4 t/ha green mass and cultivar *'Sogur'* 62.4 t/ha green mass.

The bio-morphological characteristics of the whole plant have a significant impact on the biochemical composition and feed value of the green mass. The quality of the harvested green mass of studied *Poaceae* species, is presented in Table 1. It was found that the dry matter content of the whole pearl millet plant is 220.00 g/kg, but in the harvested mass from traditional fodder crops, it varied from 182.20 g/kg in sudangrass to 307.70 g/kg in corn. Analysing the results of the biochemical composition of dry matter, we would like to mention that pearl millet fodder was characterised by a significantly higher content of proteins (10.19 %), as compared with sudangrass (8.91 %) and corn green mass (6.61 %). The concentrations of crude fats in pearl millet fodder also were high. The level of crude cellulose in pearl millet fodder was low as compared with sudangrass and higher as compared with corn green mass. The nitrogen free extract content in pearl millet fodder reached 40.28%, which was lower than in corn green mass and optimal as compared with Sudan grass. The dry matter in pearl millet fodder contained a low amount of starch and soluble sugars as compared with corn green mass. The concentrations of minerals, including calcium and phosphorus were very high in the pearl millet green mass. It was found that the concentrations of carotene in pearl millet fodder also were significantly high. Therefore, 100 kg of pearl millet green mass contained 19.3 nutritive units, 1.57 kg digestible protein and 196 MJ metabolizable energy; 100 kg of Sudan grass green mass – 17.8 nutritive units, 1.14 kg digestible protein and 188 MJ metabolizable energy; 100 kg of corn green mass – 30.0 nutritive units, 1.07 kg digestible protein and 319 MJ metabolizable energy. Different results regarding the biochemical composition and the nutritive value of the green mass from pearl millet, *Pennisetum glaucum*, whole plants are given in the specialized literature. Sheta et al. (2010) reported that "forage pearl millet contained 8.08-11.95 % CP, 71.38-77.49 % NDF, 40.07-45.45 % ADF; the application of higher nitrogen doses increased protein yields, but decreased ADF and NDF contents, while potassium application increased protein yields and decreased NDF contents". According to Heuze et al. (2015), "the average feed value of fresh pearl millet aerial part was: 19.4 % dry matter, 12.4 % CP, 2.0 % EE, 29.2 % CF, 64.8 % NDF, 34.5 % ADF, 4.2 % lignin, 2.7 % WSC, 12.3 % ash, 5.5 g/kg Ca and 2.8 g/kg P, 63.8 % DOM, 17.6 MJ/kg GE, 10.8 MJ/kg DE and 8.7 MJ/kg ME". Babiker et al., (2015) mentioned that "pearl millet contained 8.8-16.2 % CP, 29.2-43.9 % CF, 32.8-50.5 % NFE, and crude protein yield varied from 560 to 1717 kg/ha". Anjum & Cheema (2016) remarked that "the harvested fresh millet forage contained 32.15% DM, 7.12% CP, 21.82% CF, 69.81% NDF, 42.93% ADF and 52.55% TDN". Toderich et al. (2016) found that "the concentrations of nutrients in the pearl millet dry matter of the tested ecotype at the first cut were 7.31-14.88 % CP, 2.65-3.80 % EE, 24.72-30.90 % CF, 32.62-50.31 % NFE, 5.29-11.02 % minerals, 0.82% Ca and 0.32% P, but in the dry matter at the second cut: 7.81-15.34 % CP, 1.11-4.59 % EE, 24.30 - 29.77 % CF, 36.07-50.77 % NFE 6.80-12.13 % minerals, 0.83% Ca and 0.30% P, respectively, and in third cut dry matter: 7.22-15.37 % CP, 1.07-2.04 % EE, 24.32 -30.49 % CF, 42.69-

51.47 % NFE, 6.96-11.51% minerals, 0.80% Ca and 0.33% P". Other researchers, such as Costa et al., (2018) found that "the chemical-bromatological composition of pearl millet was 314 g/kg DM, 149 g/kg CP, 545 g/kg NDF, 308 g/kg ADF, 48 g/kg EE, 20 g/kg ash, 695 g/kg TDN with 692 g/kg IVDMD". Machicek et al., (2019) compared the forage production and the feed quality of green mass from pearl millet and sorghum-sudangrass and found that "pearl millet produced 6.29 - 9.87 t/ha DM with 4.3-5.1 % CP, 58.9-64.5 % NDF, 38.0-39.3 % ADF, 58.6-59.9 % TDN, RFV 85.5-90.8, while sorghum-Sudan grass hybrid – 11.05-15.51 t/ha DM with 4.2-4.4 % CP, 58.3-62.0 % NDF, 38.60-39.9 % ADF, 57.9-59.5 % TDN, RFV 88.5-92.5". Muhanov (2019) revealed that "*Pennisetum glaucum* green mass contained 233-253 g/kg dry matter with 11.7-12.4 % CP, 1.9 % EE, 32.6-32.8 % CF, 2.2-2.3 % TSS, 9.0 % ash, 20.1-20.5 mg/kg carotene, 0.20-0.22 nutritive units/kg green mass and metabolizable energy 2.14-2.33 MJ/kg green mass, but *Sorghum sudanense* green mass contained 217-233 g/kg dry matter with 10.7-11.4% CP, 2.2-2.3 % EE, 33.6-34.7 % CF, 1.1-1.2 % TSS, 19.8-20.1 mg/kg carotene, 7.8-8.2 % ash, 0.20-0.21 nutritive units/kg green mass and metabolizable energy 2.17-2.33 MJ/kg".

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

| Indices | *Pennisetum glaucum* | *Zea mays* | *Sorghum sudanense* |
|---|---|---|---|
| Dry matter content, g/kg | 220.00 | 307.70 | 182.20 |
| Crude protein, % DM | 10.19 | 6.61 | 8.91 |
| Crude fats, % DM | 3.11 | 2.85 | 2.56 |
| Crude cellulose, % DM | 31.61 | 19.19 | 43.52 |
| Nitrogen free extract, % DM | 40.28 | 67.44 | 34.99 |
| Soluble sugars, % DM | 5.45 | 9.65 | - |
| Starch, % DM | 1.79 | 23.42 | - |
| Ash, % DM | 14.80 | 3.91 | 10.02 |
| Nutritive units/ kg GM | 0.19 | 0.30 | 0.18 |
| Metabolizable energy, MJ/kg GM | 1.96 | 3.19 | 1.88 |
| Calcium, % | 0.60 | 0.24 | 0.49 |
| Phosphorus, % | 0.39 | 0.19 | 0.23 |
| Carotene, mg/ kg GM | 50.75 | 15.83 | 42.00 |

Table 2. The biochemical composition and the fodder value of the silage from studied *Poaceae* species

| Indices | *Pennisetum glaucum* | *Zea mays* | *Sorghum sudanense* |
|---|---|---|---|
| Dry matter content, g/kg | 205.9 | 312.9 | 200.0 |
| pH index | 4.08 | 3.88 | 3.82 |
| Content of organic acids, g/kg | 32.3 | 32.2 | 33.6 |
| Free acetic acid, g/kg | 3.3 | 3.0 | 2.5 |
| Free butyric acid, g/kg | 0 | 0 | 0 |
| Free lactic acid, g/kg | 10.3 | 9.1 | 12.3 |
| Fixed acetic acid, g/kg | 4.0 | 3.4 | 2.4 |
| Fixed butyric acid, g/kg | 0 | 0 | 0.1 |
| Fixed lactic acid, g/kg | 14.7 | 16.7 | 16.3 |
| Total acetic acid, g/kg | 7.3 | 6.4 | 4.9 |
| Total butyric acid, g/kg | 0 | 0 | 0.1 |
| Total lactic acid, g/kg | 25.0 | 25.8 | 28.6 |
| Acetic acid, % of organic acids | 22.6 | 19.9 | 14.6 |
| Butyric acid, % of organic acids | 0 | 0 | 0.3 |
| Lactic acid, % of organic acids | 77.4 | 80.2 | 85.1 |
| Crude protein, % DM | 7.42 | 6.68 | 5.38 |
| Crude fats, % DM | 3.87 | 4.10 | 2.51 |
| Crude cellulose, % DM | 30.56 | 18.16 | 41.32 |
| Nitrogen free extract, % DM | 47.29 | 67.33 | 43.49 |
| Soluble sugars, % DM | 1.55 | 2.30 | - |
| Starch, % DM | 1.19 | 24.77 | - |
| Ash, % DM | 10.86 | 3.19 | 7.30 |
| Nutritive units/ kg GM | 0.19 | 0.30 | 0.19 |
| Metabolizable energy, MJ/kg GM | 1.93 | 3.19 | 2.03 |
| Calcium, % DM | 0.42 | 0.28 | - |
| Phosphorus, % DM | 0.27 | 0.21 | - |
| Carotene, mg/ kg GM | 28.00 | 24.77 | 38.5 |

According to Gurinovich et al. (2020), in the harvested green mass of the new '*Gurso*' cultivar of pearl millet, the content of dry matter ranged from 15.1 to 18.0%, the dry matter contained 14.6% CP, 9.5% DP, 27.3% CF, 10.5% sugar with nutritive value 0.69 feed units/kg and 9.25 MJ/kg metabolizable energy. Salama et al. (2020) found that “the concentrations of nutrients and energy in the dry matter of the tested genotype of pearl millet at the first harvest, were 6.5-7.07 % CP, 64.47-68.22 % NDF, 33.36-35.89 % ADF, 2.94-3.75 % ADL, 49.52-54.38 % NFE, 40.35-42.17 % TDN.

Silage is the main conserved green succulent roughage fodder for domestic herbivores, important way for reducing feed costs and increasing profitability. During the sensorial assessment, it was found that, in terms of colour, the silage from pearl millet had specific dark green leaves and red-maroon stems and panicles, with pleasant smell, specific to pickled apples, while the silage made from corn and sudangrass were homogeneous green-yellow with pleasant smell, specific to pickled vegetables. The results regarding the quality of the prepared silage are shown in Table 2. It has been determined that the pH values of the prepared silage depended on the species, thus, *Pennisetum glaucum* silage had higher pH value than *Sorghum sudanense* and *Zea mays* silages. The content of organic acids in the silages prepared from the studied *Poaceae* species did not vary essentially, most organic acids were in fixed form. Butyric acid was not detected in pearl millet silage, but acetic acid level reached 7.3 g/kg, which was higher in comparison with corn and sudangrass silages. It was found that during the process of ensiling, the concentrations of crude protein and soluble sugars decreased, but the level of crude cellulose did not modify essentially in comparison with the green mass. In pearl millet and sudangrass silages, the amount of nitrogen free extract was high, but lower as compared with corn silage.

Several studies have evaluated the potential of pearl millet as silage for ruminants. According to Hernández et al. (2013), the chemical composition of silage was: 10.26-10.98 % CP, 8.68-9.31 % DP, 57.80-61.87% NDF, 35.05-37.12% ADF, 5.24-6.01% EE, 12.82-13.04% ash, 0.48% Ca, 0.17-0.18%P. Anjum & Cheema (2016) reported that “the silage was characterized by 31.97 % DM, pH 4.12, 6.18% lactic acid, 7.02% CP, 22.15% CF, 71.82% NDF, 44.15% ADF and 55.18% TDN. Costa et al. (2018) found that “the monocropped pearl millet silage was characterized by pH 3.75, 47.3 g/kg lactic acid, 6.7 g/kg acetic acid, 0.1 g/kg butyric acid, 148.1 g/kg CP, 573.2 g/kg NDF, 337.1 g/kg ADF, 47.3 g/kg EE, 16.7 g/kg ash, 689 g/kg TDN with 683.5 g/kg IVDMD”. Alix et al. (2019) remarked that “after 90 ensiling days, the pearl millet silage had pH 3.8, 55-60 g/kg lactic acid, 10-12 g/kg acetic acid, 0.33-0.46 g/kg propionic acid; the silage corn had pH 3.7-3.8, 34 g/kg lactic acid, 8-12 g/kg acetic acid, 0.07-0.17 g/kg propionic acid; sweet sorghum silage had pH 3.8, 49-73 g/kg lactic acid, 14-17 g/kg acetic acid, 0.17-0.43 g/kg propionic acid and 0.02-0.43 g/kg butyric acid”.

## CONCLUSIONS

The introduced ecotype of pearl millet, *Pennisetum glaucum*, under the climatic conditions of the Republic of Moldova, was characterized by optimal growth rate and productivity.

The green mass and silage prepared from pearl millet contain a lot of nutrients, which make them suitable to be used as a part of diverse livestock diets.

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