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AMINO ACID COMPOSITION OF PEARL MILLET GRAIN AND HERBAGE

Sergey Ivanovich KAPUSTIN[1], Alexander Borisovich VOLODIN[1], Andrey Sergeevich KAPUSTIN[2], Nikolai Viktorovich SAMOKISH[3]

[1]North Caucasus Federal Agrarian Research Center, Nikonov str. 49, Mikhailovsk, Stavropol region, 356241, Russia, Phone: +79624512303; E-mail: sniish@mail.ru
[2]North Caucasus Federal University, Pushkin str. 1, Stavropol, 355017, Russia, Phone: +78652330291; E-mail: hpplus@bk.ru
[3]Stavropol State Agrarian University, Zootekhnicheskiy Lane 12, Stavropol 355017, Russia, Phone: +78652352282; E-mail: inf@stgau.ru

Corresponding author: hpplus@bk.ru

Abstract

Object of the research is 5 new lines of pearl millet. They were bred in the Federal State Budgetary Scientific Institution "North Caucasus FARC". The purpose of the research was to specify the presence of nutrients (protein, fat, fiber, NFE), the level of essential and other amino acids in these new lines. Their content in the feed determines its biological value. The highest content of crude protein (12.92%) in the dry matter, which was obtained during the studies in 2021-2022, was found in line No. 1. This parameter ranged from 10.51 to 11.52% in other varieties. As for the grain, lines No. 5 (16.47%), No. 3 (16.45%) and No. 1 (16.29%) had the highest content of crude protein. The standards of Siberian millet and proso millet had significantly lower content of protein. It was 13.45 and 11.32%, respectively. The grain of the new lines showed the highest levels of crude fat in lines No. 4 (7.34%) and No. 5 (7.09%). The amount of crude gluten in the grain and dry matter of pearl millet was relatively low. On average, the dry matter of pearl millet had lower levels of essential amino acids (0.36%) compared to non-essential ones (0.72%). The new lines No. 1 and No. 5 had the highest content of essential amino acids in the grain. The content of non-essential amino acids in the grain was significantly higher than in the dry matter, averaging 1.2% and 0.72% respectively. The new lines No. 4, No. 3, and No. 1 had the maximum content of these amino acids. In terms of amino acid content, pearl millet grain exceeded the standards of proso millet and Siberian millet grain.

Key words*: *millet, amino acid content, protein, dry matter

INTRODUCTION

Pearl millet (*Pennisetum thyphoideum* Richt) is a valuable crop that is grown for green fodder, hay, silage, grain and pastureland. It has a fibrous root system that penetrates deep into the soil. The stems are light green, erect. Nodes are thickened. The length is about 3 meters or more. The plant bushes well. The number of sprouts in the bush ranges from 3 to 10. The leaves are large, hard, and scabrous along the edges. The inflorescence is a dense spiked panicle from 10 to 30 cm long [6]. The digestibility of nutrients in grain is high: simple protein – 75, protein – 74, fat – 79, NFE – 79, fiber – 33, in herbage, respectively – 70, 60, 60, 70, 66, and in hay – 60, 55, 45, 71, 53 [9]. Pearl millet produces green fodder that is coarser than Sudan grass, but softer than sorghum [6, 8]. In order to produce hay and green fodder, they cut it down at a height of 12-15 cm 1-2 weeks before the inflorescence development. This ensures better growth of the aftermath and obtaining the second cut for green fodder [1].

African millet grain is used for fattening animals and poultry, as well as for human nutrition. It produces flour, cereals, cooking dietary dishes, cereals, cookies and bread. The vegetative mass is fed to animals in the form of hay, silage, green mass. The culture does not contain hydrocyanic acid.

African millet is grown by individual farms in the North Caucasus, the Lower Volga region and the arid regions of the Trans-Urals (Orenburg, Kurgan, Omsk and other regions). The annual sowing area is 25-27 thousand hectares. The yield of green mass is 35-50 t/ha, the grain yield is 2-2.5 t/ha. Accounting for African millet in Rosstat is not conducted, the data are given for the Stavropol Territory.

The use and cultivation technology of pearl millet have been widely studied. In order to develop new early-ripening and late-ripening varieties with herbage yield from 30 to 60 t/ha, selective breeding is being carried out at the Federal State Budgetary Scientific Institution "North Caucasus Federal Agricultural Research Center". The quality characteristics of grain and herbage of these new samples are being specified now, which is the aim of our research.

The quality of feed is largely determined by the genetic traits of varieties [5, 10]. By applying genetic variation in studies, Tarik, A.S., Akram, Z., et al. have improved grain quality [11]. Content heterosis of sugar, crude protein and crude fat was established. Proteins show significant differences between the obtained hybrids and their parental forms. Nitrogen-free substances of the organic part of the feed include fat, fiber, NFE. Crude fat is a substance that dissolves only in organic solvents. It is a source of energy nutrition. Crude fiber determines the digestibility of the feed.

Grain fermentation increases the total amino acid content. The presence of essential amino acids increases to their total content. A number of literary sources [12] point to the role of histidine, serine, glutamic acid, and arginine, which form hydrogen bonds and stabilize binding of the sugar donor. The accumulation of free amino acids is less in seeds and seedlings with high content of tannin [3].

In feeding, protein cannot be replaced by any other nutrient. Approximately 20 unique amino acids participate in the synthesis of animal protein. Certain amino acids must be provided through feed. The biological quality of the feed is dictated by the concentration of these indispensable amino acids. Valine, leucine, isoleucine, threonine, histidine, lysine, phenylalanine, methionine are essential amino acids. Leucine regulates blood sugar level; phenylalanine is the starting material for insulin [7, 13]. Valine contributes to the regulation and reduction of neurological diseases. Histidine prevents atherosclerosis, hypertension, and heart attacks. Isoleucine is necessary for wound healing and hemoglobin synthesis. Together with threonine, they enhance immunity.

Non-essential amino acids that can be synthesized by the body include aspartic and glutamic acids, arginine, tyrosine, alanine, proline, glycine, serine. They also play an important role. Aspartic acid is important for the proper functioning of the endocrine and nervous systems. It promotes the production of testosterone. Along with alanine, this acid activates the antibody production, which strengthens the immune system. Glutamic acid is found in the brain and spinal cord, the fluid part of the muscles. It promotes the production of new cells and prevents early aging. Arginine activates the production of hormones, insulin.

Various sources of germ plasm with high nutrient density are used in crossbreeding programs for including this trait in the breeding process in order to improve nutritional quality [2]. As a result of a derangement of redox processes in the cytoplasm of pollen grains, their starches and fats are depleted. The composition and amount of amino acids change. The content of alanine in sterile anthers is higher than in fertile ones. There is also a difference in the content of proline and asparagine. Proline is actually found only in fertile anthers. Pollen grains in sterile forms are depleted in other amino acids and fats.

The aim of the research is to specify the presence of nutrients (protein, fat, fiber, NFE) in the dry matter and the content level of essential and other amino acids in 5 new varieties of pearl millet.

MATERIALS AND METHODS

The studies were carried out by the methods of field and laboratory experiments on the experimental field of the FSBSI "North Caucasus Federal Agricultural Research Center", the soil cover of which was a typical black soil with 120 cm of humus horizon.

The sowing was carried out in 2021-2022. It was wide-rowed with row spacing of 70 cm. The area of the registration plot was 25 m2. The density of plants was 160 thousand per hectare. The parameters of feed analysis and amino acid composition of the dry mass were established in the certified laboratory “Feed and Metabolism” at the Stavropol State Agrarian University. Out of the 22 known amino acids, the content of 16 acids was specified. The protein content was determined by the Kjeldahl method (GOST 13496-4-93), fiber – by the Henneberg and Shtokman`s method (GOST 31675-2012), fat – by extractive method (GOST 13496-15-97), dry matter – by weight method (GOST 31640-2012).

The object of the study was 5 new lines of pearl millet, which were bred by the North Caucasus Federal Agricultural Research Center. Observations, records, and measurements were performed in accordance with the Methodology for State Testing of Agricultural Crops [4] and the Volgin`s Method [13].

RESULTS AND DISCUSSIONS

New lines of pearl millet do not get destroyed or have a reduced susceptibility to bacterial disease, smut and aphids. An important characteristic of the studied crop is the stable yield of herbage, the level of which varied from 30 to 60 t/ha. This was due to the long growing season, tall plants and the presence of other positive features.

According to the data in table 1, the quality of the obtained herbage and grain was assessed in the air-dry matter. Samples were taken during the mowing of pearl millet in milk-wax stage of herbage (1-4 varieties) and full ripeness (5-11 varieties). Crude protein is the total amount of nitrogen-containing substances in the feed. It contains proteins and amides. Proteins consist of amino acids, which are linked together by peptide bonds. In feeding, protein cannot be replaced by any other nutrient. Only a plant can form protein from non-protein compounds.

Table 1. Main parameters of pearl millet feed analysis (average for 2021-2022)

Experimental varieties		Crude protein, %	Crude fat, %	Crude fiber, %	Crude ash, %	NFE, %
Herbage	Line No. 1	12.92	2.83	26.48	7.79	52.98
	Line No. 2	10.51	2.48	30.03	9.08	47.89
	Line No. 3	11.41	1.01	30.54	9.66	47.37
	Line No. 4	11.52	0.74	30.17	10.07	47.50
Grain	Line No. 1	16.29	6.24	1.92	1.94	73.61
	Line No. 2	16.03	6.48	1.46	1.70	74.32
	Line No. 3	16.45	6.54	1.90	1.71	73.39
	Line No. 4	15.50	7.34	2.02	1.91	73.23
	Line No. 5	16.47	7.09	1.38	1.40	73.65
	Proso millet variety	11.32	4.31	9.82	3.67	70.87
	Siberian millet variety	13.45	3.89	10.29	3.40	69.07

Source: developed by the authors based on [4, 13].

The highest content of crude protein (12.92%) in the dry matter, which was obtained during the research, was found in line No. 1. As for other varieties, this parameter ranged from 10.51 to 11.52%. The highest content of crude protein in the grain was obtained in lines No. 5 (16.47%), No. 3 (16.45%) and No. 1 (16.29%). The content of protein in the standards of Siberian millet and proso millet was significantly lower (13.45 and 11.32%), respectively.

Nitrogen-free substances of the organic part of feed include fat, fiber, and NFE. The studied variants of dry matter had the best parameters of fat in lines No. 1 (2.83%) and No. 2 (2.48%). These varieties, in comparison with other numbers, had lower content of crude fiber (26.48-30.03%), crude ash (7.79-9.08%) and higher content of NFE (47.89-52.98%).

The maximum crude fat parameters in the grain of the new lines of pearl millet were established in No. 4 (7.34%) and No. 5 (7.09%). The standards of proso millet and Siberian millet had values of 4.31 and 3.89%. The presence of crude fiber in the grain of the studied lines (1.38-2.02%) and crude ash (1.40-194%) was significantly less than in the standards of proso millet and Siberian millet, in which their content was 9.82-10.29% and 3.40-3.67%, respectively. Crude fiber determines the digestibility of the feed. As far as our experience is concerned, the total content of crude fiber in the grain and dry matter of pearl millet was low.

The composition of essential and non-essential amino acids present in the dry matter of pearl millet (harvested during the milk-wax stage) and in the grain of this crop is displayed in Table 2.

Table 2. Amino acid composition of pearl millet grain and dry matter for the years 2021-2022

Varieties		Indispensable amino acids, %								Dispensable amino acids, %							
		Valine	Leucine	Isoleucine	Threonine	Histidine	Lysine	Phenylalanine	Methionine	Aspartic acid	Arginine	Glutamic acid	Tyrosine	Alanine	Proline	Glycine	Serine
Herbage	Line No. 1	0.59	1.04	0.47	0.46	0.22	0.53	0.48	0.16	1.46	0.64	1.84	0.29	0.86	0.87	0.56	0.63
	Line No. 2	0.38	0.63	0.29	0.31	0.15	0.28	0.32	0.09	0.93	0.37	1.24	0.18	0.61	0.54	0.46	0.42
	Line No. 3	0.43	0.56	0.29	0.33	0.12	0.40	0.32	0.10	1.74	0.46	0.90	0.17	0.54	1.23	0.42	0.48
	Line No. 4	0.35	0.54	0.29	0.27	0.15	0.39	0.30	0.09	1.51	0.44	0.79	0.15	0.55	0.95	0.39	0.42
	Average	**0.44**	**0.70**	**0.34**	**0.34**	**0.16**	**0.40**	**0.36**	**0.11**	**1.41**	**0.48**	**1.19**	**0.20**	**0.64**	**0.90**	**0.46**	**0.49**
	LSD_{05}, %	**0.020**	**0.031**	**0.015**	**0.016**	**0.007**	**0.018**	**0.017**	**0.006**	**0.067**	**0.022**	**0.057**	**0.009**	**0.029**	**0.044**	**0.021**	**0.023**
Grain	Line No. 1	0.77	1.67	0.62	0.49	0.55	0.47	0.78	0.26	1.29	0.74	3.40	0.38	1.30	1.04	0.53	0.76
	Line No. 2	0.68	1.70	0.59	0.49	0.33	0.42	0.71	0.38	1.28	0.70	3.65	0.42	1.33	1.09	0.48	0.81
	Line No. 3	0.75	1.75	0.58	0.56	0.37	0.43	0.71	0.29	1.40	0.74	3.79	0.42	1.37	1.15	0.51	0.87
	Line No. 4	0.57	1.53	0.50	0.48	0.34	0.42	0.60	0.28	1.21	0.71	3.20	0.38	1.24	0.92	0.48	0.75
	Line No. 5	0.73	1.83	0.62	0.57	0.37	0.42	0.77	0.33	1.40	0.70	3.86	0.44	1.41	1.15	0.50	0.86
	Average	0.70	1.70	0.58	0.52	0.39	0.43	0.71	0.31	1.32	0.72	3.58	0.41	1.33	1.07	0.50	0.51
	Proso millet – St	0.36	1.27	0.30	0.30	0.20	0.26	0.46	0.32	0.65	0.42	2.45	0.33	1.15	0.77	0.27	0.64
	Siberian millet – St	0.63	1.58	0.47	0.53	0.26	0.28	0.81	0.30	1.05	0.41	2.81	0.37	1.02	1.22	0.37	0.59
	LSD_{05}, %	**0.033**	**0.077**	**0.029**	**0.025**	**0.019**	**0.020**	**0.034**	**0.016**	**0.063**	**0.034**	**0.170**	**0.020**	**0.060**	**0.051**	**0.024**	**0.036**

Source: developed by the authors based on [4, 13].

The content of essential amino acids in the dry matter of pearl millet, on average (0.36%), was lower in comparison to non-essential ones (0.72%). Thus, methionine (0.11%) and histidine (0.16%) were contained in dry matter in very small quantities. As for essential amino acids, leucine (0.7%) and phenylalanine (0.81%) showed the highest amount. Line No. 1 exhibited the highest concentration of essential amino acids in the dry matter, while line No. 4 displayed the lowest.

The grain of pearl millet had an average content of 0.67% for these amino acids, which was significantly less than the non-essential amino acids at 1.22%. Among the essential amino acids, methionine (0.31%), histidine (0.39%), and lysine (0.43%) had the minimum presence in the grain, while leucine (1.7%) and phenylalanine (0.71%) had the highest. The highest content of essential amino acids in the grain was observed in the new lines No. 1 and No. 5.

Examination of the non-essential amino acids content revealed an average content of 0.72% in the dry matter and 1.22% in the grain. Tyrosine (0.20%), arginine (0.48%), glycine (0.46%) and serine (0.49%) had the lowest presence in the dry matter. At the same time, aspartic acid content was 1.41%, glutamic acid – 1.19%, proline – 0.9%. The highest content of non-essential amino acids was found in lines No. 1, No. 3 and No. 4. Their parameters exceeded the values of the grain of proso millet and Siberian millet standards.

The content of non-essential amino acids in the grain was significantly higher than in the dry matter and averaged 1.22 and 0.71%, respectively. The average superiority was 0.50%. The most significant content was found in glutamic acid – 3.58%, aspartic acid – 1.32%, alanine – 1.33% and proline –

1.07%. The content of remaining non-essential amino acids in the grain was 0.41-0.81%. The maximum content of these amino acids was established in new lines No. 5, No. 3 and No. 1. In terms of amino acid content, pearl millet grain exceeds the parameters of standard proso millet and standard Siberian millet grain.

CONCLUSIONS

The highest content of crude protein (12.92%) in dry matter was found in line No. 1. As for other varieties, this parameter ranged from 10.51 to 11.52%.

The concentration of essential amino acids in the dry substance of pearl millet, on average (0.36%), was lower compared to the concentration of non-essential amino acids (0.72%). Leucine (1.7%) and phenylalanine (0.71%) exhibited the highest levels among essential amino acids in the grain.

In terms of amino acid content, the grain of pearl millet was superior to the grain of standards – proso millet and Siberian millet.

REFERENCES

[1]Andreev, N.G., 1975, Meadow and arable fodder cropping. Moscow: Kolos, 504 p.

[2]Are, A.K., Srivastava, R.K., Mahalingam, G., Gorthy, S., Gaddameedi, A.,Kunapareddy, A., Kotla, A., Jaganathan, J., 2018, Application of plant breeding and genomics for improved sorghum and pearl millet grain nutritional quality. Sorghum and Millets: Chemistry, Technology, and Nutritional Attributes: 51-68. DOI: 10.1016/B978-0-12-811527-5.00003-4

[3]Chavan, J.K., Kadam, S.S., Salunkhe, D.K., 1981, Changes in Tannin, Free Amino Acids, Reducing Sugars, and Starch During Seed Germination of Low and High Tannin Cultivars of Sorghum. Journal of Food Science. 46(2): 638-639. DOI: 10.1111/j.1365-2621.1981.tb04930.x

[4]Fedin, M.A., 1985, Methodology of the State Variety Testing of Agricultural Crops. Moscow: Ministry of Agriculture of the USSR, 267 p.

[5]Impa, S.M., Perumal, R., Bean, S.R., John Sunoj, V.S., Jagadish, S.V.K., 2019, Water deficit and heat stress induced alterations in grain physico-chemical characteristics and micronutrient composition in field grown grain sorghum. Journal of Cereal Science. 86: 124-131. DOI: 10.1016/j.jcs.2019.01.013

[6]Kapustin, S.I., Volodin, A.B., 2022, Cultivation of sorghum and annual fodder crops in arid conditions in the south of Russia. Stavropol: Service School, 103 p.

[7]Kapustin, S., Volodin, A., Kapustin, A., Samokish, N., 2022, Feed Quality of New Sudan Grass Varieties. Journal of Agriculture and Nature, 25(2): 400-405. DOI: 10.18016/ksutarimdoga.vi.916295

[8]Kapustin, S.I., Volodin, A.B., Kapustin, A.S., Vlasova, O.I., Donets, I.A., 2021, Reaction of Sudan grass and sorghum-Sudan hybrids to salinity. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development. 21(3): 491-496.

[9]Medvedev, P.F., 1981, Forage plants of the European part of the USSR. Leningrad: Kolos, 336 p.

[10]Mishra, J.S., Thakur, N.S., Kewalanand, Sujathamma, P., Kushwaha, B.B., Rao, S.S., Patil, J.V., 2015, Response of Sweet Sorghum Genotypes for Biomass, Grain Yield and Ethanol Production under Different Fertility Levels in Rainfed Conditions. Sugar Tech. 17(2): 204-209. DOI: 10.1007/s12355-014-0315-4

[11]Tariq, A.S., Akram, Z., Shabbir, G., Khan, K.S., Mahmood, T., Iqbal, M.S., 2014, Heterosis and combining ability evaluation for quality traits in forage sorghum (*Sorghum bicolor* L.). Sabrao Journal of Breeding and Genetics, 46(2): 174-182.

[12]Thorsoe, K.S., Bak, S., Olsen, C.E., Imberty, A., Breton, C., Moller, B.L., 2005, Determination of catalytic key amino acids and UDP sugar donor specificity of the cyanohydrin glycosyltransferase UGT85B1 from Sorghum bicolor. Molecular modeling substantiated by site-specific mutagenesis and biochemical analyses. Plant Physiology. 139(2): 664-673. DOI: 10.1104/pp.105.063842

[13]Volgin, V.I., Romanenko, L.V., Prokhorenko, P.N., 2008, The method of calculating the metabolizable energy in feed based on the content of raw nutrients. Dubrovitsy: Publishing House of the Research Institute of Animal Husbandry of the Russian Agricultural Academy, 252 p.