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S. Sots, PhD of Technical Science, Associate Professor, *E-mail: sotsserega@gmail.com*
ORCID: 0000-0002-3267-2384; ResearcherID: G-9192-2019; Scopus Author ID: 57210357520
I. Kustov, PhD of Technical Science, Associate Professor, *E-mail: i.kustov1988@gmail.com*
ORCID: https://orcid.org/0000-0001-7632-1626, ResearcherID: I-3249-2016
V. Chehlatoniev, post graduate student, *E-mail: vovacheg81@gmail.com*
O. Donii, postgraduate student, *E-mail: doniy.lesya99@gmail.com*
Odesa National University of Technology, 112, Kanatna Str., Odesa, 65039, Ukraine

MILLET GRAIN: PROSPECTS OF USE AND EXPANSION OF THE PRODUCT RANGE

Abstract

Millet grain is a promising crop for expanding the current assortment of cereal production products. Products of millet processing in the world include a wide range of food and feed products, as well as biofuel produced on the basis of food production waste (husks). Groats, flakes, plucked grains, extruded food products are produced from millet, millet flour is widely used for the production of composite flour mixtures with baking flour, bakery and confectionery products, etc. In the Register of plant varieties suitable for distribution on the territory of Ukraine (Register) 35 varieties of common millet Panicum miliaceum L., which can be used as a food grain, are registered. The most common millet variety in Ukraine is Myronivs'ke 51. It was entered into the Register in 1978. Indirectly, depending on varietal characteristics and growing conditions, millet can contain 8-18% protein, 3-5% fat, 59-69% carbohydrates, 2-3% sugars, 1-3% fiber and 2-3% ash. The chemical composition of millet contains water-soluble vitamins B_1, B_2, B_5, B_6, B_9, PP, and millet is also an important source of macroelements such as Cu, I, Br, Ca, Fe, Zn. One of the possible solutions for increasing the quantitative indicators of millet processing and increasing the yield values of finished products is the inclusion of water-heat treatment in the stage of grain preparation before husking. Conducting water-heat treatment makes it possible to strengthen the core and, accordingly, reduce by 5-7% the amount of formation at the dehulling and pearling stage of by-products and waste. The lack of a water-heat treatment stage in the traditional scheme is also due to the fact that at the time of publication and approval of the Rules, there was no technological equipment that would allow detecting and removing potentially damaged grains from the technological process effectively enough, especially considering the characteristics of millet grain. In addition, millet is the only crop in the range of which the Rules recommend producing only one type of groat. Taking into account the sufficiently balanced chemical composition of millet, there is a need to expand the range of products from this grain and justify their production modes, as well as to modernize and revise the existing technological process for the production of classic millet groats in the direction of using modern technological equipment, which will allow to increase the controllability of various stages of the technological process at simultaneous reduction of energy costs for production. Today, instant cereals or cereals that do not require cooking, flaked products and cereal breakfasts, muesli, cereal bars, multi-grain cereals, granola, etc. are widely popular in the World and also in Ukraine.

Key words: millet, groats, chemical composition of grain, grain production, varieties, assortment expansion, water-heat treatment, optical separators.

Introduction

In the nutrition structure of a modern person, groats and groats products occupy 20...30% of the total volume of consumption of cereal products.A feature of groats production is the presence of a wide range of processed raw materials. The groats factories process eight main grain crops: rice, millet, buckwheat, oats, barley, corn, wheat and legumes - peas, as well as, in small quantities, sorghum and chickpeas, etc.

The processing of these crops involves complex energy-intensive operations of the technological process. As a rule, most types of groats and flakes have a low yield and a relatively lower nutritional value compared to unprocessed grains. In the process of dehulling and pearling of grain, a significant part of the protein, vitamins, minerals, dietary fibers, etc. is extracted. For example, the protein content in barley grain is 14.5 g per 100 g of grain, and in pearl barley obtained from it at a yield of 45%, it is 7.3 g of protein in 100 g of grain, which is about 50% of the use of protein from its content in grains. In modern conditions, such low indicators in the production of cereals and cereal products are insufficient. The groats branch of the food industry belongs to the socially significant branches of the agro-industrial complex. The state and development of the groats industry of the state is one of the determining factors of the well-being, working capacity and health of its population.

In many countries of the World, there is a tendency to expand the assortment of cereal products. Expansion of the assortment and high efficiency of processing is achieved due to the use of new cereal crops. The appearance of more efficient modern equipment leads to the fact that grain enterprises increasingly focus on grain and leguminous crops, which 10-15 years ago were not considered promising for grain production and were used more for fodder purposes.

Thus, to expand the range of finished products, it is proposed to use new varieties and types of cereal crops, which will significantly improve the ecological condition of finished products, their quality, nutritional value, consumer properties, will allow to shorten the technological process by reducing the number of processing stages, increase the yield of finished products products, reduce energy costs for production.

Literary review

Millet grain is a promising crop for expanding the current assortment of groats production products. Millet has been known to mankind for a long time, the first mentions of it are known as far back as 4-5 thousand years BC. The homeland of millet is considered to be the regions of East and Central Asia, from there it began to spread around the world along with the migration of people to other regions. Due to its undemanding requirements for growing conditions and sufficiently balanced chemical composition, millet grain is still one of the main crops that provide food needs in developing countries on the African and Eurasian continents [1,2].

According to the volume of cultivation in the World, millet can be classified as one of the main grain crops. The total area of millet cultivation in the world is up to 40 million hectares. The main countries focused on growing millet are China and Mongolia, millet is also grown in the USA, India, Japan, Afghanistan, Bulgaria, Hungary, Poland, some African countries, etc. The average volume of millet cultivation in the world is up to 32 million tons per year. For Ukraine, millet is one of the eight traditional grain crops, but in terms of its cultivation volume and the volume of produced food products, this crop can be classified as a niche crop. Small agricultural holdings or even home farms are engaged in the cultivation of millet in Ukraine. The cultivated area of millet in Ukraine does not exceed 300,000 hectares and in recent years has a tendency to decrease. The main regions of millet cultivation in Ukraine are the Steppe and Forest Steppe, and the volume of grown grain usually does not exceed 120-140 thousand tons annually. Such relatively small volumes of millet cultivation in Ukraine are primarily aimed at meeting the needs of the domestic market for food and fodder products. According to research data, the physiological norm of millet consumption per person is up to 2.6 kg per year [3, 4].

Among the many types of millet, four main types can be distinguished: the most common type of millet is Pearl millet (*Pennisetum glaucum*) or African millet, it is widely used for the production of food products and, accordingly, this type of millet occupies the largest share in world production (up to 40%), Foxtail millet (*Setaria italica*) or millet (*Chumiza Italiana*), Proso millet or white millet (*Panicum miliaceum*) or millet, common, panicle white and Finger Millet (*Eleusine coracana*) which are also widely distributed throughout the World and are used for a wide range of needs and prospects in the grain processing industry are also of great importance. Millet can be classified as a small-seeded crop. According to the mass index of 1000 grains, the grain is divided into three groups: large millet (the grain is obtained by passing through a sieve ø 1.8 mm) from 7g, medium in size (passing through a sieve ø 1.8 mm and passing through a sieve ø 1.5 mm) in between 5-7 g, small grain (sieve passage ø 1.5 mm) up to 5 g. Millet grain can be spherical, oval or elongated in shape. A spherical grain is characterized by almost the same width, length and thickness, with an elongated shape, the length exceeds the thickness and width by approximately two times. The color of millet can be grayish-white, brown, cream, yellow, purple, red, gray, light blue. [5, 6].

Products of millet processing in the World include a wide range of food and feed products, as well as biofuel produced on the basis of food production waste (husk). Groats, flakes, plucked grains, extruded food products are produced from millet, millet flour is widely used for the production of composite flour mixtures with baking flour, bakery and confectionery products, etc. In Japan, products made from millet grain are used for dietary and therapeutic nutrition in the treatment of cardiovascular diseases, high blood pressure, diabetes, and liver disorders. Millet grain is also used in brewing to produce malt. During the processing of millet, technical oil is obtained, during advanced processing, starch, amelopectin and dextrins are obtained, as well as many other biologically active substances. The husk obtained after dehulling millet grain is used as biofuel [7,8,9].

Formulation of the problem

In the Register of plant varieties suitable for distribution on the territory of Ukraine (Register) [10]. 35 varieties of common millet (*Panicum miliaceum L.)*, which can be used as a food grain, are registered. The most common millet variety in Ukraine is *Myronivs'ke 51*. It was entered into the Register in 1978. The following varieties, *Kyivs'ke 87* and Kyivs'ke 96, were registered in 1991 and 1999, respectively. Then, during the first two decades of the 21st century, new varieties of millet were registered almost every year. The largest number of varieties was introduced in 2006 - varieties *Denviks`ke*, *Zolushka*, *Konstantynivs`ke*, *Lana*, *Tavriis`ke*. Over the past four years, 6 varieties of millet have been registered: *Dyvovyzhne* (2020), *Kazkove dzherelo* (2020), *Kornberger Mittelfruhe* (2020), *Yardush* (2021), *Kesha* (2022), *Peremozhne* (2023). The data of the Register indicate that the work on the selection of millet in Ukraine has not stopped, and in our country there are promising modern varieties of millet for expanding the raw material base of grain factories. A brief description of millet varieties included in the register is given in Table 1.

According to the anatomical structure, the millet grain, like all cereal crops, consists of seed coat, aleurone layer, endosperm and embryo. At the same time, chemical substances are unevenly distributed over the anatomical parts of the grain, as in most cultures, hulls mainly contain components that are difficult for the human body to absorb, germ parts are partly protein and the main part of fat, endosperm - protein and starch. Indirectly, depending on varietal characteristics and growing conditions, millet can contain 8-18% protein, 3-5% fat, 59-69% carbohydrates, 2-3% sugars, 1-3% fiber and 2-3% ash. The chemical composition of millet contains water-soluble vitamins B_1, B_2, B_5, B_6, B_9, PP, and millet is also an important source of trace elements such as Cu, I, Br, Ca, Fe, Zn [6, 14-17].

The important technological indicators of millet grain, which determine the modes of the technological process of processing, are hulls content, volume weight, and the weight of 1000 grains. Compared to other traditional grain crops, millet is a small-seeded grain with a mass index of 1000 grains of 5.2-9.5 g and volume weight of 680-820 g/l. Hulls content of millet grain var-

Table 1 – Technological characteristics of millet varieties entered in the Register [10-12]

Name	Year of registration	Weight of 1000 grains, g	Hulls, %	Mass fraction of protein %	Kernel content, %
Myronivs'ke 51	1978	7,5	18	12,5	78
Kyivs'ke 87	1991	7,7	17	13,5	79
Kyivs'ke 96	1999	7,7	17	12,5	79
Slobozhans`ke	2001	8,0	17	11,9	81
Novokyivs`ke 01	2004	7,4	13	13,6	83
Omriiane	2005	8,0	14	12,6	81
Poltavs`ke zolotyste	2005	8,2	13	12,4	81
Denviks`ke	2006	8,6	18	11,5	79
Zolushka	2006	8,2	16	14,3	80
Konstantynivs`ke	2006	7,3	13	14,7	82
Lana	2006	8,5	16	14,8	79
Tavriis`ke	2006	8,0	19	14,4	76
Vitrylo	2008	8,1	17	14,8	79
Olitan	2008	8,2	17	12,5	79
Kozats`ke	2010	6,5	16	10,9	82
Askol`do	2011	8,1	17	10,8	79
Poliano	2011	8,1	17	10,4	79
Bila al`tanka	2012	8,9	13	11,2	81
Zapovitne	2014	8,0	17	13,0	77
Polto	2015	8,1	17	13,6	78
Skado	2015	7,9	18	12,9	78
Chabanivs`ke	2015	7,7	18	13,1	77
Nezalezhne	2016	7,8	17	12,2	77
Sonechko slobids`ke	2016	7,7	17	12,8	77
Bohatyrs`ke	2017	8,0	19	13,2	76
Veselka	2018	7,8	16	12,9	70
Al`ternatyvne	2019	7,8	19	12,9	77
Zhyvynka	2019	7,1	18	14,0	78
Osoblyve	2019	7,6	20	13,3	76
Dyvovyzhne	2020	8,0	17	13,6	78
Kazkove dzherelo	2020	7,1	17	14,2	79
Kornberger Mittelfruhe	2020	7,3	15	13,9	81
Yardush	2021	7,2	17	14,5	79
Kesha	2022	9,2	19	14,3	78

ies between 15-22% depending on varietal characteristics [18-20].

Materials and methods

The purpose of the work: substantiation of the expediency and prospects of expanding the range of food products obtained from millet processing.

Task:

- to analyze the volume of millet cultivation in the World and in Ukraine, to determine current trends, problems of cultivation and processing;
- to analyze the existing methods of millet processing and to justify promising processing methods to expand the assortment of the obtained products.

Results of the study and their discussion

The most common food product that is obtained in Ukraine during the processing of millet grain is pearled millet groats. This product is regulated and is a pearled millet kernel freed from hulls. But despite the fact that millet processing technology into pearled millet groats is regulated by the Rules for conducting and organizing the technological process at groats factories [21] and is widely popular in comparison with other grain

products in our country, this grain does not have it, which to some extent holds back its introduction in the domestic grain industry of new food products obtained from it. At the same time, it is necessary to note the high export potential of this culture and its processing products, especially to the countries of the European Union, where the popularity of processed millet food products has only been growing in recent years. It should be noted that at the end of 2023, in the Cherkasy region, Ukraine construction was completed and lines for processing millet into groats were launched precisely for the purpose of further export of finished products to EU countries [22].

In Ukraine, millet grain is governed by DSTU 5026:2008 "Millet. Technical conditions" [23]. According to the standard, millet is divided into three types by color: type I - grain with white and cream color, type II - grain from golden yellow to dark and gray-yellow color, type III - from light red to dark red and brown color. And it divides the grain according to its purpose into four classes: it is recommended to use grain 1 and 2 for the production of groats and other food products, for the production of malt - grain of the third class, for fodder and technical needs - grain of the fourth class. It should be noted that in accordance with the requirements of the standard for the production of food products, grain of any of the three types is allowed, but at the same time, such indicators as grain size are limited (for grain of the 1st class at least 90%, for the second - at least 80%), mass fraction impurities: grain (no more than 5% for 1st class grain, no more than 8% for second class grain), garbage (no more than 2% for first class grain, no more than 3.5% for second class grain), kernel content (grain 1st class not less than 76%, for the second - not less than 74%). For the production of starch and derivative substances, it is recommended to use millet with an amylopectin content of at least 95%.

For Ukraine, millet is a traditional groats crop, the technological process of processing of which is regulated by the Rules for conducting and organizing the technological process at grain factories [21]. The technology involves the cleaning of grain from impurities, dehulling, sorting of dehulling products, pearling of the obtained kernel, sorting of pearling products and control. Grain cleaning is carried out using three systems of sieve-air separators, a stone separator and a plansifter. Classical technology does not include the stage of water-heat treatment of grain or pearled kernel, which is associated with the potential possibility of strengthening the grain during the water-heat treatment process, which can potentially be damaged and its subsequent entry into the end groats and decrease its quality. Processing of cleaned grain includes its successive dehulling on two or four systems in fractions or in one flow. For dehulling, it is recommended to use one or two-deck rolling hullers. Sorting of dehulling products is carried out after each dehulling system using air separators. Pearling of the kernel is carried out on the same system with the use of machines of the A1-ZShN type or special screw-press grinding machines U1-BSHP. Pearling products are also sorted on air separators.

The analysis of the classical technology shows that its main drawback is the limited range and the relatively insignificant values of the yields of the end product that can be obtained when using it - 65%, while the indicator of the amount of hulls removed after dehulling is 15.5%, everything else is waste that is the result excessive formation of particles of crushed kernel and flour in the process of dehulling and pearling. One of the possible solutions for increasing the quantitative indicators of millet processing and increasing the yield values of finished products is the inclusion of water-heat treatment in the stage of grain preparation before dehulling. Conducting water-heat treatment makes it possible to strengthen the kernel and, accordingly, reduce by 5-7% the amount of formation at the pearling stage of by-products and waste. The lack of a water-heat treatment stage in the traditional scheme is also due to the fact that at the time of publication and approval of the Rules, there was no technological equipment that would allow detecting and removing potentially damaged grains from the technological process effectively enough, especially considering the characteristics of millet grain. In addition, millet is the only crop in the range of which the Rules [21] recommend producing only one type of groats. Taking into account the sufficiently balanced chemical composition of millet, there is a need to expand the range of products from this grain and justify their production modes, as well as to modernize and revise the existing technological process for the production of classic millet groats in the direction of using modern technological equipment, which will allow to increase the controllability of various stages of the technological process at simultaneous reduction of energy costs for production. Today, instant groats or groats that do not require cooking, flaked products and cereal breakfasts, muesli, cereal bars, multigrain cereals, granola, etc. are widely popular in the World and also in Ukraine. The basis of the production of the entire modern range of products must be the stage of water-heat treatment, either before the main dehulling and pearling operations, or for ready-made groats before packaging or further processing into flaked groats. This is confirmed by modern research conducted in various countries of the world [24-26].

There is a known method of dehulling and preparing millet (*Finger Millet (Eleusine coracana*) for dehulling, which involves cleaning, soaking, steaming, drying, dehulling, sorting of dehulling products, which ensures the production of dehuled kernels, particles of crushed kernels, hulls and flour. Millet soaking is carried out in water with a temperature from 20 to 70 ^{o}C for 2 to 16 hours. Steaming of grains prepared in this way is carried out at atmospheric or excess pressure up to 0.5 MPa (5 kg/cm^2) for 2 to 20 minutes. After steaming, the grain is dried to a humidity of 8 -16% and sent to dehulling. Carrying out the water-heat treatment proposed in this method in the form of soaking-steaming-drying before dehulling contributes to an almost 1.5-fold increase in the number of whole kernels at the dehulling stage, which is the result of a reduction in the proportion of the formation of crushed kernels and flour at the stage dehulling [27].

Another important factor for the modernization of the existing technology of processing millet into cereals and cereal products is the introduction of a technological operation for the analysis of grain by color using optical separators. This will make it possible to effective-

	Machine width (mm)	Depth-doors open (mm)	Depth- doors shut (mm)	Height (mm)	Height (kg)	Typical air requirements L/s 0.6 - 0.8 Mpa	Max power consumption (kW)* (200-240V; 50/60 Hz monofásica) TXTX	TITI
J1	1062	2347	1665	1908 to 1920	668	8,6	1,95	1,65
J2	1800	2347	1665	1908 to 1920	913	17,2	2,85	2,55
J3	1800	2347	1665	1908 to 1920	958	25,8	3,10	2,90
J4	2400	2347	1665	1908 to 1920	1335	39,4	3,95	3,90
J5	2400	2347	1665	1908 to 1920	1380	43	4,80	4,70
J6	3040	2347	1665	1908 to 1920	1599	51,6	5,45	5,60
J7	3040	2347	1665	1908 to 1920	1644	60,2	5,70	6,10

Fig. 1. Buhler Sortex J Spectravision

ly distinguish the grains of other types of millet by color and increase the efficiency of the technological process of processing and the quality of finished products. The Buhler company offers a solution for the production of two products from millet - pearled groats and flour, during the production of which, in addition to the standard stages of cleaning, dehulling, sorting, pearling, it is proposed to use optical separators both at the stage of cleaning the grain and at the final stage of the production of groats, to control the finished products. It is proposed to introduce modern optical separators of the latest generation Sortex J Spectravision (Fig. 1), which, with the help of specially developed software and artificial intelligence, most efficiently implement the analysis of grain and its processing products by color [28].

Conclusions

Millet grain is one of the most promising crops. Due to its balanced chemical composition, millet, from which only one type of groats is produced in Ukraine, can be used to expand the existing assortment of groats products in Ukraine with proper justification of the assortment and processing modes. The analysis of modern solutions for the implementation of water-heat treatment and optical separators in the grain preparation process shows the high feasibility of studying these stages and their influence when using millet grain grown in Ukraine, which in turn will allow to reduce the amount of by-products and waste at the stages of dehulling and pearling and improve the quality of the end products. Taking into account the increase in demand in EU countries for healthy food products, including millet, it is necessary to use the potential of this crop for export and increase the amount of cultivation and processing of millet into more modern products - instant cereals, cereal breakfasts, cereal bars, etc. in Ukraine that in in turn, the development and justification of the production of these products is needed.

REFERENCES

1. House, L.R. (1995). Sorghum and millets: History, taxonomy, and distribution.
2. Wang, R., Hunt, H.V., Qiao, Z., Wang, L., & Han, Y. (2016). Diversity and cultivation of broomcorn millet (Panicum miliaceum L.) in China: a review. Economic Botany, 70: 332-342.
3. Averchev, O. . (2011). Efektyvnist vyrobnytstva i realizatsii prosa v Ukraini.
4. Averchev, O.V., & Nikitenko, M.P. (2021). Rynok prosa v Ukraini.
5. Averchev, O.V., & Nikitenko, M.P. (2021). Analiz vyrobnytstva prosa v Ukraini. Khersonskyi derzhavnyi ahrarno-ekonomichnyi universytet.
6. Kliuchevych M. M., Stoliar S. H. Proso – perspektyvna kultura. Honcharivski chytannia, prysviacheni 84-richchiu z dnia narodzhennia doktora s.-h. nauk, prof. M. D. Honcharova : zb. tez Mizhnar. nauk.-prakt. konf., 28 trav. 2013 r. Sumy : SNAU, 2013: 128–131.
7. Kliuchevych M. M., Stoliar S. H. Proso – tsinna krup'iana kultura. Perspektyvy rozvytku roslynnytskoi haluzi v suchasnykh ekonomichnykh umovakh : zb. tez Mizhnar. nauk.-prakt. konf., prysviach. 50-i richnytsi vid pochatku rozvytku rysivnytstva v Ukraini, 6–8 serp. 2013 r. Skadovsk : In-t rysu NAAN, 2013: 113–114.
8. Maman N. Variety and management level influence on pearl millet production in Niger / N. Maman, S.C. Mason, S. Sirifi. // African Crop Science Journal, 2000, № 8: 25–34.
9. Chandrasekara A and Shahidi F (2011). Determination of antioxidant activity in free and hydrolyzed fractions of millet grains and characterization of their phenolic profiles by HPLC-DAD-ESI-MSn. Journal of Functional Foods, 3: 144-58.
10. Jaybhaye, R.V., Pardeshi, I.L., Vengaiah, P.C., & Srivastav, P.P. (2014). Processing and technology for millet based food products: a review. Journal of ready to eat food, 1(2): 32-48.
11. The Register of plant varieties suitable for distribution on the territory of Ukraine
12. Informatsiino-dovidkova systema sort [Online], available at: http://sort.sops.gov.ua/
13. Ahrarii razom https://agrarii-razom.com.ua/list-culture-varieties?culture=1375&plant=364
14. Shen, R., Ma, Y., Jiang, L., Dong, J., Zhu, Y., & Ren, G. (2018). Chemical composition, antioxidant, and antiproliferative activities of nine Chinese proso millet varieties. Food and Agricultural Immunology, 29(1): 625-637.
15. Abdelrahman, A., Hoseney, R. C., & Varriano-Marston, E. (1984). The proportions and chemical compositions of hand-dissected anatomical parts of pearl millet. Journal of Cereal Science, 2(2): 127-133.
16. Ouattara-Cheik AT, Aly S, Yaya B, Alfred TS. A comparative study on nutritional and technological quality of fourteen cultivars of pearl millets Pennisetum glaucum (L) Leek in Burkina Faso. Pakistan J Nutr. 2006;5(6): 512–21.

17. Hassan, Z.M., Sebola, N.A., & Mabelebele, M. (2021). The nutritional use of millet grain for food and feed: a review. Agriculture & food security, 10: 1-14.
18. Mahajan, P., Bera, M. B., Panesar, P. S., & Chauhan, A. (2021). Millet starch: A review. International Journal of Biological Macromolecules, 180: 61-79.
19. KOSTETsKA, K. (2011). Tekhnolohichni vlastyvosti zerna prosa sortu Veselopodilske 16. Vkliucheno do perelikiv № 1 i № 6 fakhovykh vydan VAK Ukrainy z silskohospodarskykh ta ekonomichnykh nauk (Biuleten VAK Ukrainy № 8 i № 11, 2009 rik). U zbirnyku vysvitleno rezultaty naukovykh doslidzhen, provedenykh pratsivnykamy Umanskoho natsionalnoho universytetu, 133.
20. Husieva, N.S., & Andronovych, H.M. TEKhNOLOHIChNI VLASTYVOSTI ZERNA PRYZNAChENOHO DLIa VYROBNYTsTVA KRUP.
21. Shutenko, Ye.I. Tekhnolohiia krup'ianoho vyrobnytstva: navch. Posibnyk [Tekst] / Ye.I. Shutenko, S.M. Sots. – K.: Osvita Ukrainy, 2010: 272.
22. Kroshko, GD (1998). Rules for organizing and maintaining the technological process at the mill factories. K .: WIPOL.
23. AgroPortal [Online], available at: https://agroportal.ua/ru/news/novosti-kompanii/v-ukrajini-vidkrili-zavod-z-virobnictva-pshona-yake-eksportuvatimut-do-yes
24. DSTU 5026: 2008 "Millet grain", [Online], available at: http://www.dnaop.com/html/33900
25. Takhellambam, R. D., Chimmad, B. V., & Prkasam, J. N. (2016). Ready-to-cook millet flakes based on minor millets for modern consumer. Journal of food science and technology, 53: 1312-1318.
26. Vijayakumar, P. T., & Mohankumar, J. B. (2009). Formulation and characterization of millet flour blend incorporated composite flour. International Journal of Agriculture Sciences, 1(2): 46.
27. Karnavat, D., & Chaudhari, D. Formulation and standardization of millet-based protein-mineral enriched granola bar.
28. Malleshi, N. G. (2006). U.S. Patent No. 7,029,720. Washington, DC: U.S. Patent and Trademark Office.
29. Buhler group [Online], available at: https://www.buhlergroup.com/

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С.М. Соц, канд. техн. наук, доцент, *E-mail: sotsserega@gmail.com*
І.О. Кустов, канд. техн. наук, доцент, *E-mail: i.kustov1988@gmail.com*
В. Чеглатонєв, аспірант, *E-mail: vovacheg81@gmail.com*
О.І. Доній, аспірант, *E-mail: doniy.lesya99@gmail.com*
Одеський національний технологічний університет, вул. Канатна, 112, Одеса, 65039, Україна

ЗЕРНО ПРОСА: ПЕРСПЕКТИВА ВИКОРИСТАННЯ І РОЗШИРЕННЯ АСОРТИМЕНТУ ПРОДУКЦІЇ

Анотація

Перспективною культурою для розширення діючого асортименту продуктів круп'яного виробництва є зерно проса. Продуктами переробки проса у світі є широкий спектр харчових і кормових продуктів, а також біопалива яке виробляють на основі відходів виробництва харчових продуктів (лузги). З проса виробляють крупи, пластівці,зірвані зерна, екструдовані харчові продукти, борошно з проса широко використовують для виробництва борошняних композиційних сумішей з хлібопекарським борошном, хлібобулочні і кондитерські вироби тощо. В реєстр сортів рослин придатних для поширення на території України зареєстровано 35 сортів проса посівного звичайного Panicum miliaceum L. яке можна використовувати як круп'яне зерно. Найпоширенішим в Україні сортом проса є Миронівське 51 його внесли в Реєстр у 1978 році. Опосередковано просо в залежності від сортових особливостей та умов вирощування може містити 8-18 % білка, 3-5 % жиру, 59-69 % вуглеводів, 2-3 % цукристих речовин, 1-3 % клітковини та 2-3 % золи. У хімічному складі проса присутні водорозчинні вітаміни B1, B_2, B_5, B_6, B_9, PP а також просо є важливим джерелом мікроелементів таких як Cu, I, Br, Ca, Fe, Zn. Одним із можливих рішень по підвищенню кількісних показників переробки проса і збільшенню значень виходу готової продукції є включення до етапу підготовки зерна перед лущенням воднотеплової обробки зерна. Проведення воднотеплової обробки дозволяє провести зміцнення ядра і відповідно зменшити на 5-7 % кількість утворення на етапі лущення побічних продуктів і відходів. Відсутність етапу воднотеплової обробки у традиційній схемі пов'язано також з тим що на момент публікації і затвердження Правил не існувало технологічного обладнання яке дозволило б виявити і вилучити потенційно зіпсовані зерна із технологічного процесу достатньо ефективно особливо враховуючи характеристики зерна проса. Окрім цього просо є єдиною культурою в асортименті якої у Правилах рекомендовано виробляти тільки один вид крупи. Враховуючи достатньо збалансований хімічний склад проса виникає потреба у розширенні асортименту продуктів з цього зерна і обґрунтування режимів їх виробництва, а також модернізації і перегляду існуючого технологічного процесу з виробництва класичної крупи з проса у напрямку застосування сучасного технологічного обладнання що дозволить збільшити контрольованість різних етапів технологічного процесу при одночасному зменшенні енергетичних витрат на виробництво. На сьогодні широкою популярністю в Україні та світі користуються крупи швидкого приготування або крупи які не потребують варіння, плющені продукти і вироблені на їх основі зернові сніданки, мюслі, зернові батончики, мультизернові пластівці, гранола тощо.

Ключові слова: просо, крупа, хімічний склад зерна, круп'яне виробництво, сорт, розширення асортименту, пропарювання, фотосепаратори.

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