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Зерновые продукты и комбикорма
Grain Products and Mixed Fodder's

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CONTENT

ЗМІСТ

Журнал „Зернові продукти і комбікорми" згідно до наказу МОН України № 1301 від 15.10.2019 (Додаток 8) входить до списку друкованих (електронних) періодичних видань, що включаються до Переліку наукових фахових видань України категорії Б, в яких можуть публікуватися основні результати дисертаційних робіт на здобуття наукових ступенів доктора і кандидата технічних наук спеціальності 181

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NIBULON НІБУЛОН

In 30 years of its activities, NIBULON has created a unique grain logistics infrastructure in Ukraine, consisting of transshipment terminals and complexes for grain and oilseeds receipt, storage and shipment, a high-capacity fleet, and production branches located across Ukraine. At present the company's facilities operate in most regions of our country.

The total grain storage capacity is 2.25 million tons (the total elevator capacity is 2.08 million tons).

In 2009, NIBULON started implementing its investment project to revive the Dnipro and the Southern Buh Rivers as transport waterways of Ukraine. As part of this project, the company has built 18 elevator complexes and transshipment terminals in various regions of Ukraine. At present, the company's network consists of 27 transshipment terminals and complexes for grain and oilseeds receipt, storage and shipment, namely **445 silos to store grain, which is the largest number in Ukraine**.

NIBULON renders services directly to farmers; thus, the elevator complexes and transshipment terminals are brought closer to them. In the 2020/21 marketing year, the company signed 4,500 agricultural commodity supply agreements in the domestic market.

The transshipment terminal for grain and oilseeds shipments in Mykolaiv is unique not only in Ukraine but also in Europe. The transshipment terminal was acknowledged as Ukraine's best industrial facility constructed and put into operation in 2004. In June 2008, the team headed by Oleksiy Vadaturskyy received the Ukrainian State Prize for Architecture under the Ukraine President's Decree No. 569/2008 entitled "The Award of the State Prizes of Ukraine in Architecture of 2008".

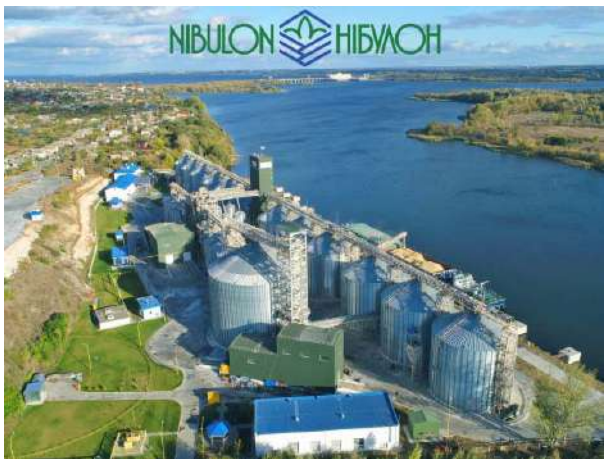
The terminal has modern complexes to receive, ship, dry, and to treat grain, plus a warehouse of floor storage with active ventilation and a capacity of up to 8 thousand tons. NIBULON can also receive different quality agricultural commodities and improve them to export standards, thereby ensuring that cargoes exported are guaranteed to meet world quality standards.

The checkpoint through the Ukrainian state border for international sea cargo that operates round-the-clock is located at the transshipment terminal. Border control and customs controls, and other types of control over persons, vehicles, cargoes and other property transiting the state border is organized according to the "single office" principle. To this end, NIBULON provided official premises with separate entrances (about 400 m2) free of charge on the ground floor of its administrative and laboratory building to the separate departments of the control authorities.

In May 2018, NIBULON put into operation its new elevator complex for grain and oilseeds transshipments (43 thousand tons) as part of the transshipment terminal. Thus, the total grain storage capacity was increased to 173 thousand tons at Mykolaiv transshipment terminal. It allows the company to store a large number of crops separately and simultaneously and to sort grain by quality. As a result, farmers can deliver grain to store it, and the company can store and maintain product quality as well as form grain batches in compliance with export contracts. In addition, the terminal can receive all crops throughout the entire marketing year and handle agricultural commodity cargoes transported along the Southern Buh and the Dnipro.

The company also put the reconstructed cargo berth into operation, which was extended from 104 to 222 m. As a result, the terminal's berth length is almost 800 m, enabling the company to load five vessels simultaneously. This enables the company to load seagoing vessels more efficiently and to increase the efficiency of the company's own fleet built at NIBULON shipbuilding and repair yard LLC.

The production and technological laboratory of the transshipment terminal is certified by the National Accreditation Agency of Ukraine (the certificate 21082 of 07.12.2017 is valid to 06.12.2020) to carry out physical-chemical and molecular genetic tests of grain, leguminous and oil crops. The production and technological laboratory confirms its competence in carrying out measurements during scheduled inspections of the National Accreditation Agency of Ukraine. The laboratory is acknowledged by the Grain and Feed Trade Association (GAFTA); every six months it successfully participates in inter-laboratory comparative rounds, which qualify it for GAFTA and BIPEA certificates to perform grain measurements. The competence in measuring the presence of GMO and safety indicators is confirmed by the international rounds of inter-laboratory comparative measurements.



The international recognition and cooperation with international and state agents when exporting grain products encourages NIBULON's employees to continuously improve their knowledge, to participate in international programs, etc. The production and technological laboratory is divided into two separate buildings: a laboratory that ensures grain quality control during receipts from/shipments on road transport located in the three-story laboratory and administrative building – is one of the most up-to-date facilities in Ukraine; a laboratory that ensures grain quality control during receipts from/shipments on rail transport, water transport (non-self-propelled vessels and motor vessels) located on the transshipment terminal's berth. Both laboratories are equipped (in compliance with the highest world standards) with laboratory and research equipment. NIBULON has been successfully audited for compliance with ISCC EU and ISCC PLUS requirements. ISCC certification indicates that the company's products are sustainable and that product cultivation is environmentally friendly, whilst respecting the principles of social responsibility; its distribution is carried out with the use of effective control systems. This enables NIBULON to export wheat, corn, rapeseed, sunflower, soybean as raw materials to the EU under the ISCC EU certificates for biofuel production. Barley is exported to the EU under the ISCC PLUS certificate for feed use.

NIBULON's process to take and sample from road transport is unique in Ukraine. The laboratory has the capacity to take and sample from three lines of road transport simultaneously; thus, it increases the speed of grain quality analysis without stopping cargo flow, thereby tripling the terminal's traffic capacity.

The safety of grain and oilseeds is measured according to the following criteria: content of mycotoxins (aflatoxins, ochratoxin A, zearalenone); residual amount of pesticides; content of toxic elements and radionuclides; presence or absence of GMO in grain and oilseeds is determined in accordance with the List of Food Products approved in Ukraine; content of protein in grain and oilseeds and fatty acid composition; the laboratory measures oil content in oilseeds by express and chemical methods using standard methods recognized throughout the world. In addition to grain, leguminous and oilseeds, food products are also analysed. Depending on the number of samples and the number of safety indicators to be checked, it takes from 5 hours to 3 days to complete the analysis. The laboratory is equipped with devices from world's leading manufacturers, such as FOSS Analytical AB (Sweden): Infratec 1241 grain analyzer, Infratec NOVA, Kjeltec 8400 analyzer; Dickey John (the USA): GAC 2100 grain moisture tester, Instalab 700 analyzer to measure glucosinolate in rapeseeds; Perten Instrument (Sweden): FALLING NUMBER 1900, FALLING NUMBER 1500, FALLING NUMBER 1000 devices to measure falling number, ML 3310 laboratory mill, Glutomatyk system; NG alveograph-consistograph from Chopin Technologies for comprehensive determination of rheological properties of flour. The chemical department of the laboratory uses the best high-precision equipment, such as Dionex Ultimate 3000 liquid chromatography (Germany), Agilent 7890A gas chromatographs (the USA), AA240Z and AA240FS atomic absorption spectrophotometers produced by Varian (Australia).

The production and technological laboratory is located in the administrative and laboratory building at each elevator complex and is equipped with the most modern equipment, devices and high-precision measuring equipment, such as Rakoraf mechanical samplers, PFEUFFER sample splitters, Binder drying cabinets, Infratec 1241 grain analyzers, Instalab 600, Instalab 700 analyzers, Perten, PCHP-7 devices to measure falling number, Glutomatyk systems for mechanical washing of gluten, analytical and laboratory scales, PKH-1 and PKH-2 testers, VDK-3M gluten strain gauges, and DE water stills.

The current prices for agricultural commodities at each elevator complex and transshipment terminal are posted on the Purchase price section on NIBULON's website.

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DETERMINATION OF QUINO SEED SAMPLES

Abstract

Quinoa is a promising crop due to its use in the food industry for the development of functional products. But there are very few recommendations in the world literature and almost no practical experience in the storage and processing of quinoa seeds. The study of quinoa and its properties in Western countries, as well as the development of modern methods of organic production in South America have led to the fact that quinoa is rapidly gaining popularity as a healthy and healthy product rich in vitamins and minerals and gluten-free. This has caused a boom in production and exports in Latin America, which continues to this day.

In Ukraine, quinoa has gained popularity in recent years, many Ukrainian cereal producers now include quinoa in their range. But so far, raw materials have been purchased abroad, primarily in Latin America.

Grain quality is a set of properties and characteristics (organoleptic, biological, physicochemical, technological, consumer) that determine the suitability of grain for its intended use. The main indicators of quinoa grain quality of different types: white, red and black are determined in the work. The quality of the studied samples was determined by organoleptic, chemical and microbiological indicators.

The results of the sensory analysis confirm the high results and the display of the grain of the cinoa by species.

The acidity of the grain of kinoa is determined, and it is set according to the indicators of acidity, until the acidity of the grain of kinoa is brought to good grain.

The results of microbiological studies show that the highest content of bacteria was found in samples of red quinoa seeds. The analysis of the obtained results showed that the predominant component of the bacterial microflora of quinoa grain is the non-spore-forming bacillus Erwinia herbicola. Molds of the genus Aspergillus and Muccor were found in samples of white quinoa seeds, fungi of the genus Penicillium in samples of red quinoa seeds, and no molds were found in samples of red quinoa seeds. Microbiological study showed that all samples were free of both pathogenic and opportunistic pathogens.

Organoleptic, chemical and microbiological indicators confirm the satisfactory quality of the studied quinoa grain samples.

Key words: **quinoa, grain quality, organoleptic indicators, microbiological indicators, acidity.**

Introduction

Quinoa is a fashionable product, one of the most popular superfoods in the world. Back in the 1990s, NASA scientists identified it as the ideal cereal for astronauts because it fully meets the nutrient needs of the human body. In light of the current trend, as long as you can stay young and healthy, interest in quinoa has grown again.

Quinoa (quinoa, quince) - a cereal crop belonging to the pseudograin, an annual plant of the Amaranth family.

At present, quinoa seeds are no longer an exotic product for Ukrainians, they can be found on the shelves of all major supermarkets, as well as tried in leading restaurants. Quinoa is widely represented in the recipes of vegetarian, gluten-free diets, weight control diets, as a low-calorie protein product, the amino acid composition of which is close to milk [1-4].

Despite the fact that the yield of quinoa is three times higher than the yield of buckwheat (5-6 t/ha against 1.5-3 t/ha), the cost of quinoa is significantly higher. The reason for the high cost is that the plant is much more demanding of growing conditions and does not tolerate low temperatures. In fact, the high price is due to the peculiarity of cultivation and distance of transportation [5, 6].

Interest in the culture of quinoa as a non-traditional raw ingredient for the consumer when creating multi-component recipes is justified by its high nutritional value and chemical composition. In terms of chemical composition, quinoa seeds contain all the necessary macronutrients: proteins - 14… 20 %, fats - 6.1 % and carbohydrates - 57.2 %.

A distinctive feature of quinoa culture is the content of high quality protein. In terms of protein content, quinoa seeds have the highest values, which exceed the data on corn protein by 4.6 times, rice - 2.1; wheat - 1.8; millet and oats - 1.6 times. The high protein content of quinoa grains allows it to compete with well-known high-protein plant products such as barley, buckwheat and amaranth. Moreover, some varieties of quinoa seeds contain more than 20 % protein [3, 5].

An additional positive aspect of the evaluation of the protein component of quinoa seeds is the fact that, unlike wheat and rice, which contain a small amount of lysine, the amino acid composition of quinoa grain proteins is quite balanced and close to milk protein, which reaches 20 types of amino acids.

Calculation of the biological value of the protein component of quinoa grains revealed the presence of 2 limiting essential amino acids. However, this does not reduce the value of quinoa culture as a promising source of protein in the composition of multicomponent food recipes [1, 3-5].

In Ukraine, quinoa has gained popularity in recent years, many Ukrainian cereal producers now include

quinoa in their range. But so far, raw materials have been purchased abroad, primarily in Latin America. However, since 2019, work has been underway on sowing quinoa seeds in Ukraine [2, 6, 7].

There are three main varieties of quinoa seeds - red, yellow and black. Each species differs in both color and taste. Also a popular variation of "tricolor" - or tricolor mixture.

Note that all three types of quinoa seeds have identical characteristics - that is, we can not say that one of them is better or more useful than the other. However, the color of quinoa seeds is due to the presence (or absence) of a protective shell - and a number of substances that are part of it.

The bitter taste of some quinoa species is due to the presence of saponins in the shell of the grain - natural pesticides that protect crops from birds and insects. Most often, before going on sale, the shell is removed mechanically - that is, the grain is cleaned. That is why the yellowish-white quinoa seeds have a milder taste and are traditionally used for cooking and baking. In turn, red and black quinoa seeds have a denser structure and are better suited for adding to salads.

Grain quality is a set of properties and characteristics (organoleptic, biological, physicochemical, technological, consumer) that determine the suitability of grain for its intended use. The quality of grain supplied to enterprises affects the conditions and time of storage. Even a slight excess of this figure leads to the inevitable deterioration of the grain mass.

Normally ripe, healthy grain has characteristics (shape, size, condition of integumentary tissues, gloss, color, which characterize the appearance), as well as smell and taste (determined in addition). Various adverse factors that occur during the cultivation of grain, active biological processes that occur during improper storage, can lead to loss of freshness and quality of grain. Grains with significant deviations in color (discolored or darkened) are classified as defective in grain or waste impurities.

Fresh grain should not have foreign odors, their appearance indicates a deviation from the norm as a result of adverse effects. Foreign odors in grain are divided into two groups: sorption origin (absorbed) and decomposition odors (as a result of undesirable biological processes).

The aim of the work is to determine the quality of quinoa seeds of different species.

Object of research: quinoa seed quality indicators.

Subject of research: three types of quinoa seeds: red, black and white.

Research methodology

Determination of quinoa grain quality was performed on the following main indicators: organoleptic indicators, acidity and microbiological indicators.

Organoleptic assessment of grain quality is of great practical importance, as it gives a preliminary idea of the benefits of grain mass, and is of paramount importance to the consumer, as quickly, without any physico-chemical studies gives a general idea of product quality. It is these indicators that have the psychological effect on the consumer, as a result of which he leaves his choice on this product [8]. Organoleptic indicators of grain quality include color, odor, taste. Organoleptic evaluation of quinoa seeds was determined in accordance with GOST 10967-90 and the developed score scale taking into account the weighting factors (Table 1).

The scoring system allows for organoleptic evaluation of quinoa seed samples with their assignment to one of the following categories: "excellent" (with a total score of 4.5-5.0 points), "good" (4.0-4.5 points), satisfactory "(3.5-4.0 points) and" unsatisfactory "(below 3.5 points).

According to DSTU ISO 6658: 2005 - "Sensory research. Methodology. General guidelines "sensory analysis was performed using methods of analytical evaluation by descriptive method (profiling method) and the method of using scales and categories (scoring) [8].

To study such important components of consumer properties of the product as "taste", "smell" and "color" used the method of profiling, the essence of which is that the complex concept of one of the organo

Table 1 - Scale for assessing the quality of quinoa seed samples

Quality indicators	Weighting factor	Characteristics of the indicator, points				
		5	**4**	**3**	**2**	**1**
1	2	3	4	5	6	7
Color	0,2	Pleasant, matching the color of the seeds by type	Quite nice, matching the color of the seeds in appearance	Not pleasant enough, the color of the products slightly does not match the color of the seeds in appearance	Unpleasant, different shades	Not typical of this type of seed
Taste	0,5	Pleasant, suitable for this type of seed, pronounced, without extraneous flavors	Pleasant, suitable for this type of seed, pronounced, without extraneous flavors	Weakly expressed	Not expressed taste	Not appropriate, outsider flavor
Smell	0,3	Pleasant, appropriate, pronounced, odorless	Pleasant, appropriate, pronounced, odorless	Weak odor	Unscented odor	Unsuitable odor

leptic properties is represented as a set of simple components evaluated by tasters , intensity and order of manifestation [9]. This method is the most informative because it covers all aspects of sensory quality of food and allows you to identify which components of taste, smell, color and texture are most relevant to the consumer properties of the product.

Acidity was determined according to GOST 26971-86. The method is based on potentiometric titration with sodium hydroxide solution of the total amount of free fatty acids, organic acids, end groups of proteins contained in grain and products of its processing and able to pass into the aqueous extract.

Microbiological studies of samples were performed for three samples of quinoa seeds of different species using both modern methods of determination (microbiological analyzer BakTrak 4300), whose work is based on recording changes in electrical resistance of the nutrient medium due to microorganisms, and classical methods. Samples were taken in sterile containers under aseptic conditions, which exclude contamination of the product with microbes from the environment. The composition of the microbiota of quinoa grain was determined by microbiological and sanitary indicators, which include the number of mesophilic aerobic and facultative anaerobic microorganisms (MAFANM), micromycetes (molds and yeasts), bacteria of the Escherichia coli group (followed by Escherichia coli). Staphylococcus aureus.

The total number of bacteria was determined by sowing washes of varying degrees of dilution in meat-peton agar (MPA), molds and yeast - in wort agar (CA) followed by cultivation at a temperature of (30 ± 1) ° C for 24-48 hours and (28 ± 1) ° C for 5-7 days, respectively. Spore forms of bacteria were determined in pasteurized washes from samples that were sown on a complex nutrient medium MPA and CA in a ratio of (1:1).

The presence of bacteria of the Escherichia coli group was established by sowing the grain wash in Kessler medium by the method of fermentation samples and evaluated by gas formation and turbidity of the medium.

The presence of potentially pathogenic staphylococci was established by accumulating them in meat-peptone broth with NaCl 6% and reseeding on milk salt agar. Cultivated in both crops for 24 hours at a temperature of (37 ± 1) ° C.

Quinoa grain was also analyzed for the presence of mycotoxins (aflatoxins B1, zearalenone, deoxynivalenol) using the Veratox test system.

Research results

Panels of taste, color and smell descriptors were presented for tasting, and the tasters gave their scores on a conditional five-point scale. The research results are shown in Fig. 1-3.

The following descriptors were taken into account during the study of taste by profiling:

- positive - general impression, harmonious, grain;

- negative - fresh, bitter, unpleasant aftertaste.

As can be seen from the profilogram, all types of quinoa seeds were characterized by harmonious taste, pleasant and grainy taste.

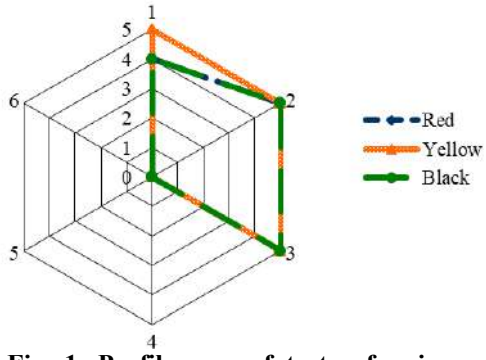

Fig. 1. Profilogram of taste of quinoa seed samples: 1 - general impression; 2 - harmonious; 3 -grain; 4 - fresh; 5 - rancid; 6 - unpleasant aftertaste

To evaluate the samples of quinoa seeds by color and odor, profilograms were constructed, which are shown in Fig. 2-3.

As can be seen from the profilograms presented in Fig. 2-3, quinoa seed samples, regardless of color and odor, have an attractive, pleasant color and a pronounced grain odor

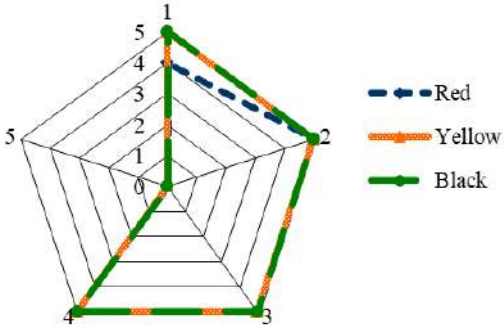

Fig. 2. Profilogram of color samples of quinoa seeds: 1 - attractive; 2 - pleasant; 3 - corresponding to the type of seed; 4 - uneven; 5 - does not correspond to the type of seed

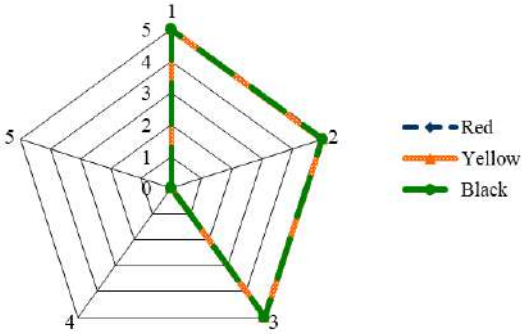

Fig. 3. Prophylogram of the smell of quinoa seed samples: 1 - pronounced, .2 - grain; 3 - pleasant; 4 - mild; 5 - third party

The tasting commission also evaluated the quinoa seed samples according to the developed score (Table 1), the results of which are shown in Table 2.

Thus, the results of sensory analysis confirm the high results of samples of quinoa seeds by species. Samples of quinoa seeds, regardless of color, are characterized by a harmonious taste, a pleasant slightly grainy taste and have a pleasant color. According to the results of the tasting evaluation, the samples received the highest

Table 2 - Evaluation of organoleptic quality indicators of quinoa seed samples, scores

P≥0,95, n=3

Type of quinoa seeds	Name of indicators without weighting factor / with weighting factor			Overall quality assessment	Quality category
	Color	Taste	Smell		
Red	5,0/1,0	5,0/2,5	5,0/1,5	5,0	perfectly
Yellow	5,0/1,0	5,0/2,5	5,0/1,5	5,0	perfectly
Black	5,0/1,0	4,9/2,45	5,0/1,5	4,95	perfectly

number of points, which corresponds to the quality category "excellent".

Grain acidity is an important indicator of their quality. During storage and grain acidity, as a rule, increases. Thus, it can serve as an indicator of quality, more precisely, an indicator of the freshness of grain or products of its processing.

Grain acidity depends, first, on proteins that are known to contain carboxyl groups that bind alkali. Secondly, the acidity of the grain also depends on the fatty acids that are released as a result of the breakdown of fats by lipase. Third, the acidity of grain and flour depends on phosphoric acid, which in the form of various compounds contained in the grain in significant quantities. Fourth, the acidity of the grain also depends on acetic, lactic, malic and other organic acids (including the Krebs cycle), which are usually contained in grains and flour in small quantities. The content of acetic and lactic acids increases significantly if the grain, cereals or flour spoiled as a result of self-heating or acidification [10]. As a result of the experiments, the following acidity values were obtained for different types of quinoa grain: white - 1.8 deg., Red - 2.4 deg., Black - 2.1 deg. All tested samples of quinoa grain belong to good quality grain.

Seeds are a living organism, and therefore it is a set of chemical transformations - metabolism, which ensures their viability. Metabolic processes in a living organism have a dual direction - anabolic (synthesis) and catabolic (splitting of synthesized substances). During anabolism there are processes of energy absorption by mainly reductive chemical processes, during catabolism - oxidative chemical reactions and energy is released [11-14].

The composition and more developed microbiota of grain and products of its processing are significantly affected by different storage regimes [11, 12]. Infection of products with microorganisms is on average - tens of thousands of bacteria per 1 g [12]. The products are dominated by bacteria Erwinia herbicola, the number of which reaches 70-90% of the total number of bacteria, spore-forming and cocci contains 5-15%. The content of fungal spores ranges from one percent to 1-5% of the total number of microorganisms. The fungal flora of the seeds is represented mainly by species of Penicillium [14]. During long-term storage in conditions where the humidity of the product and temperature exclude the possibility of microbiota development, there is a gradual decrease in the total number of bacteria as a result of the death of non-spore-forming forms [15].

Therefore, the study of the qualitative and quantitative composition of the microflora is important for the development and practical application of various processing methods to improve the stability and extend the shelf life of quinoa grain for further use in food, feed, pharmaceutical, microbiological and feed industries.

The indicator of the number of mesophilic aerobic and facultative anaerobic microorganisms (MAFANM) is the most common microbiological indicator. It is used in the food industry as an indicator of the sanitary condition of production.

We determined the qualitative composition of the microflora is an indicator of safety, as the presence of pathogenic microorganisms or increased content of opportunistic pathogens compared to the permissible norm can be the cause of poisoning.

The results of microbiological study of quinoa grain are given in table. 3

Table 3 - Results of microbiological examination of quinoa seed samples

Type of quinoa seeds	Bacteria, CFU/g	Molds, CFU/g
White	$1,1 \cdot 10^2$	90
Red	$5,2 \cdot 10^2$	Not found
Black	$1,0 \cdot 10^2$	600

The results of microbiological studies show that the highest content of bacteria was found in samples of red quinoa. The analysis of the obtained results showed that the predominant component of the bacterial microflora of millet grain is the non-spore-forming bacillus Erwinia herbicola - a representative of the epiphytic microflora. It is believed that the number of these bacteria is an indicator of grain freshness. The percentage of Erwinia herbicola bacteria from the total number of all bacteria is 75%, which confirms the good quality of grain. The share of coliform bacteria in millet grain was 15.6%.

Molds of the genus Aspergillus and Muccor were found in white quinoa samples, fungi of the genus Penicillium in samples of red quinoa, and no molds were found in red quinoa samples.

Microbiological study showed that all samples were free of both pathogenic and opportunistic pathogens.

Conclusions

In Ukraine, quinoa has gained popularity in recent years, many Ukrainian cereal producers now include quinoa in their range. But so far, raw materials have been purchased abroad, primarily in Latin America.

We have identified the main indicators of quinoa grain quality, which determine the suitability of grain for its intended use. According to organoleptic parameters, regardless of color, quinoa grain samples are characterized by a harmonious taste, a pleasant slightly grainy

taste and have a pleasant color.

Red quinoa has the highest acidity - 2.4 degrees, but all studied samples of quinoa grain are of good quality grain.

As a result of the experiments, the following acidity values were obtained for different types of quinoa grain: white - 1.8 deg., Red - 2.4 deg., Black - 2.1 deg. All tested samples of quinoa grain belong to good quality grain, as the acidity value is not 3 degrees.

The results of microbiological studies show that the highest content of bacteria was found in samples of red quinoa. The analysis of the obtained results showed that the predominant component of the bacterial microflora of millet grain is the non-spore-forming bacillus Erwinia herbicola - a representative of the epiphytic microflora.

Among the micromycetes previously, mold fungi of the genus Aspergillus and field fungi of the genus Mucor were detected in white quinoa samples, and mold fungi of the genus Penicillium in red quinoa samples, and molds were not detected in red quinoa samples.

Thus, organoleptic, chemical and microbiological indicators confirm the satisfactory quality of the studied samples of quinoa grain.

REFERENCES

1. *Valevs'ka L.O., Sokolovs'ka O.H., Shulyans'ka A.O Biolohichna tsinnist' zernovykh superfudiv // Vcheni zapysky TNU imeni V.I. Vernads'koho. Seriya: tekhnichni nauky Tom 31 (70) № 1 2020 CH.2. 116-120.*
2. *Valevskaya, L. i Sokolovskaya, O. Determination of physical and technological properties of quino grain - the main stages of justification of storage and processing technology// Grain Products and Mixed Fodder's. Volume 21, Issue 1 (81). 2021 P. 4-8. DOI:https://doi.org/10.15673/gpmf.v21i1.2089.*
3. *Koziol M. Chemical composition and nutritional evaluation of quinoa (Chenopodium quinoa Willd.) // Journal of Food Composition and Analysis №5.1992. 35-68*
4. *Sekhavatizadeh, S. S., Hosseinzadeh, S., & Mohebbi, G. (2021). Nutritional, antioxidant properties and polyphenol content of quinoa (chenopodium quinoa willd) cultivated in Iran. Future of Food: Journal on Food, Agriculture and Society, 2021, 9(2). P. 68- 79*
5. *5. Lilian E.Abugoch Quinoa (Chenopodium quinoa Willd.): Composition, Chemistry, Nutritional, and Functional Properties// Advances in Food and Nutrition Research Volume 58, 2009, Pages 1-31*
6. *D. Bazile, S.-E. Jacobsen and A.Verniau The Global Expansion of Quinoa: Trends and Limits // Frontiers in Plant Science 09 May 2016 | https://doi.org/10.3389/fpls.2016.00622*
7. *Trotsenko V.I., Kovalenko I.M., Il'chenko V.O. Stan ta perspektyvy kul'tury kinoa v pivnichno-skhidnomu lisostepu Ukrayiny// Visnyk Sums'koho natsional'noho ahrarnoho universytetu. Seriya «Ahronomiya i biolohiya», vypusk 9 (34), 2017. 77-81*
8. *Doslidzhennya sensorne. Metodolohiya. Zahal'ni nastanovy: DSTU ISO 6658:2005. Chynnyy vid 2006-07-01. K.: Derzhspozhyvstandart Ukrayiny, 2006. 17 . (Natsional'ni standarty Ukrayiny).*
9. *Rodina, T.G. Sensornyy analiz prodovol'stvennykh tovarov: uchebnik dlya studentov vuzov. Moskva: Akademiya, 2004. 208.*
10. *Kazakov Ye.D., Karpilenko G.P. Biokhimiya zerna i khleboproduktov: Ucheb. posobiye SPb.: GIORD, 2005. 512.*
11. *Mikrobiologiya pishchevykh proizvodstv: uchebnik /Il'yashenko N. G. i dr. Moskva: KolosS. 2008. 412*
12. *Mikroflora novykh vidov ekstrudirovannykh sukhikh zavtrakov i yeye izmeneniye pri khranenii/Velichko T.A. i dr.//Khraneniye i pererabotka zerna. 2009. №8. 42-49.*
13. *Smirnova T.A., Kostrova Ye.I. Mikrobiologiya zerna i produktov yego pererabotki: Ucheb. posobiye dlya vuzov. Moskva: Agropromishchdat, 1989. 159*
14. *14 Tekhnicheskaya mikrobiologiya / L. V. Kaprel'yants, L. N. Pilipenko, A. V. Yegorova, Ye. N. Kananykhina, S. M. Kobeleva, T. A. Velichko; pod red. L. V. Kaprel'yantsa. – Odessa: Druk, 2006. 308*
15. *F. Fayet-Moore Breakfast and Breakfast Cereal Choice and Its Impact on Nutrient and Sugar Intakes and Anthropometric Measures among a Nationally Representative Sample of Australian Children and Adolescents //Nutrients. 2017. № 9, p. 1045. https://doi.org/10.3390/nu9101045*

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ВИЗНАЧЕННЯ ПОКАЗНИКІВ ЯКОСТІ ЗРАЗКІВ НАСІННЯ КІНОА

Анотація

Кіноа є перспективною культурою з огляду використання у харчовій промисловості для розробки продуктів функціонального призначення. Але у світовій літературі досить мало рекомендацій та майже відсутній практичний досвід щодо зберігання та обробки кіноа. Вивчення кіноа і його властивостей в західних країнах, а також розвиток сучасних методів органічного виробництва в Південній Америці привели до того, що кіноа стрімко завойовує популярність в якості здорового і корисного продукту, багатого вітамінами і мінералами і не містить глютен. Це викликало бум виробництва і експорту в латиноамериканських країнах, який триває до теперішнього часу.

В Україні кіноа придбала популярність в останні роки, багато українських виробників круп зараз включають кіноа в свій асортимент. Але до теперішнього часу закуповували сировину за кордоном, в першу чергу в країнах Латинської Америки.

Якість зерна – це сукупність властивостей та ознак (біологічних, фізико-хімічних, технологічних, споживних), які визначають придатність зерна до вживання за призначенням. В роботі визначено основні показники якості зерна кіноа різних видів: білі, червоне, чорне. Визначення якості досліджуваних зразків проводилося за органолептичними, хімічними та мікробіологічними показниками.

Результати сенсорного аналізу підтверджують високі результати зразків насіння зерен кіноа за видами.

Визначено кислотність зерна кіноа, та встановлено що за показниками кислотності усі досліджувані зразки зерна кіноа відносяться до доброякісного зерна.

За результатами мікробіологічних досліджень видно, що найбільший вміст бактерій виявлено у зразках червоного кіноа. Аналіз отриманих результатів показав, що переважною складовою бактеріальної мікрофлори зерна просо є неспороутворююча паличка Erwinia herbicola. У зразках білого кіноа було виявлено плісеневі гриби роду Aspergillus та Muccor, у зразках чорго кіноа – гриби роду Penicillium, при цьому у зразках червоного кіноа плісеневі гриби не виявлено. Мікробіологічне дослідження показало, що в усіх зразках відсутні як патогенні, так і умовно патогенні мікроорганізми.

Органолептичні, хімічні та мікробіологічні показники підтверджують задовільну якість досліджених зразків зерна кіноа.

Ключові слова: кіноа, якість зерна, органолептичні показники, мікробіологічні показники, кислотність.

ЛІТЕРАТУРА

1. *Валевська Л.О., Соколовська О.Г., Шулянська А.О Біологічна цінність зернових суперфудів // Вчені записки ТНУ імені В.І. Вернадського. Серія: технічні науки Том 31 (70) № 1 2020 Ч.2 С.116-120*
2. *Valevskaya, L. i Sokolovskaya, O. Determination of physical and technological properties of quino grain - the main stages of justification of storage and processing technology// Grain Products and Mixed Fodder's. Volume 21, Issue 1 (81). 2021 P. 4-8. DOI:https://doi.org/10.15673/gpmf.v21i1.2089.*
3. *Koziol M. Chemical composition and nutritional evaluation of quinoa (Chenopodium quinoa Willd.) // Journal of Food Composition and Analysis №5.1992. 35-68*
4. *Sekhavatizadeh, S. S., Hosseinzadeh, S., & Mohebbi, G. (2021). Nutritional, antioxidant properties and polyphenol content of quinoa (chenopodium quinoa willd) cultivated in Iran. Future of Food: Journal on Food, Agriculture and Society, 2021, 9(2). P. 68- 79*
5. *5. Lilian E.Abugoch Quinoa (Chenopodium quinoa Willd.): Composition, Chemistry, Nutritional, and Functional Properties// Advances in Food and Nutrition Research Volume 58, 2009, Pages 1-31*
6. *D. Bazile, S.-E. Jacobsen and A.Verniau The Global Expansion of Quinoa: Trends and Limits // Frontiers in Plant Science 09 May 2016 | https://doi.org/10.3389/fpls.2016.00622*
7. *Троценко В.І., Коваленко І.М., Ільченко В.О. Стан та перспективи культури кіноа в північно-східному лісостепу України// Вісник Сумського національного аграрного університету. Серія «Агрономія і біологія», випуск 9 (34), 2017. С. 77-81*
8. *Дослідження сенсорне. Методологія. Загальні настанови: ДСТУ ISO 6658:2005. – Чинний від 2006-07-01. – К.: Держспоживстандарт України, 2006. – 17 с. – (Національні стандарти України).*
9. *Родина, Т.Г. Сенсорный анализ продовольственных товаров: учебник для студентов вузов. Москва: Академия, 2004. 208 с.*
10. *Казаков Е.Д., Карпиленко Г.П. Биохимия зерна и хлебопродуктов: Учеб. пособие СПб.: ГИОРД, 2005. 512 с.*
11. *Микробиология пищевых производств: учебник /Ильяшенко Н. Г. и др. Москва: КолосС. 2008. 412 с*
12. *Микрофлора новых видов экструдированных сухих завтраков и ее изменение при хранении/Величко Т.А. и др.//Хранение и переработка зерна. 2009. №8 С. 42-49.*
13. *Смирнова Т.А., Кострова Е.И. Микробиология зерна и продуктов его переработки: Учеб. пособие для вузов. Москва: Агропромиздат, 1989. 159 с*
14. *14 Техническая микробиология / Л. В. Капрельянц, Л. Н. Пилипенко, А. В. Егорова, Е. Н. Кананыхина, С. М. Кобелева, Т. А. Величко; под ред. Л. В. Капрельянца. – Одесса: Друк, 2006. 308 с.*
15. *F. Fayet-Moore Breakfast and Breakfast Cereal Choice and Its Impact on Nutrient and Sugar Intakes and Anthropometric Measures among a Nationally Representative Sample of Australian Children and Adolescents //Nutrients. 2017. № 9, p. 1045. https://doi.org/10.3390/nu9101045*

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REGULATION OF BAKING PROPERTIES OF WHEAT FLOUR BY USING OF POTATO PRODUCTS

Abstract

The most common in Ukraine today is the use of a synthetic group of technological additives used in flour mills, bakeries, confectioneries, etc. However, more promising and natural is the group of herbal supplements. The article analyzes the influence of different potato products in the amount of 4-10 % and extrudates of different cereals on the quality of flour products. The change of properties of trial baking in comparison with the control sample is investigated.

The materials of the article show the quality indicators of wheat flour TM "Bogumila" in comparison with the requirements of GSTU 46.004-99. The composition of model mixtures of wheat flour: potatoes in the ratios 96...90: 4...10, as well as mashed potatoes and mash 5-10% was developed. Physicochemical parameters of laboratory baking of bread were determined for the obtained samples.

Extrusion of model mixtures of grain with raw potatoes at a temperature of + 100-120 °C and a vapor pressure of 0.2 MPa. Extruded mixtures of wheat and potatoes were added to wheat flour TM "Bogumila" in the amount of 5; 7.5 and 10 % by weight of flour before kneading the dough and performed a test baking of bread. Organoleptic and physicochemical parameters were evaluated for the obtained bread samples. Changes in the baking properties of flour with the addition of similar crushed extrudates in different proportions have been studied. It was found that the starch content in extruded samples increases with increasing humidity and reaches a minimum value with a minimum content of potatoes and grains of 1.6 and 0.6 mm.

It was found that the addition of 7.5 % raw potato pulp and raw 5 % mashed potato in patent baking wheat flour is optimal due to the best quality indicators of products without significant deterioration of traditional organoleptic properties and somewhat delayed staling. Extruded wheat flour obtained from a mixture of wheat and potato, is recommended as an additive to baking flour in an amount of not more than 7.5 %.

Keywords: baking properties, wheat flour, potato, mashed potato, potato juice, potato pulp, extrudate.

Introduction. Formulation of the problem

To improve the quality of bread, bakery and flour confectionery products, regulation of technological processes use a variety of food additives, which by origin are conventionally divided into 3 groups: plant – fruit, herbal, algae and vegetable powders, flour of other cereals and legumes, ordinary and modified starch, extruded flour, fiber, dry wheat gluten, bran, malt, etc.; animal – milk powder and skim milk, whey powder, etc.; synthetic – microbiological (enzyme preparations) or chemical synthesis (oxidants, synthetic preparations of vitamins, amino acids, etc.) [1-8].

The most common today in Ukraine is the use of the latest group of technological additives used in flour mills, bakeries, confectioneries, etc. However, more promising and natural, from our point of view, is the first group of additives. Their use allows not only to change the properties of baking flour, improve the taste of bread, increase the porosity of bread, slow down staling, but also to enrich it with certain biologically active substances, give it a dietary, therapeutic and prophylactic effect, certain functional properties [1, 6, 9-11].

Analysis of recent research and publications

A great contribution to the development of theoretical and practical bases for the use of plant additives in the production of bakery and flour products, including potato products, was made by domestic scientists: L.Ya. Auerman, G.O. Magomedov, B.A. Baranov, R.Z. Grigorieva, L. I. Kazanska, V.I. Drobot, V.M. Kovbasa and others.

Potato is high-energy nutritious product. Existing technologies of its cultivation from 1 hectare of land allow to receive in 2.5-3 times more exchange energy, than at grain crops, productivity reaches 170 tones / hectare [12]. Potato is used as food, fodder crops, raw materials for starch, alcohol, chemical, textile, confectionery and other industries [13]. Potato protein (tuberin) has a high biological value, little inferior to egg white and meat. In comparison with chicken egg white, the biological value of tuberin reaches 85%, ideal protein – 70%. Potato also contains vitamins A (β-carotene), B1, B2, B6, C, PP, silicic acid, minerals such as potassium, sodium, calcium, magnesium, as well as iron, zinc, copper, manganese, cobalt [14].

The greatest contribution to the development of theoretical and practical bases of application of potato products in the production of bakery and flour products was made by L.Ya. Auerman. He substantiated the recommendations on the organization of the technological scheme of potato processing directly at bakeries, the use of boiled or raw potato in the production of bread from both rye and wheat flour. It was recommended to replace one part of flour with 3-4 parts of prepared potato [15].

Currently, potato products are added in the amount of 3-15% by weight of flour in various forms – mashed potato, flakes, starch, flour, etc. to supplement the insufficient amount of starch in the flour. This improves the quality of the crumb, especially in the case of excessively strong or short-grained gluten [16].

It is known from the literature that the introduction of up to 10% of potato products in the flour does not adversely affect the quality of bakery products, while in the case of 25% deterioration of their physico-chemical and organoleptic characteristics [17].

The results of other studies [18] show that the addition of 20% mashed potato in bakery products obtained the best quality indicators. This dosage maintains a pleasant appearance, improves the taste of the product, the structure of porosity, shape stability, increases the specific volume. The addition of mashed potato accelerates the ripening of the dough, significantly affects the nutritional value, increases the content of dietary fiber, vitamin PP, adds β-carotene, absent in flour, reduces the energy value of products.

It has been scientifically proven that fresh potato juice has a high nutritional value: it contains at least 12 free amino acids, in particular, valine, leucine, methionine, lysine, arginine, tyrosine. It is noted that fresh potato juice also contains B vitamins, ascorbic acid, carotene, pantothenic acid. The value of the minerals of potato juice: a large amount of phosphorus, calcium and magnesium compounds [19]. In [20], the authors note that the use of potato juice, which contains active lipoxygenase, is one of the effective ways to improve the quality of bakery products: increases the volume of bread, improves the structural and mechanical properties of the crumb.

Known ready-made flour mixtures for functional varieties of bakery products that contain potato flakes [21]. Increasingly, these flakes are used as an alternative to chemical leavening agents and preserving ways used in baking. NUFT conducted studies using potato flakes in the amount of 5-15% by weight of flour to extend the shelf life of bakery products. It was found that the introduction of more potato flakes significantly delays staling, but slightly worsens their physical and chemical quality. [22]. Increasing the dosage of potato flakes gives the bread a sweet taste, it increases the content of sugar and dextrins, freshness lasts longer, but the optimal dose of potato flakes is not more than 5% by weight of flour [23].

Dry potato fiber is a promising source of dietary fiber in the production of bread, it is hypoallergenic, finely dispersed; has advantages over dietary fiber in wheat bran, fruits and vegetables because it does not contain phytin, which prevents the absorption of calcium. This allows it to enrich bakery products [24,25]. Given the dispersion of potato fiber, bread with its content can be recommended for people with diseases of the gastrointestinal tract. Potato fiber should be added to the recipe of bread from wheat flour in an amount not exceeding 5% by weight of flour [26].

The aim of the work is to study the influence of processed and unprocessed potato products on the quality of wheat flour bread. Objectives of the study:

- to determine the quality indicators of patent wheat baking flour;
- to enter into the composition various potato products into the flour and to investigate the change in the properties of test baking in comparison with the control sample;
- to extrude model mixes with raw potato and to investigate the change of baking properties of flour with the addition of similar ground extrudates in different proportions.

Research materials and methods

The subject of research – patent baking wheat flour TM "Bogumyla", raw mashed potato and juice, mashed potato, wheat, extrudates. All studies were performed according to standardized methods (Table 1) in the laboratory at the Department of Grain Processing Technology and at the Department of Feed and Biofuel Technology at ONAFT.

At the first stage of research, the quality indicators of patent wheat baking flour TM "Bogumyla" were determined (Table 1) and their full compliance with the requirements of GSTU 46.004-99 was established.

In the studied potato tubers the dry matter content was determined according to [27] and the initial moisture of 75±1% was calculated.

Table 1 – Methods for determining the quality of grain, flour and laboratory baking of bread

Quality indicators	Method of determination
Moisture	*DSTU GOST 29144:2009 (ISO 711-85).* Grain and grain products. Determination of moisture
Quantity and quality of gluten	*GOST 13586.1-68.* Grain. Methods for determining the amount and quality of gluten in wheat
Starch	*Evers method*
Acidity by beaten-up flour and water	*GOST 27493-87.* Flour and bran. Method for determination of acidity by beaten-up flour and water
The content of crude ash	*GOST 10847-74.* Grain. Methods for determining the ash content
Whiteness of flour	*GOST 26361-84.* Flour. Whiteness determination method
Flour size (particle size distribution)	*GOST 27560-87.* Flour. Size determination method
Laboratory baking of bread	*GOST 27669-88.* Baking wheat flour. Method of trial laboratory baking

Table 2 – Quality indicators of patent wheat flour (n=3, p=0.95)

№	Quality indicators	Flour TM "Bogumyla"	Requirements of GSTU 46.004-99
1	Color	White with a yellow tinge	White or white with a yellow tinge
2	Odor	Inherent in wheat flour, odorless, not musty, not moldy	Inherent in wheat flour, odorless, not musty, not moldy
3	Taste	Inherent in wheat flour, without foreign flavors, not sour, not bitter	Inherent in wheat flour, without foreign flavors, not sour, not bitter
4	Moisture, %	14.2	Not more 15.0
5	Whiteness, un.	58	54 and more
6	The amount of crude gluten, %	27.0	No less 24.0
7	Gluten quality group	2	Not lower than the 2nd group
8	Size	3.9	5
9	Overtails on the sieve № 43, %	2	Not limited

To enter the potato into the dough, its tubers were cleaned of soil contaminants, washed, peeled, ground to a pulp and included in the dough in the following combinations:

- potato juice instead of water, which is usually used for mixing;
- mashed potato left after squeezing the juice (pulp), in the amount of 5.0; 7.5 and 10.0% by weight of flour;
- raw mashed potato in the amount of 5.0; 7.5 and 10.0% by weight of flour.

The quality indicators of wheat that was subjected to extrusion are as follows: moisture 11.3-11.5%, bulk density 780-790 g/l. To achieve the weighted average grain size: 1.6 mm; 0.8 mm and 0.6 mm – it was ground on a Nagema roller machine. Tubers of the same potato were prepared for extrusion similarly to the previous series of experiments. The moisture of the samples varied due to the different content of raw potato in the range of 4-10% of the total weight of the mixture, which provided its initial moisture of 14.2-18.3%. The mixture was mixed thoroughly, then kept under sealed conditions for 60-90 min to evenly redistribute moisture throughout the volume and extruded at a temperature of +100-120 °C and a vapor pressure of 0.2 MPa.

Table 3 – The composition of the model mixtures, %

Components	Sample mixture №			
	1	2	3	4
Wheat	96	94	92	90
Potato	4	6	8	10
Total	100	100	100	100

Extrusion of the samples was carried out on a production single-screw press extruder brand EZ-150 (manufacturer Cherkasyelevatormash).

Results of the research and their discussion

A control sample of bread was baked without the addition of potato products. Trial baking of bread was carried out according to GOST 27669-88. Evaluation of bread quality was performed the day after baking according to the main physical and chemical parameters (Table 4).

It is believed that potato juice is valuable in terms of baking, as it contains active lipoxygenase. This enzyme has an important role associated with improving the baking properties of flour. The oxidation products of fatty acids formed under the influence of the enzyme can cause oxidation of a number of other components of flour (pigments, SH-groups of gluten proteins, enzymes, etc.). At the same time there is a clarification of flour, strengthening of gluten, decrease in activity of proteolytic enzymes [19].

The addition of potato juice in the selected amount led to a darkening of the color of the crumb. Perhaps this is due to the presence among the nitrogenous substances of the potato juice of the amino acid tyrosine, which oxidizes to form dark melanins, which give a gray tint to the bread crumbs. The crust of bread has numerous tears, the porosity is underdeveloped, the crumb is inelastic, poorly baked. There is a significant decrease in the quality of bread not only in organoleptic but also physicochemical parameters when baking using potato juice in the selected amount: reduction of specific volume by 50%, porosity – by 45%, and moisture increases by 43% compared with a

Table 4 – Physico-chemical parameters of the laboratory baking of bread

Indicators	Control	Sample with the addition of potato						
		juice	mashed			pulp		
			5	7,5	10	5	7,5	10
Specific volume, cm^3/g	2.7	1.34	2.4	2.9	2.3	2.4	2.6	2.4
Moisture, %	40.7	50.0	41.0	41.8	43	40.8	41.6	42.0
Porosity, %	79	45	79	78	50	75	70	70
Acidity, degree	1.2	1.4	1.2	1.3	1.4	1.3	1.5	1.6

control sample.

Thus, for this sample of flour (with sufficiently strong gluten), the addition of potato juice led to a decrease in its baking quality.

However, the addition of 5% raw mashed potato on the contrary has a positive effect on the quality of laboratory baking. In terms of porosity and acidity, the test samples are not inferior to the control sample, and the specific volume and moisture are even higher than the control. However, with an increase in the content of mashed potato to 10%, the porosity of the product decreases sharply by 37%, the specific volume – by 17%, and moisture increases to 43%, which is associated with a decrease in the mass content of gluten, lower viscosity of the dough. According to organoleptic evaluation, this sample differs little from the sample with the addition of potato juice.

The addition of raw potato pulp has a less negative effect on the quality of laboratory baking, compared to the control and samples for the addition of raw mashed potato and potato juice. In terms of porosity and acidity, the test samples are slightly inferior to the control sample by an average of 11%, the moisture level is close to the control. However, as the content of mashed potato increases to 10%, the porosity of the product remains constant and the moisture increases to 42%, the specific volume of the product corresponds to the sample with 5% pulp. The 7.5% pulp sample has similar quality indicators to the control sample: close specific volume and slightly higher moisture and acidity.

The obtained results show that the sample with the addition of 7.5% potato pulp and 5% mashed potato has the best quality indicators and a slightly delayed staling period. The only organoleptic disadvantage of the prototypes is a slightly darker shade of bread. This is consistent with other scientific studies: in [17] it is noted that due to the dark color of the pulp of bakery products are often used not raw potato, and potato products: starch, protein concentrate, puree, grits, flakes, etc. That is, the addition of potato products should be carried out after their heat treatment, such as extrusion.

Extrusion is a technological process of forming product harnesses everywhere forming a hole of the matrix in order to obtain products of a given shape and improved physical and mechanical properties. Its essence is to convert the mechanical energy that occurs when moving wet material through the press, into heat by overcoming internal friction and plastic deformation, and thus increase the pressure in the machine; and in "decompression shock", which occurs at the outlet of the raw material from the extruder at a sharp drop in pressure and temperature due to evaporation of moisture [28,29]. A significant contribution to the development of extrusion technology is made by prominent scientists: Kovbasa V.M., Drobot V.I., Pivovarov P.P., Egorov B.V., Vinnikova L.G., etc., who substantiate the technology of production and use of extruded product (EP) in food concentrate, confectionery, meat processing, confectionery, feed industries [28-36].

In recent years, research has emerged on the use of EP, including cereals, in baking. The use of EP (extrudates of rice, corn, rye, barley, oats) is considered one of the promising areas of functional enrichment of bakery products [37] and at the same time - one of the ways to change the baking properties of flour [38,39].

Thus, according to prof. Kovbasa V.M. extruded wheat flour of the highest grade improves the organoleptic properties (color, aroma, porosity of the crumb), as well as intensification of the fermentation process, mainly due to increased gas-forming ability, has high solubility and water absorption, increased dextrin content compared to conventional. Its introduction in the amount of 10% in the recipe of wheat bread from second grade flour promotes the formation of dough close in consistency to the traditional, improves the organoleptic characteristics of the finished product), prolongs the shelf life of bread [40].

According to [41, 42], the use of extruded corn flour obtained by hot extrusion in a mixture with patent wheat flour for the manufacture of biscuits increases the elasticity of gluten in a dosage of up to 15% with its constant quality.

Adding the extrudate to the formulation of bakery products increases the water absorption capacity of the dough; the proportion of increase in bound water depends on the amount of extruded material added, not on the type of source cereals. From a rheological point of view, the most suitable improver is extruded corn middlings. Rye extrudate, which was added to wheat-rye dough, improved the organoleptic properties of the finished products, as well as slowed down the staling process. Wheat middlings extrudate did not significantly affect the quality of the product. Extruded patent wheat flour provided improved organoleptic properties (color, odor, porosity of the crumb), as well as intensified the fermentation process, mainly by increasing the gas-forming ability. In the case of using flour with deteriorating baking properties, there was an improvement in the shape-retaining ability of bread [30, 36, 38, 40].

The possibility of production of bakery products with the addition of extrudates from whole grain barley in the amount of up to 25% of flour according to the recipe was studied [43]. According to other studies, the rational amount of barley extrudate is 5-15% by weight of patent wheat flour, which contributes to the intensification of alcohol fermentation and increase the nutritional value of bread: it has an attractive appearance, pleasant taste and odor. Porosity structure: medium, uniform, developed; bread crumb is well baked, not moist, not sticky, with barely noticeable inclusions of barley extrudate particles. The color of the crumb of the finished bread is light and light with a grayish-yellow tinge [44].

The addition of crushed extruded wheat bran to wheat flour in the production of bread also leads to an increase in the autolytic activity and gas-forming ability of the flour mixture, as well as to an increase in the quality of gluten. The recommended optimal amount of additive introduced into the formulation of products is 5-15% by weight of flour [45, 46].

The authors [47, 48] consider dry mashed potato as a raw material for extrusion products. However, recent scientific studies have shown the possibility of using energy-efficient technologies, avoiding the drying process, to include in the extruded grain product (EGP) raw materials with high moisture (fruits, vegetables), including potato [48]. Theoretically, it is possible to use extru-

Table 5 – Properties of samples of model mixtures

№ sample	The weighted average particle size, mm	Indicators of extrudate quality				
		Moisture, %	Starch content, %	The content of destroyed starch, %	Volumetric mass, g/cm^3	Extension index
1	1,0	9.5	39.0	57	0.14	2.4
2		9.6	39.6	51	0.20	2.3
3		11.3	40.0	40	0.20	2.2
4		12.6	41.1	34	0.25	2.0
1	0.8	10.3	60.3	29	0.18	1.6
2		11.2	61.5	26	0.17	1.4
3		11.6	64.3	23	0.26	1.25
4		12.9	68.5	20	0.24	1.15
1	0.6	10.3	39.0	55	0.18	2.2
2		10.8	47.6	36	0.17	1.9
3		11.0	65.4	21	0.21	1.3
4		11.2	70.7	10	0.20	1

Table 6 – Physico-chemical parameters of the laboratory baking of bread

Indicators	Control	Sample with EP content in amount, %		
		5	7,5	10
Specific volume, cm^3/g	2.7	2.8	2.9	2.2
Moisture, %	40.7	40.4	40.4	40
Porosity, %	79	76	76	50
Acidity, deg	1.2	1.6	1.6	1.7

sion of a mixture of cereals with shredded raw potato, rather than dry mashed potato, for efficient heat treatment of the latter and at the same time directed change in the structure of grain biopolymers to obtain further "swellable" flour. It is proposed to extrude shredded potato in combination with other dry components (adsorbents) in a ratio that provides its weighted average moisture at the level of optimal for this process [50, 51].

At the next stage of research on model samples of mixtures (Table 4) studied the effect of the size of the grinding of wheat and the initial moisture of the raw material on the efficiency of the extrusion process. In the obtained samples of extrudates quality indicators were determined (table 6): moisture, expansion index, bulk density, starch content and content of destroyed starch [52]. The expansion index was defined as the ratio of the diameter of the cross section of the extrudate to the hole diameter of the die of the extruder.

Starch as the main component of potato and mixtures, in the process of extrusion plays the role of structurant, which is manifested in its swelling and the formation of macroporous structure. With increasing moisture level, which corresponds to fluctuations from 4 to 10% of the potato content, changes in chemical composition are observed. This is confirmed by experimental studies. As can be seen from Table 5, the starch content in the extruded samples increases with increasing moisture level in it and reaches a minimum value with a minimum content of potato and grain particle size of 1,6 and 0,6 mm.

As can be seen from Table 5, the expansion index acquires the greatest value at a mass fraction of potato of 4-6%, regardless of the size of the grinding of grain raw materials. It reaches the maximum value of 2.2-2.4 at a content of 4% of potato and the size of grinding of grain raw materials 1,6 and 0,6 mm, i.e. the dominant influence on the expansion index has moisture (i.e. potato content). As the mass fraction of moisture in the raw material increases, the mass becomes less porous, because the optimal conditions for efficient evaporation of moisture at the outlet of the extruder are not created: the pressure and temperature drop.

Another indicator of the quality of the extrudate that correlates with the index of expansion is the bulk density. It varied in direct proportion to the mass fraction of raw material moisture (Table 5). This dependence is explained by the influence of moisture on the rheological properties of the mass and the nature of stress relaxation, which lead to the formation of extrudates with a small number of air pores [47]. As the moisture in the raw material decreases, the bulk density decreases as the porosity of the extrudate increases. The minimum value of the bulk density is reached by a sample with a content of 4% of potato and a grinding size of 1.6 mm of grain, which corresponds to the maximum value of the expansion index.

The degree of destruction of starch also correlates with previous indicators and has a linear relationship: decreases with increasing moisture of raw materials (Table 5); the maximum value has a sample № 1 with a grinding particle size of 1.6 mm. Its total amount increases due to the cleavage of amylose and amylopectin molecules as a result of pressure, temperature and moisture.

The extruded mixture of wheat with potato (EP) sample № 1 (with a minimum content of potato with satisfactory quality of the extrudate) was ground on a laboratory process mill to a powder state (full pass of the sieve № 43) and added to the patent wheat flour TM "Bogumyla" (Table 1) in the amount of 5; 7.5 and 10% by weight of flour before kneading the dough. A control sample of bread was baked without the addition of powder. Trial baking of bread was carried out according to GOST 27669-88, the next day after baking – assessment by organoleptic and physicochemical parameters (Table 6).

When adding 5% of crushed extruded flour to the weight of high-grade wheat flour, the specific volume and porosity of bread is slightly greater than the control (4%), moisture – within the limits set by DSTU 7517:2014 [53], the acidity increased by 0.4 degrees. The use of this amount of crushed extrudate does not significantly change the structure of porosity and nutritional value of bread.

When adding 7.5% of crushed extruded flour to the mass of patent wheat flour, the specific volume of bread increases by 7%, porosity decreases by 3.7%, acidity is 0.4 degrees above the control level, moisture – within the limits set by the standard [53]. The bread has a satisfactory appearance, pleasant taste and odor.

When using 10% crushed extruded flour to patent wheat flour, the specific volume of bread decreases sharply by 19% and porosity – by 37%, acidity 0.5 degrees above the control level, but within the limits set by the standard [53], moisture – within the limits established by the standard. Bread has an unattractive appearance, the color of the crumb – grayish, the crust has numerous bursts.

Conclusion

As a result of this work, the influence of processed and unprocessed potato products on the quality of wheat flour bread was studied.

It has been found that the addition of 7.5% raw potato pulp and raw 5% mashed potato to patent baking wheat flour is optimal due to the best product quality indicators without significant deterioration of traditional organoleptic properties and somewhat delayed staling time. Extruded wheat flour obtained from a mixture of wheat and potato is recommended to be used as an additive to baking wheat flour in the amount of up to 7.5%, as exceeding its amount leads to a deterioration in the quality of bakery products.

REFERENCES

1. *Veršinina OL, Kornen NN, Il'inova SA. Primenenie piševyh dobavok v tehnologii hlebopečeniâ. Izvestiâ vyssih učebnyh zavedenij. Piševaâ tehnologiâ. 2000;5-6:27-30.*
2. *Bystrova AI, Tokareva GA, Bystrova KL. Novye ulučšiteli, tehnologii i hlebobuločnye izdeliâ. Hleboprodukty. 1998;8:24-26.*
3. *Kiyah VA, Lavitskiy VP, Shalevskaya VN. Povyšenie kačestva hlebobuločnyh izdelij putem ispol'zovaniâ dopolnitel'nyh syr'evyh komponentov. Nauč.tr. DonNUÈT imeni Mihaila Tugan-Baranovskogo, 2017. S. 78.*
4. *Levašov RR, Mihajlova ES, Danilova AV, Mingaleeva ZŠ. Tehnologiâ buločnogo i mučnogo konditers'kogo izdelij s ulučšennimi potrebitel'skimi svojstvami. Nauka molodyh - budušee Rossii. 2016. S. 368-370.*
5. *Ɛvčuk ÂV. Zastosuvannâ netradicijnoï sirovini v tehnologiï hliba. Visnik ŽNAEU. 2017;1(58):211–221.*
6. *Nilova LP, Dubrovskaâ NO. Optimizaciâ kačestva hlebobuločnyh izdelij, polučennyh s ispol'zovaniem netradicionnogo syr'â. Vestnik Ûžno-Ural'skogo gosudarstvennogo universiteta. Seriâ: Èkonomika i menedžment. 2007;27(99):70–75.*
7. *Matveeva I, Nesterenko V. Modificirovannye krahmaly dlâ formirovaniâ kačestva hlebobuločnyh i makaronnyh izdelij. Hleboprodukty. 2011;4:65-67.*
8. *Kasabova ER, Samohvalova OV. Vliâniâ dobavok, soderžaŝih piševye volokna, na hlebopekarnye svojstva pšeničnoj muki. Naučnye vedomosti Belgorodskogo gosudarstvennogo universiteta. Seriâ: Estestvennye nauki. 2013;(167):111–116.*
9. *Pajmulina AV, Androsova NV, Naumenko NV. Perspektivy ispol'zovaniâ obogaŝaûŝih dobavok v tehnologii hlebobuločnyh izdelij. Vestnik Ûžno-Ural'skogo gosudarstvennogo universiteta. Seriâ: Piševye i biotehnologii. 2016;4(4):95–104.*
10. *Šmatkova NN. Primenenie èkstrudata smesi zerna pšenicy i semân rastoropši v tehnologii ržano-pšeničnogo zavarnogo hleba. Innovacionnaâ tehnika i tehnologiâ. 2016;2:53–60.*
11. *Lihačeva EI, Azin DL. Ob ispol'zovanii ovošnyh poroškov v kačestve piševyh dobavok. Meždunar. simp. «Èkol. čeloveka: piš tehnol i produkty na poroge 21 v.», Pâtigorsk, 1997. Pâtigorsk;1997:150–151.*
12. *Gončarov MD, Kožuško NS. Selekcìâ kartoplì na produktivnìst' ì âkìst'. Vìsnik Sums'kogo deržavnogo agrarnogo unìversitetu: agronomìâ ì bìologìâ. 2001;5:36-37.*
13. *Ulânič OÌ, Vorobjova NV. Urožajnìst' sortìv kartoplì rann'ostigloï v pravoberežnomu Lìsostepu Ukraïni. Naukovij vìsnik Nacìonal'nogo unìversitetu bìoresursìv ì prirodokoristuvannâ Ukraïni. Ser.: Agronomìâ. 2013;183(1):214-219.*
14. *Musina ON, Šetinin MT, Sahrynin MN. Sovremennye tendencii ispol'zovaniâ dobavok v proizvodstve piševyh produktov. Barnaul: Izd-vo AltGTU, 2010.*
15. *Auèrman LÂ. Tehnologiâ hlebopekarnogo proizvodstva. Moska: Piševaâ promyšlennost', 1984.*
16. *Bìlik OA, Halìkova EF, Faìn AV. Kartoplânì produkti u hlìbopečennì. Hlìbopekars'ka ì konditers'ka promislovìst' Ukraïni. 2014;6:7–9.*
17. *Serdûk LV. Vliânie vvoda dobavok produktov pererabotki kartofelâ na kačestvo muki i hleba. «Izv. vuzov. Piš. tehnol.» Krasnodar, 1985.*
18. *Tipsina NN, Selezněva GK. Kartofel'noe pûre kak ulučšitel' kačestva buločnyh izdelij. Vestnik Krasnoârskogo gosudarstvennogo agrarnogo universiteta. 2015;12:81–86.*
19. *Koneva SI. Kletočnyj sok kartofelâ kak ulučšitel' kačestva hleba. Materialy dokladov Meždunarodnoj konferencii «Hlebopekarnoe proizvodstvo–2014» Meždunarodnaâ promyšlennaâ akademiâ 1-3 dekabrâ 2014 g. Moskva, 2014;1:28-31.*
20. *Stuter. Potato granules as ingredients in the bakery and snacks food industry. Food ingredients Eur. Conf. Proc., Paris, 8-10 Oct., 1991. Maarssen, 1991:261-265.*
21. *Lihačeva EI, Azin DL. Ob ispol'zovanii ovošnyh poroškov v kačestve piševyh dobavok. 5 Meždunar. simp. «Èkol. čeloveka: piš tehnol i produkty na poroge 21 v.», Pâtigorsk, 1997. Pâtigorsk, 1997:150-151.*

22. *Drobot V, Bilik O, Savčuk N, Bahtir'ov S. Kartoplâni plastivci u hlibobuločnih virobah. Hlibopekars'ka i konditers'ka promislovist' Ukraïni. 2009;07-08(56-57):43-44.*
23. *Fedorova RA, Ponomarenko VM. Primenenie funkcional'nyh dobavok i netradicionnyh vidov syr'â v hlebopekarnoj promyšlennosti. Naučnyj žurnal NIU ITMO. Seriâ «Processy i apparaty piševyh proizvodstv». 2011;1:209-217.*
24. *Potato-based dietary fibre. Functional foods & nutraceuticals. 2005 Nov:55.*
25. *Pastuszewska B, Antushevich H, Tusnio A, Taciak M. Potato dietary fibre: preliminary characterization of the properties and nutritional effects: a review. Polish journal of food and nutrition sciences. 2009;59(3):205-210.*
26. *Drobot VI, Grišenko AN. Ispol'zovanie kartofel'noj kletčatki v tehnologii hlebobuločnyh izdelij. Hranitelna nauka, tehnika i tehnologii 2013:Naučni trudove. Plovdiv. 2013;LX:105-108.*
27. *Metodika provedennâ kvalìfikacìjnoï ekspertizi sortìv roslin na pridatnìst' do poširennâ v Ukraïnì: Metodi viznačennâ pokaznikìv âkostì produkcìï roslinnictva. Mìnìsterstvo agrarnoï polìtiki ta prodovol'stva Ukraïni. Kiïv, 2016.*
28. *Bogatyrev AH, Ûr'ev VP, redakt. Termoplastičeskaâ èkstruziâ: naučnye osnovy tehnologii, oborudovanie. Moskva:«Stupen'», 1994.*
29. *Kas'ânov GI, Burcev AV, Grickih VA. Tehnologiâ proizvodstva suhih zavtrakov. Učebno-praktičeskoe posobie. Seriâ "Tehnologiâ piševyh proizvodstv". Rostov n/D: "Izdatel'skij centr MarT", 2002.*
30. *Kovbasa VM, Hìvrič BÌ, Dorohovič AM. Zastosuvannâ ekstruzìï u virobnictvì novih harčovih produktìv. 1995.*
31. *Annênkova NB, Rudavs'ka GB. Klasifikacìâ produktìv ekstruzìjnoï tehnologìï ta možlivostì rozširennâ ïh asortimentu. Nauk. pracì «Progresivna tehnìka ta tehnologìï harčovih virobnictv, restorannogo gospodarstva ì torgìvlì» Harkìv: HDUHT, 2006:264-271.*
32. *Šaburova GV. Èkstrudirovannyj âčmen' kak komponent funkcional'nyh piševyh produktov. Piševaâ promyšlennost', 2012;10:44–45.*
33. *Šaburova GV, Voronina PK, Šmatkova NN. Èkstrudirovannyj oves kak syr'e dlâ obogaŝeniâ hleba. V sb-ke: Piševaâ promyšlennost' i agropromyšlennyj kompleks: dostiženiâ, problemy, perspektivy: sbornik statej 8 Meždunarodnoj naučno-praktičeskoj konferencii. Pod red. V.A. Avrorova. Penza, 2014:97–101.*
34. *Kuročkin AA. i dr. Regulirovanie struktury èkstrudatov krahmalsoderžaŝego zernovogo syr'â. Izvestiâ Samarskoj gosudarstvennoj sel'skohozâjstvennoj akademii. 2013;4:94-99.*
35. *Šaburova GV, Kuročkin AA, Voronina PK. Povyšenie tehnologičeskogo potenciala nesoloženyh zernoproduktov. Tehnika i tehnologiâ piševyh proizvodstv. 2014;1(32):90-96.*
36. *Kovbasa VN. i dr. Èkstrudirovannyj pšeničnyj krahmal kak ulučšitel' dlâ hlebopekarnyh izdelij. Izvestiâ vysših učebnyh zavedenij. Piševaâ tehnologiâ. 1998;2-3:21- 23.*
37. *Derkanosova N. i dr. Issledovanie adsorbcionnyh svojstv zernovyh èkstrudatov. Hleboprodukty. 2008;3:41–43.*
38. *Kovbasa VM, ta ìn. Zernovì ekstrudovanì materìali - polìpšuvačì hlìbopekars'kogo virobnictva. Vikoristannâ produktìv ekstruzìï ì metodìv ekstruzìjnoï obrobki u hlìbopekars'komu virobnictvì. 1996:5-8.*
39. *Šmal'ko NA, Belikova AV, Roslâkov ÛF. Ispol'zovanie èkstrudirovannyh produktov v hlebopečenii. Fundamental'nye issledovaniâ. 2007;7:90-92.*
40. *Kovbasa VM, ta ìn. Zastosuvannâ ekstruzìjnoï tehnologìï dlâ virobnictva hrumkogo hlìba. Vikoristannâ produktìv ekstruzìï ì metodìv ekstruzìjnoï obrobki u hlìbopekars'komu virobnictvì. 1996;3:10-11.*
41. *Lìsovs'ka TO, Pokotilo OS, Čorna NV. Vivčennâ možlivostì vikoristannâ borošna kukurudzânogo ekstrudovanogo v tehnologìï bìskvìtnogo napìvfabrikatu. Naukovij vìsnik L'vìvs'kogo nacìonal'nogo unìversitetu veterinarnoï medicini ta bìotehnologìj ìm. Gžic'kogo. 2014;2(3):133-139.*
42. *Lìsovs'ka TO, Čorna NV, D'âkov OG. Doslìdžennâ reologìčnih vlastivostej bìskvìtnogo tìsta z vikoristannâm ekstrudovanogo kukurudzânogo borošna. Vostočno-Evropejskij žurnal peredovыh tehnologij. 2016;2(11): 19-23.*
43. *Demčenko VI, i dr. Èkstrudaty âčmenâ v proizvodstve hlebobuločnyh izdelij. IV Meždunar. nauč.– prakt. konf. «Introdukciâ netradic. i red. s.– h. rastenij»: Materialy. Ul'ânovsk, 2002;1:238–241.*
44. *Šaburova GV, Voronina PK. Ispol'zovanie produktov pererabotki âčmenâ v hlebopečenii. Innovacionnaâ tehnika i tehnologiâ. 2015;3:23-27.*
45. *Malkina VD. Povyšenie èffektivnosti hlebopekarnogo proizvodstva na osnove modifikacii svojstv syr'â: avtoreferat dis. … d-ra tehn. nauk: 05.18.01 M., 1996.*
46. *Voronina PK. Praktičeskie perspektivy termoplastičeskoj èkstruzii krahmalsoderžaŝego zernovogo syr'â v formirovanii kačestva prodovol'stvennyh tovarov. Innovacionnaâ tehnika i tehnologiâ. 2015;3:5-12.*
47. *Šul'ga OS, Kovbasa VM. Doslìdžennâ možlivostì oderžannâ produktìv ekstruzìï na osnovì suhogo kartoplânogo pûre. Nauk. pr. Nacìonal'nij unìversitet harčovih tehnologìj. Kiïv, 2007;22:14-17.*
48. *Šul'ga OS. Rozroblennâ tehnologìï ekstruzìjnih kartopleproduktìv pìdvišenoï harčovoï cìnnostì: avtoref. dis. na zdobuttâ nauk. stupenâ kand. tehn. nauk: spec. 05.18.01 «Zberìgannâ ì tehnologìâ pererobki zerna, vigotovlennâ zernovih ì hlìbopekars'kih virobìv ta kombìkormìv». K., 2009.*
49. *Êgorov BV. Formuvannâ spožìvnih vlastivostej harčovih produktìv novogo pokolìnnâ šlâhom ekstruzìï. Hranenie i pererabotka zerna. 2014;182(5):64-67.*
50. *Ostrikov AN, Abramov OV, Rudometkin AS. Èkstruziâ v piševoj tehnologii. SPb.: GIORD, 2004.*
51. *Burcev AV, Grickih VA, Kas'ânov GI. Sovremennaâ tehnika i tehnologiâ termoplastičeskoj èkstruzii v proizvodstve «suhih zavtrakov». Krasnodar: «Èkoinvest», 2004.*
52. *Êgorov BV, ta ìn. Metodičnì vkazìvki do vikonannâ laboratornoï roboti po kursu „Učbovo-doslìdna robota studentìv" dlâ studentìv, âkì navčaût'sâ za navčal'nim planom specìalìstìv specìal'nostì 7.091701 dennoï formi navčannâ (rosìjs'koû movoû). Odesa: ONAHT, 2004. 42s.*
53. *DSTU 7517:2014 Hlìb z pšeničnogo borošna. Zagal'nì tehnìčnì umovi. Kiïv, 2014. 14 s*

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РЕГУЛЮВАННЯ ХЛІБОПЕКАРСЬКИХ ВЛАСТИВОСТЕЙ ПШЕНИЧНОГО БОРОШНА ЗА ДОПОМОГОЮ КАРТОПЛЯНИХ ПРОДУКТІВ

Анотація

Найпоширенішим на сьогоднішній день в Україні є використання синтетичної групи технологічних добавок, що застосовують як на борошномельних заводах, так і у хлібопеченні, кондитерських комбінатах, тощо. Проте більш перспективною та природною, є група рослинних добавок. В статті проаналізовано вплив різних картопляних продуктів у кількості 4-10% та екструдатів різних злакових культур на якість борошняних виробів. Досліджена зміна властивостей пробної випічки порівняно з контрольним зразком.

В матеріалах статті наведено показники якості борошна пшеничного ТМ «Богумила» у порівнянні до вимог ДСТУ 46.004-99. Розроблено склад модельних сумішей пшеничне борошно : картопля у співвідношеннях 96...90 : 4...10, а також картопляного пюре і мезги 5-10 %. Для отриманих зразків визначені фізико-хімічні показники лабораторного випікання хліба. Проведено екструдування модельних сумішей зерна з сирою картоплею при температурі +100-120 °С і тиску пари 0,2 МПа. Екструдовані суміші пшениці з картоплею додавали до борошна пшеничного ТМ «Богумила» у кількості 5; 7,5 і 10% від маси борошна перед замісом тіста та здійснили пробне випікання хліба. Для отриманих зразків хліба провели оцінку за органолептичними та фізико-хімічними показниками. Досліджено зміни хлібопекарських властивостей борошна з додаванням аналогічних подрібнених екструдатів у різних пропорціях. Встановлео, що вміст крохмалю в екструдованих зразках збільшується з підвищенням в них рівня вологості і досягає мінімального значення при мінімальному вмісті картоплі та зерна розміром 1,6 і 0,6 мм.

Встановлено, що додавання 7,5 % сирої картопляної мезги та сирого 5 % картопляного пюре у хлібопекарське пшеничне борошно вищого сорту є оптимальним через найкращі показники якості виробів без значного погіршення традиційних органолептичних властивостей та дещо відстрочений термін черствіння. Екструдоване пшеничне борошно, отримане із суміші пшениці та картоплі, рекомендовано застосовувати у якості добавки до хлібопекарського пшеничного борошна у кількості не більше 7,5 %.

Ключові слова: хлібопекарські властивості, борошно пшеничне, картопля, картопляне пюре, картопляний сік, картопляна мезга, екструдат.

ЛІТЕРАТУРА

1. *Вершинина О.Л., Корнен Н.Н., Ильинова С.А. Применение пищевых добавок в технологии хлебопечения. Известия высших учебных заведений. Пищевая технология. 2000;5-6:27-30.*
2. *Бустрова А.И., Токарева Г.А., Бустрова К.Л. Новые улучшители, технологии и хлебобулочные изделия. Хлебопродукты. 1998;8:24-26.*
3. *Киях В.А., Лавицкий В.П., Шалевская В.Н. Повышение качества хлебобулочных изделий путем использования дополнительных сырьевых компонентов. Науч.тр. ДонНУПТ имени Михаила Туган-Барановского, 2017. 78.*
4. *Левашов Р.Р., Михайлова Е.С., Данилова А.В., Мингалеева З. Технология булочного и мучного кондитерского изделий с улучшенными потребительскими свойствами. Наука молодых - будущее России. 2016. 368-370.*
5. *Євчук А.В. Застосування нетрадиційної сировини в технології хліба. Вісник ЖНАЕУ. 2017;1(58):211–221.*
6. *Нилова Л.П., Дубровская Н.О. Оптимизация качества хлебобулочных изделий, полученных с использованием нетрадиционного сырья. Вестник Южно-Уральского государственного университета. Серия: Экономика и менеджмент. 2007;27(99):70–75.*
7. *Матвеева И., Нестеренко В. Модифицированные крахмалы для формирования качества хлебобулочных и макаронных изделий. Хлебопродукты. 2011;4:65-67.*
8. *Касабова Е.Р., Самохвалова О.В.. Влияния добавок, содержащих пищевые волокна, на хлебопекарные свойства пшеничной муки. Научные ведомости Белгородского государственного университета. Серия: Естественные науки. 2013;(167):111–116.*
9. *Паймулина А.В., Андросова Н.В., Науменко Н.В.. Перспективы использования обогащающих добавок в технологии хлебобулочных изделий. Вестник Южно-Уральского государственного университета. Серия: Пищевые и биотехнологии. 2016;4(4):95–104.*
10. *Шматкова Н.Н. Применение экспортной смеси зерна пшеницы и семян расторопши в технологии ржано-пшеничного заварного хлеба. Инновационная техника и технология. 2016;2:53–60.*
11. *Лихачева Э.И., Азин Д.Л. Об использовании овощных порошков в качестве пищевых добавок. Междунар. симп. «Экол. человека: пищ. технол. и продукты на пороге 21 в.», Пятигорск, 1997. Пятигорск; 1997: 150–151.*
12. *Гончаров М.Д., Кожушко Н.С. Селекція картоплі на продуктивність і якість. Вісник Сумского державного аграрного університету: агрономія і біологія. 2001;5:36-37.*
13. *Уланич О.М., Воробьйова Н.В. Врожайність сортів картоплі ранньостиглої в правобережному лісостепу України. Науковий вісник Національного університету біоресурсів і природи України. Сер.: Агрономія. 2013;183(1):214-219.*
14. *Мусина О.Н., Четинин М.Т., Сахрынин М.Н. Современные тенденции использования добавок в производстве пищевых продуктов. Барнаул: Изд-во АлтГТУ, 2010.*
15. *Ауэрман Л.А. Технология хлебопекарного производства. Москва: Пищевая промышленность, 1984.*
16. *Білик О.А., Халікова Є.Ф., Фаін А.В. Картопляні продукти у хлібопеченні. Хлібопекарська кондитерська промисловість України. 2014; 6:7–9.*
17. *Сердюк Л.В. Влияние ввода добавок продуктов переработки картофеля на качество муки и хлеба. «Изв. вузов. Пищ. технол.» Краснодар, 1985.*
18. *Типсина Н.Н., Селезнёва Г.К.. Картофельное пюре как улучшитель качества булочных изделий. Вестник Красноярского государственного аграрного университета. 2015;12:81–86.*
19. *Конева С.И. Клеточный сок картофеля как улучшитель качество хлеба. Материалы докладов Международной конференции «Хлебопекарное производство–2014» Международная промышленная академия 1-3 декабря 2014 г. Москва, 2014;1:28-31.*
20. *Stuter. Potato granules as ingredients in the bakery and snacks food industry. Food ingredients Eur. Conf. Proc., Paris, 8-10 Oct., 1991. Maarssen, 1991:261-265.*

21. *Лихачева Э.И., Азин Д.Л. Об использовании овощных порошков в качестве пищевых добавок. 5 Междунар. симп. «Экол. человека: пищ. технол. и продукты на пороге 21 в.», Пятигорск, 1997. Пятигорск, 1997: 150-151.*
22. *Дробот В., Билик О., Савчук Н., Бахтиров С. Картопляні пластівці у хлібобулочних виробах. Хлібопекарська і кондитерська промисловість України. 2009;07-08(56-57):43-44.*
23. *Федорова Р.А., Пономаренко В.М. Применение функциональных добавок и нетрадиционных видов сырья в хлебопекарной промышленности. Научный журнал НИУ ИТМО. Серия «Процессы и аппараты пищевых производств». 2011;1:209-217.*
24. *Potato-based dietary fibre. Functional foods & nutraceuticals. 2005 Nov:55.*
25. *Pastuszewska B, Antushevich H, Tusnio A, Taciak M. Potato dietary fibre: preliminary characterization of the properties and nutritional effects: a review. Polish journal of food and nutrition sciences. 2009;59(3):205-210.*
26. *Дробот В.И., Грищенко А.Н. Использование картофельной клетки в технологии хлебобулочных изделий. Hranitelna nauka, tehnika i tehnologii 2013:Naučni trudove. Plovdiv. 2013;LX:105-108.*
27. *Методика проведення кваліфікаційної експертизи сортів рослин на придатність до поширення в Україні: Методи визначення показників в складі продукції рослинництва. Міністерство аграрної політики та продовольства України. Київ, 2016.*
28. *Богатырев А.Х., Урьев В.П., редакт. Термопластическая экструзия: научные основы технологии, оборудование. Москва: «Ступени», 1994.*
29. *Касьянов Г.И., Бурцев А.В., Грицких В.А. Технология производства сухих завтраков. Учебно-практическое пособие. Серия «Технология пищевых производств». Ростов н/Д: «Издательский центр МарТ», 2002.*
30. *Ковбаса В.М., Хівріч Б.М., Дорохович А.М. Застосування екструзії у виробництві нових харчових продуктів. 1995.*
31. *Анненкова Н.Б., Рудавська Г.Б. Класифікація продуктів екструзійної технології і можливості розширення їх асортименту. Наук. праці «Прогресивна техніка та технології харчових виробництв, ресторанного господарства і торгівлі» Харків: ХДУХТ, 2006:264-271.*
32. *Шабурова Г.В. Экструдированный экстракт как компонент функциональных пищевых продуктов. Пищевая промышленность, 2012;10:44–45.*
33. *Шабурова Г.В., Воронина П.К., Шматкова Н.Н. Экструдированный овес как сырье для обогащения хлеба. В сб-ке: Пищевая промышленность и агропромышленный комплекс: достижения, проблемы, перспективы: сборник статей 8 Международной научно-практической конференции. Pod red. В.А. Авророва. Пенза, 2014. С. 97–101.*
34. *Курочкин А.А. и др. Регулирование структуры экструдатов крахмалсодержащего зернового сыра. Известия Самарской государственной сельскохозяйственной академии. 2013;4:94-99.*
35. *Шабурова Г.В., Курочкин А.А., Воронина П.К. Повышение технологического потенциала несоложеных зернопродуктов. Техника и технология пищевых производств. 2014;1(32):90-96.*
36. *Ковбаса В.Н. и др. Экструдированный пшеничный крахмал как улучшитель для хлебопекарных изделий. Известия высших учебных заведений. Пищевая технология. 1998;2-3:21-23.*
37. *Дерканосова Н. и др. Исследование адсорбционных свойств зерновых экструдатов. Хлебопродукты. 2008; 3:41–43.*
38. *Ковбаса В.М., та ін. Зернові екструдовані матеріали - поліпшувачі хлібопекарського виробництва. Використання продуктів екструзії і методи екструзійної обробки у хлібопекарському виробництві. 1996: 5-8.*
39. *Шмалько Н.А., Беликова А.В., Росляков Ю.Ф. Использование экструдированных продуктов в хлебопечении. Фундаментальные исследования. 2007;7:90-92.*
40. *Ковбаса В.М., та ін. Застосування екструзійної технології для виробництва хрумкого хліба. Використання продуктів екструзії і методів екструзійної обробки у хлібопекарському виробництві. 1996;3:10-11.*
41. *Лісовська Т.О., Покотило О.С., Чорна Н.В. Вивчення можливості використання борошна кукурудзяного екструдованого в технології бісквітного напівфабрикату. Науковий весник Львівського національного університету ветеринарної медицини та біотехнологій ім. Гажицького. 2014;2(3):133-139.*
42. *Лісовська Т.О., Чорна Н.В., Дьяков О.Г. Дослідження реологічних властивостей бісквітного тіста з використанням екструдованого кукурудзяного борошна. Восточно-Европейский журнал передовых технологий. 2016;2(11): 19-23.*
43. *Демченко В.И. и др. Экструдаты ячменя в производстве хлебобулочных изделий. IV Междунар. науч. – практ. конф. «Интродукция нетрадиц. и ред. с.–х. растений»: Материалы. Ульяновск, 2002; 1. С. 238–241.*
44. *Шабурова Г.В., Воронина П.К. Использование продуктов переработки ячменя в хлебопечении. Инновационная техника и технология. 2015;3:23-27.*
45. *Малкина В.Д. Повышение эффективности хлебопекарного производства на основе модификации свойств сырья: автореферат дис. … д-ра техн. наук: 18.05.01 М., 1996.*
46. *Воронина П.К. Практические перспективы термопластической экструзии крахмалсодержащего зернового сырья в формировании качества производственных товаров. Инновационная техника и технология. 2015;3:5-12.*
47. *Шульга О.С., Ковбаса В.М. Дослідження можливості одержання продуктів екструзії на основі сухого картопляного пюре. Наук. пр. Національний університет харчових технологій. Київ, 2007; 22:14-17.*
48. *Шульга О.С. Розроблення технології екструзійних картоплепродуктів підвищеної харчової цінності: автореф. дис. на здобуття наук. ступеня канд. техн. наук: спец. 18.05.01 «Зберігання і технологія переробки зерна, виготовлення зернових і хлібопекарських виробів та комбікормів». К., 2009*
49. *Єгоров Б.В. Формування споживних властивостей харчових продуктів нового покоління шляхом екструзії. Зберігання і переробка зерна. 2014;182(5):64-67.*
50. *Остріков А.Н., Абрамов О.В., Рудометкін А.С. Екструзія в харчовій технології. СПб.: ГІОРД, 2004*
51. *Бурцев А.В., Грицьких В.А., Касянов Г.І. Сучасна техніка і технологія термопластичної екструзії в виробництві «сухих сніданків». Краснодар: «Екоінвест», 2004.*
52. *Єгоров Б.В., та ін. Методичні вказівки до навчання лабораторної роботи по курсу «Учбово-дослідна робота студентів» для студентів, які навчаються за навчальним планом спеціалізації (спеціальності 97017). Одеса: ОНАХТ, 2004. – 42 с.*
53. *ДСТУ 7517:2014 Хліб з пшеничного борошна. Загальні технічні умови. Київ, 2014. 14.*

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PASTRY BASED ON FLOUR WITH SPECIFIC CHARACTERISTICS

Abstract

Preservation of initially high quality of the pastry based on the natural ingredients throughout their shelf-life is a major factor to ensure their competitiveness. One of the effective ways of solving this task is using the types of wheat flour with specific characteristics. Differential approach to the technological characteristics of flour, depending on baked goods types, makes it possible to ensure the stability of the technological process and the quality of the produced products without usage of inorganic improvers. Among the types of wheat flour with specific characteristics the flour of waxy wheat, the starch of which does not contain amylose, which plays an important role in the stealing of flour products, is to particular interest. The studies found that waxy wheat flour characterised with higher gassing power and water absorption compare with control. According to their technological characteristics it is suggested to use wheat flours with specific characteristics in the technology of yeast-containg cakes, hardtacks with lower sugar capacity. Flour of extra-soft wheat Oksana is characterized by low water absorption and weak gluten, which are desirable technological properties for the production of most types of confectionery dough. It was found that waffles and wafers based on extra-soft wheat Oksana flour are characterized with lower density and better porosity and texture compared with the control. It is shown that the use of waxy wheat flour and biscuit wheat flour in the technology of mentioned pastry types leads to the technological process intensification, stabilization of their rheological characteristics, product quality and their freshness without adding of improvers.

Keywords: waxy wheat, extra-soft wheat, wheat flour, pastry, quality, staling.

Introduction

In the total volume of confectionery products, pastry occupy a large share [1]. Food manufacturers pay considerable attention to the production of these products in order to increase the profitability of their enterprises. Therefore, in addition to expanding the pastry assortment, it is actual task to ensure its stable quality during the whole period of storage, which will enhance the competitiveness of products in the current conditions of market [2].

The task of improving, stabilizing the quality of pastry is closely related with the problem of providing necessary quality characteristics of raw materials, their effective and purposed usage. Thus, the technological properties of wheat flour, a main ingredient of the flour product, is a significant factor that determines the technological process, the quality of semi-finished products and the texture of final products [3]. The requirements for flour quality characteristics, due to the considerable variety of flour products, should vary in a sufficiently wide range and depend on the used method of leavening, the structural and mechanical properties of the dough masses, the peculiarities of their technological process, which ensure the required texture of products, etc.

In Ukraine the whole assortment of flour products are produced from bakery wheat flour, which is not always technologically suitable for the production of high-quality pastry products. After all, the technological properties of flour for production of bread and pastry dough should be different [4-6].

Considering the foregoing, it is necessary to investigate the possibility of using wheat flours with specific characteristics, breeded in the south of Ukraine, in the technology of pastry for the stabilization of their quality and enhancement of their shelf-life without using the improvers with chemical origin.

Analysis of literature data and problem statement

The current dynamic development of the food industry and market relations require to respond quickly for consumer demands by the manufacturer of pastry products [7]. This tendency provide the production of high-quality products and to ensure its organic origin and environmental friendliness [8].

Dough`s pastry is one of the most multicomponent structure, which structure-mechanical properties depend on recipe ingredients and their correlation, and technological parameters also. The dough for wide assortment of pastry differs according to their rheological characteristics, which obtain a finished product quality with a desired texture [5, 9]. For this reason, usage of flour with specific characteristics is important for at the production of pastry with various structure. In this case the most expedient for most pastry production is the usage of wheat flour with weak elastic gluten, which is unsuitable for obtaining high-quality bread.

In Ukraine in spite of other countries [10], bakery wheat flour is the only one type of wheat flour, which is used in the production of bread and pasta products. This significantly complicates the work of technologists, leads to cost increase, negative effects on the quality of products. For effective and fast solving these problems the manufacturers often add food supplements, which have inorganic origin in greater extent, which is a risk factor for the consumer`s health.

Differential approach to flour quality, depending on its use, is widespread [5,6,11]. For example, in the Europe and the USA, purposed flour is produced by the selection of wheat mixtures [12, 13]. Sometimes the blends are prepared from whole grain meals with either hard or soft wheat flour and processed into bread, cake, cookie or snack products. All bakery and pastry technologies demand special properties of flour. Treated heat flour is recommended for fancy cakes and some types of cookies production. Such type of flour can be “inactivated” or enzymatically inactive. Its treatment can be strong (with the denaturation of the whole protein) or soft, which weakly changes the properties of the flour.

The use of flour from various varieties of wheat and their mixtures for the production of certain types of products is actual. Breeders are constantly elaborate new varieties of wheat, which characterized with specific technological properties of the flour produced from it. These characteristics practically do not effect on the taste of the product, but significantly effect on the structure and quality of products. This influence is different for various types of pastry products depending on the presence and ratio of sugar and fat, as well as the method of dough leavening.

It has been established that pastry products made from soft wheat flour characterized with higher quality compared with the products based on ordinary bakery wheat flour. The positive influence on the product quality is determined by several basic physical and chemical properties, a fine dispersion, a characteristic natural soft looseness with a low percentage of damaged starch granules [14].

Waxy wheat flour represents a special interest among the new varieties of Ukrainian breeding crops with specific characteristics. A numbers of studies have been conducted to confirm its potential as a main component of the flour products recipe due to its modified starch (non-amylose) content (Fig.1).

It was found that the introduction of waxy wheat flour into the recipe of bakery goods causes to the increasing of their consumer characteristics throughout the storage period [14, 15]. It should be taken into account that the recommendations of foreign scientists and technologists regarding to the use of flour with specific characteristics for the manufacture of certain types of products can not be uniquely projected for the production of

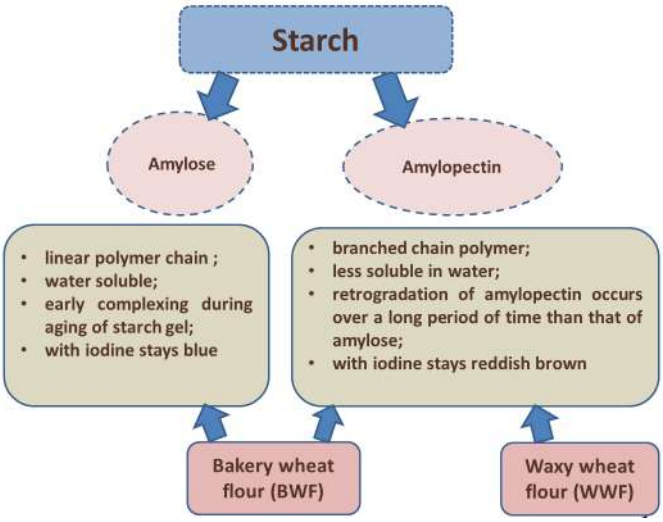


Fig. 1 - Waxy wheat starch

pastry in our country, taking into account the specifics of their classification and technology. Consequently, the pastry quality improvement is closely connected with the question of efficient and rational use of grain resources according their characteristics and the requirements of the technological process.

The main aim is to investigate the effectivness of the wheat flours with specific characteristics usage for the quality improvement and its stabilization during pastry (yeast-containing cakes, hardtacks, wafers and waffles) shelf-life without using of inorganic origin improvers.

Based on it the study stages were:

- determining the technological properties of wheat flours with specific characteristics and substantiating the choice of pastry for their rational use;
- investigating the influence of the waxy wheat flour mass fraction on the intensity of the fermentation process of yeast-containing cakes and hardtacks semi-finished products;
- investigating the influence of the biscuit Oksana wheat flour on the viscosity of wafer`s and waffle`s dough;
- evaluating the quality of pastry and its change in the process of storage.

Materials and methods of research.

In this study wheat flour produced from waxy wheat Ukrainian specie Sofiika was used for the yeast-based cake`s and hardtacks with reduced sugar content production. Jerusalem artichoke powder and maltose syrup were used as a sugar substitute agent in the hardtacks recipe. Extra-soft wheat flour (Oksana specie), which breeded in Ukraine, was used in the wafers and waffles technologies.

The intensity of gas formation in the dough was measured by AG-1M. This method is based on determining the amount of carbon dioxide formed during the dough fermentation by the volumetric method [16].

Comparative analysis of the wheat flour quality included the determination of the raw gluten content was realized by the methods presented in [14], the level of gluten plasticity measured by IDK (special device designed for determining the gluten quality group), its elasticity, estimated by the value of its deformation under the load effect. The results of measuring the gluten elasticity are expressed in conventional units of the device scale. Depending on the value of measuring results, gluten is related to the correspondent quality group.

The moisture content of flour was determinated by heating a small sample of flour for 1 hr at 130°C and taking the loss in weight as the moisture content according to ISO 27971:2015. Water absorption is the amount of water required to center the farinograph curve, which was determined using Farinograph (Brabender).

The effective viscosity *(η,* Pa·s) of the dough was determined with a rotational viscometer "Reotest-2" immediately after the preparation of wafer`s dough at a temperature of 18-20°C [17].

The determination of the hardness of the products was carried out on a device, which measured the force P of sample break down. The hardness in kg/m^2 was calculated

$$H_0 = \frac{P}{S}, \quad (1)$$

where H_0 – the hardness, kg/m^2;
P – force acting on area, kg;
S – contact area, m^2.

For the determination of the product`s density (ρ, g/cm^3), the volume of wafers/hardtacks is measured by the calculated method based on the results of two-time weighing of the product (in the air and in water). To prevent wetting, the object of the study is pre-coated with a layer of paraffin, which provides protection of its surface while immersion in water.

To determinate the density the product has been weighting on a technical scale to the nearest 0,01g. Then it is dipped into molten paraffin, whose temperature is close to its hardpoint, and quickly removed. When the paraffin on the surface of the sample has hard, it is again weighed and placed in suspension. The paraffinized sample was weighed twice with the suspension: in air and fully immersed in water at a temperature of about 20°C. The density measured in g/cm^3 calculated by the formula

$$\rho = \frac{m}{V_3 - (V_1 + V_2)}, \quad (2)$$

where ρ – density, g/cm^3
m - mass of product, g;
V_1 - volume of suspension, cm^3;
V_2 - volume of paraffin, cm^3;
V_3 - volume of paraffined product with suspension, cm^3.

The acid accumulation was evaluated on the basis of change of its total titratable acidity. It was defined as the amount of 0,1N NaOH solution (mL) used to neutralize 5 g sample weight homogenized with 50 ml of distilled water. These analyses were carried out every 30 min during all term of fermentation (90 min) [17].

The water absorption capacity of products was determined by measuring the water absorption when it submerged in water at a temperature of 20°C for a set amount of time [17]. Determination of moisture content was made according to ISO 712:2009.

The specific volume was calculated by dividing the volume by the weight of the baked product [17].

Structural-mechanical properties of soft waffle and cake`s crumb was determined on the automatic penetrometer AP-4/1 [17].

Results and discussions

Technological properties of wheat flours with specific characteristics (waxy wheat flour – WWF and biscuit Oksana wheat flour - BOWF) were studied.

The results of the evaluation of the technological properties of waxy wheat flour indicate that an increase of the mass fraction of non-amylose flour promotes the growth of the gassing power of mixtures with BWF (table 1).

Table 1 - Technological properties of flour mixtures

Mass fraction of WWF, %	Amount of CO_2, ml CO_2/100 g flour (after 5h of fermentation)	Water absorption, %
0	1314	59,0
20	1380	61,0
40	1580	63,0
60	1760	65,0
80	1815	66,0
100	1900	67,0

The normal gas-forming ability of wheat all-purpose flour for 5 hours of its fermentation is 1300-1600 ml of carbon dioxide. It is known that for the formation of such an amount of carbon dioxide, yeast must ferment at least 6 g of glucose. In this period yeast has obtain about 1 g of glucose getting from own flour sugars, and the remaining 5 g are formed as a result of amylolytic starch degradation. The increase of the carbon dioxide amount for samples with waxy wheat flour can be explained by the increased content of its own sugars in the content, which are the main energy material for yeast cells, and also by the more intense amylolysis of its starch. The increase in the water absorption capacity of flour from waxy wheat by 8 % compared to bakery wheat flour (BWF) is caused by greater sensitivity of non-amylose starch grains to mechanical damage during grinding, which contributes to the increase of their hydrophilic properties.

A comparative analysis of the wheat flour quality of bakery wheat flour (BWF) and biscuit Oksana wheat flour (BOWF) showed (table 2) that the extra-soft wheat flour is characterized by weaker gluten and it`s lower content. Qualitative characteristics of gluten-forming fractions of protein BOWF correspond to the weak III quality group. Also, this type of flour had a lower by 7 % water absorption capacity.

Considering the technological properties of biscuit Oksana wheat flour, a study of the feasibility of using in the technology of wafer products, for the production of which it is recommended to use flour with weak gluten.

Table 2 - Comparative analysis of the wheat flour quality

Quality indicators	Bakery wheat flour (BWF)	Biscuit Oksana wheat flour (BOWF)
Moisture content, %	14,2	14,3
Content of wet gluten, %	24,5	21,6
Plasticity for IDK, device units	70	85
Water absorption, %	59,0	52,0

The influence of replacing 50 % and 100 % bakery wheat flour on BOWF on the properties of batter and products from it - wafers (wafer sheets) and waffles with chemical method of leavening has been investigated.

It is obtained that substitution of BWF with BOWF leads to the lower viscosity of wafer`s and waffle`s batter and the destruction of its structure occurred at lower viscosity gradients than for control sample to a greater extent, these changes are observed with a complete replacement bakery of BOWF (fig. 2). An increase in shear rate is accompanied by a decrease in batter viscosity. At a shear rate of more than 9 s^{-1} – there approximates the viscosity of the dough to a steady value. After all, under the influence of the growing shear rate, the interaction between the particles decreases, and their orientation increases in the direction of the flow.

Thus, the viscosity of the dough based on BOWF was more reduced for waffle by 2,8 times and wafer by 1,6 times, in compare with control (at the shear rate $\gamma = 3\ s^{-1}$). The viscosity decrease may due to the weaker gluten and the low water absorption capacity of the flour of BOWF, which increases the content of the liquid phase in the dough, which contributes to better coverage of flour particles with a hydration shells and simplifies their dispensing under mechanical action, without sticking.

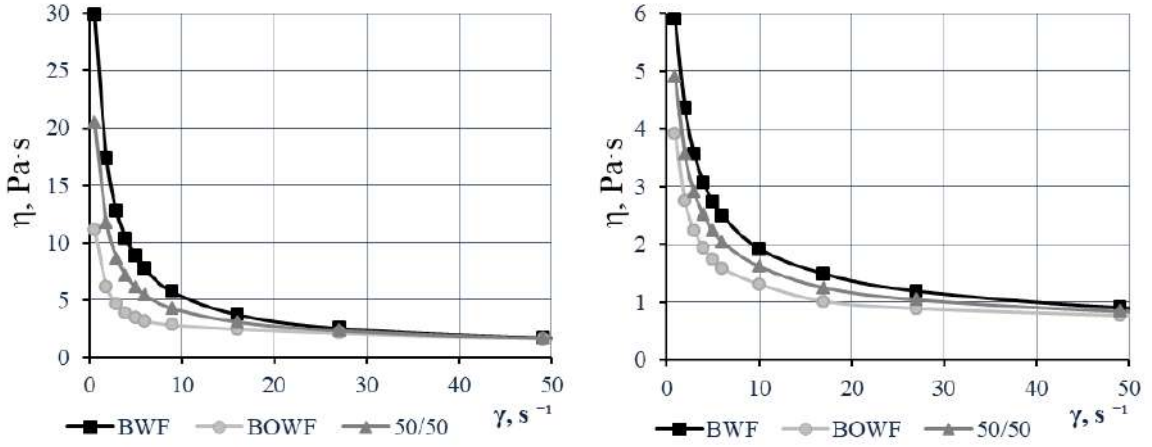
The obtained results of the quality of the finished products research show that the replacement of BWF with BOWF in the recipe of waffles leads to the improvement of the finished products quality (fig. 3a). Thus, in comparison with control, waffles were characterized by a 4,6 % increase in specific volume and increased by 8,3 % as a measure of the total compression of the crumb, this is typical for high porosity. This is probably due to the weaker gluten of BOWF, the formation of dough protein structure, which is more easily stretched under the influence of gas substances, that extend during baking.

It is obtained that waffle products based on BOWF are characterized by an increased volume, an intense color of the surface and a well-developed porous structure of the crumb. Replacement of baking flour with biscuit flour leads to the higher quality formation of wafers.

For wafer sheets density and the hardness index (fig. 3b), which correlates with the texture of products and characterizes their fragility, was determined. Thus, the hardness of wafer sheet at full replacement of BOWF is lower by 8,4 %, and about twice lower density comparing with the control sample. Reducing the hardness and density of samples based on BOWF can be explained by the formation of a less dense gluten structure due to the lower content of glutelin and prolamine protein fractions, which is characteristic for this type of flour, and leads to the increase of product porosity.

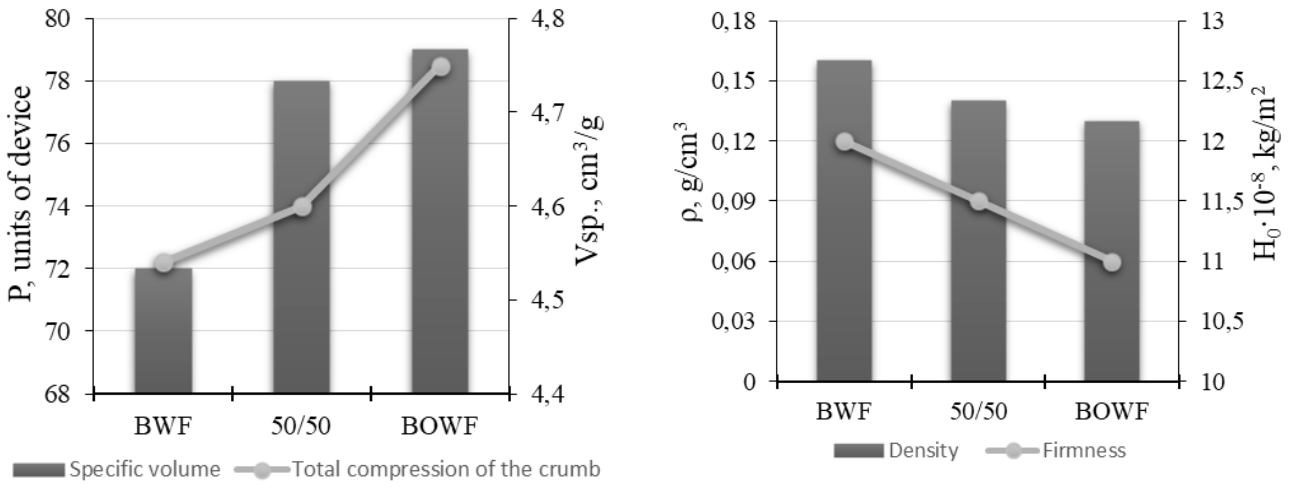
The wafers, based on BOWF, were characterized with desired crisp properties, without cracks and leaks, equal color and more homogeneous density compared to control, due to a decrease in the viscosity of the batter, which contributed to its better distribution on the baking surface.

According to the results of the investigation of technological properties of waxy wheat flour and its blends with bakery wheat flour the choice of pastry, in the production of which it is advisable to use new type of flour, has been justified. Waxy wheat flour has a higher gassing power, which can contribute to the intensification of technological process in the production of pastry products, the formation of a porous structure which is caused by the process of fermentation, and will help to stabilize their quality in the case of partial or complete



a) b)

Fig. 2 - Viscosity of waffle`s (a) and wafer`s (b) dough



a) b)

Fig. 3 - Quality index of the waffle (a) and wafer (b) products

exclusion of sugar from the recipe, which not only determines the taste of the product but also causes required intensity of biotechnological processes in the production of these products. Also, effective results can be achieved by solving the problems of rapid staling of yeast-containing cakes using in their production the waxy wheat flour, which has lower peak temperature (BWF - 88°C, WWF - 74°C) and its starch consists of amylopectin. This polysaccharide has higher resistance to retrogradation compared with amylose, which is the essential component of the starch of the bakery wheat flour [6].

Its usage in the production of hardtacks with Jerusalem artichoke powder and maltose syrup instead of the sugar in the recipe content was accompanied, by the increase of the carbon dioxide amount and final titratable acidity of the semi-finished products (fig. 4), which indicates intensification of alcoholic and lactic acid fermentation in the process of their production compared with the control sample. Based on the obtained results, it is suggested to reduce the fermentation process duration of the dough for the samples based on the WWF up to 30…60 min depending on the used type of sweetener.

It was determined that the combined use of waxy wheat flour with natural sweeteners, despite the exclusion of sugar from the recipe, was accompanied by the higher water absorption and lower density of the hardtacks compared with control samples based on the bakery wheat flour [18]. Such results indicates the better porous structure formation for the investigated samples.

The study of the quality change of hardtacks during storage showed that the introduction of non-amylose flour into their recipes provides the quality stabilization of samples. The hardtacks based on waxy wheat flour with Jerusalem artichoke powder and maltose syrup, as sugar substitutes, were characterized with better quality indicators compared to the control and similar samples based on bakery wheat flour with natural sweeteners after 90 days of storage (table 3).

Also the effect of BWF to WWF ratio on the yeast-based cakes quality was studied (fig.5). It found that samples with 60 % WWF were characterized with the highest porosity compared with the control. Such results can be obtained due to the higher gassing power of non-amylose type of wheat flour.

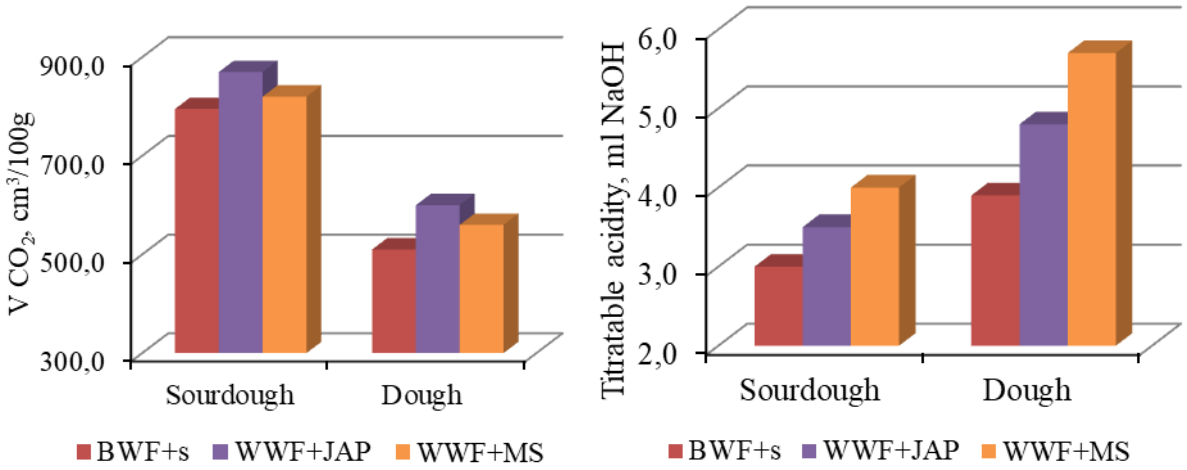


Fig. 4 - The carbon dioxide amount (a) and final titratable acidity of semi-finished products:
BWF – bakery wheat flour; WWF – waxy wheat flour; s – sugar; JAP – Jerusalem artichoke powder; MS – maltose syrup.

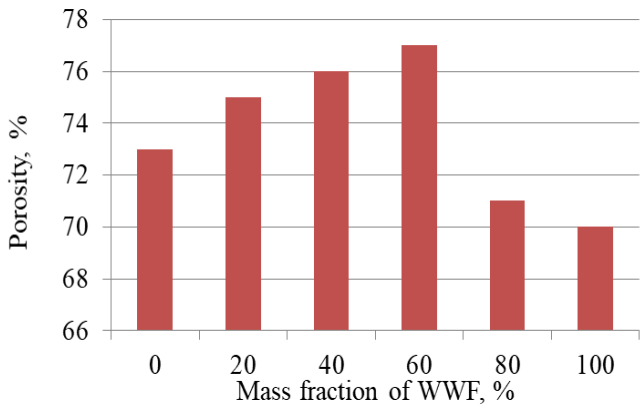


Fig. 5 – Cake`s porosity

Table 3 - Quality of hardtacks (90 days of storage)

Index	Samples				
	BWF+s (control)	BWF+JAP	BWF+MS	WWF+JAP	WWF+MS
Moisture content, %	8,9	8,4	8,8	9,3	9,6
Titratable acidity, ml NaOH	2,5	2,2	2,0	2,8	2,6
Water absorbtion, %	200	170	163	215	205
Density, g/cm^3	0,46	0,51	0,54	0,39	0,45
Firmness, kg/m^2×10^8	5,5	6,5	7,0	4,5	5,0

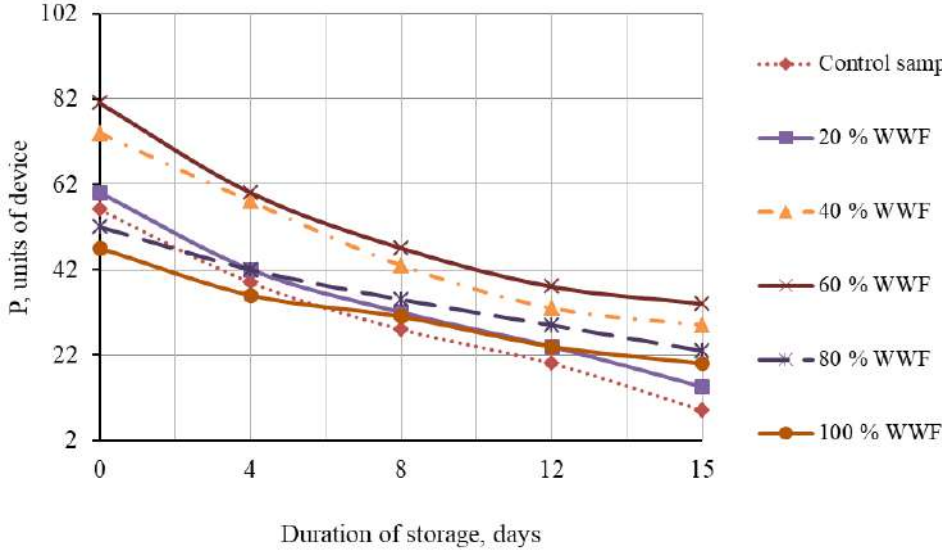


Fig 6 - Changes in the structural-mechanical properties of yeast-based cake crumb during storage

For many flour-based products, the crispy and crunchy characteristics are important for sensory acceptance on which consumer base their appreciation, as it was shown in study [19]. Usually, when storing flour products, a rapid increase in their hardness is observed, which is due to the processes of drying, staleness and crystallization. Staling is a consequence of the loss of moisture as a result of starch retrogradation. During storage, crystallization of sucrose and solid fats occurs, which increases the hardness of the products. It is important to note that the degree of crystallinization for cakes crumb, which contain non-amylose wheat flour is lower compared to the control, which indicates less intensive retrogradation of waxy wheat starch granules. Yeast-containing cakes with waxy wheat flour were stored for 15 days per piece packed in polyethylene packaging at temperature of 18 ± 2 °C at a relative humidity of 60-65 % (fig. 6). The changes in the structural and mechanical properties of the cake crumb were reduced, but the use of waxy wheat flour in the recipe of the yeast-containing cakes was accompanied by smaller changes in the structure of their crumb as we can see

It has been established that with an increase in the dosage of waxy wheat flour, the structural and mechanical properties of the crumb of pastry products improve.

Conclusions

Thus, based on the results of the research, it can be concluded that the replacement of bread wheat flour for the various types of flour with specific characteristics leads to the stabilization of the quality during the shelf-life of wide pastry assortment groups (cakes, sugar-free hardtacks, wafers and waffles). The experimental results have shown that waxy wheat flour characterised with higher gassing power and water absorption compare with control. Flour of extra-soft wheat Oksana is characterized by low water absorption and weak gluten. Using Biscuit Oksana wheat flour instead of bakery flour was accompanied by obtaining batter with lower viscosity, which leads to batter`s better distribution over the surface of wafer plates and ensured obtaining homogeneous density and thicknesses of wafer sheets. Wafers and waffles were characterized by a more porous loosened texture, which is due to the better loosening of products during baking. The use of waxy wheat flour in the production of hardtacks with Jerusalem artichoke powder and maltose syrup instead of sugar in the recipe leads to an increase of alcohol and lactic acid fermentation and an product`s porosity improvement.It was found that yeast-based cake`s with 60 % waxy wheat flour was characterized with the highest porosity compared to the control. Obtained results can be the basic of a novel technological solution to provide the technological process intensification, the quality stabilization of cakes and hardtacks with reduced sugar content based on WWF and to prolong their shelf-life without synthetic improving agents usage.

REFERENCES

1. *Ofitsiyniy Internet-sayt derzhavnogo komitetu statistiki Ukraina. URL: http://www.ukrstat.gov.ua*
2. *Estruch R. et al. Reformulation of Pastry Products to Improve Effects on Health //Nutrients. 2020. T. 12. №. 6. 1709.*
3. *Types of wheat flour // Berkeley Wellness, University of California. 2016. URL: http://www.berkeleywellness.com/healthy-eating/food/article/types-wheat-flour*
4. *Zhigunov, D.A. Analiz kachestva pshenichnoy muki tselevogo naznacheniya. Hranenie i pererabotka zerna. 2013. 3. 41-43.*
5. *Manley D. Manley's Technology of Biscuits, Crackers and Cookies. Woodhead Publishing Limited. Cambridge, 2011. 632 p.*
6. *Iorgachova K., Makarova O., Khvostenko K. (2016). The rationale of selecting pastries to be made with waxy wheat flour / Eastern-European Journal of Enterprise Technologies. – 2016. – № 2/11 (80) – P. 12–19.*
7. *Martínez-Monzó J., García-Segovia P., Albors-Garrigos J. Trends and innovations in bread, bakery, and pastry //Journal of culinary science & technology. – 2013. – T. 11. – №. 1. – C. 56-65.*
8. *Voinea L., Popescu D. V., Negrea M. T. Good practices in educating and informing the new generation of consumers on organic foodstuffs //Amfiteatru Economic Journal. – 2015. – T. 17. – №. 38. – C. 488-506.*
9. *Noorfarahzilah M. et al. Applications of composite flour in development of food products // International Food Research Journal. – 2014. – T. 21. – №. 6. – C. 2061.*
10. *Catterall P., Cauvain S. P. Flour milling //Technology of breadmaking. – Springer, Boston, MA, 2007. – C. 333-369.*
11. *Ribalka, O.I. Yakist pshenitsi ta yiyi polIpshennya / Logos. Kyiv, 2011. 496*
12. *Duyvejonck A. E. et al. Relative contribution of wheat flour constituents to solvent retention capacity profiles of European wheats //Journal of Cereal Science. – 2011. – T. 53. – №. 3. – C. 312-318.*
13. *Prabhasankar P., Rao P. H. Effect of different milling methods on chemical composition of whole wheat flour //European Food Research and Technology. – 2001. – T. 213. – №. 6. – C. 465-469.*
14. *Yu, X.R., Zhou, L., Zhang, J., Yu, H., Gao, D.R., Zhang, B.Q. et. al. (2015). Comparison of Structural Development and Biochemical Accumulation of Waxy and Non-waxy Wheat Caryopses. Cereal Research Communications. 2015. Vol. 43 (2). P. 307–317.*
15. *Xurun, Y., Heng, Y., Zhang, J., Shao, S., Zhou, L., Xiong, F. & Wang, Z. Comparison of endosperm starch granule development and physicochemical properties of starches from waxy and non-waxy wheat. International Journal of Food Properties. 2015. Vol. 18. P. 2409–2421.*
16. *Lebedenko, T. E. TehnologIya hlibopekarskogo virobnitstva. Praktikum / OsvIta Ukrayini. Odessa, 2014. 392 s.*
17. *Iorgachova K.G., Makarova O.V., Gordienko L.V., Korkach G.V. Praktikum po tehnologiyi konditerskih virobiv / za red. K.G.Iorgachovoyi. Odessa. 2011. 208 s.*
18. *Iorgachova K., Makarova O., Khvostenko K. (2018). Prospect of the new types of wheat flour usage in the production of the refined sugar-free hardtacks. Vol. 24 (5). P. 225-235.*
19. *Luyten, H., Plijter, J.J., Vliet, T.V., 2004. Crisp/crunchy crusts of cellular foods: a literature review with discussion. Journal of Texture Studies 35 (5), 445–492*

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ТІСТО НА ОСНОВІ БОРОШНА ЗІ СПЕЦИФІЧНИМИ ХАРАКТЕРИСТИКАМИ

Анотація

Основним фактором конкурентоспроможності борошняних кондитерських виробів є забезпечення високої якості та збереження її протягом усього терміну зберігання продукції при використанні для виробництва лише натуральних інгредієнтів. Одним із ефективних способів вирішення цього завдання є використання пшеничного борошна із специфічними характеристиками. Диференціальний підхід до технологічних характеристик борошна залежно від виду виробів дає змогу забезпечити стабільність технологічного процесу та якість виробленої продукції без використання неорганічних поліпшувачів. Особливий інтерес серед видів пшеничного борошна цільового призначення викликає борошно з пшениці ваксі, крохмаль якого не містить амілози, яка відіграє важливу роль в черствінні борошняних продуктів. Дослідженнями було встановлено, що борошно з ваксі-пшениці характеризується більш високою газоутворювальною та водопоглинальною здатністю порівняно з хлібопекарським борошном. Відповідно до його технологічних характеристик пропонується використовувати дане борошно в технології кексів на дріжджах, галет зі зниженою цукроємністю. Борошно з екстра-м'якозерної пшениці сорту Оксана характеризується низькою водопоглинальною здатністю та слабкою за якістю клейковиною, що є бажаними технологічними властивостями для виробництва більшості видів виробів з кондитерського тіста. Встановлено, що листові та м'які вафлі на основі борошна з пшениці Оксана відрізнялися від виробів на хлібопекарському борошні меншою густиною та кращою пористістю і текстурою. Показано, що використання борошна з пшениці ваксі та м'якозерної пшениці в технології зазначених видів борошняних кондитерських виробів призводить до інтенсифікації технологічного процесу, стабілізації реологічних характеристик напівфабрикатів, якості та свіжості продукції без додавання поліпшувачів.

Ключові слова: борошно пшеничне, пшениця ваксі, екстра-м'якозерної пшениці, борошняні кондитерські вироби, якість, зберігання.

ЛІТЕРАТУРА

1. Офіційний Internet-сайт державного комітету статистики України. URL: http://www.ukrstat.gov.ua
2. Estruch R. et al. Reformulation of Pastry Products to Improve Effects on Health //Nutrients. – 2020. – Т. 12. – №. 6. – С. 1709.
3. Types of wheat flour // Berkeley Wellness, University of California. 2016. URL: http://www.berkeleywellness.com/healthy-eating/food/article/types-wheat-flour
4. Жигунов Д.А. Анализ качества пшеничной муки целевого назначения. Хранение и переработка зерна. 2013. № 3. 41-43.
5. Manley D. Manley's Technology of Biscuits, Crackers and Cookies. Woodhead Publishing Limited. Cambridge, 2011. 632 p.
6. Iorgachova K., Makarova O., Khvostenko K. (2016). The rationale of selecting pastries to be made with waxy wheat flour / Eastern-European Journal of Enterprise Technologies. – 2016. – № 2/11 (80) – P. 12–19.
7. Martínez-Monzó J., García-Segovia P., Albors-Garrigos J. Trends and innovations in bread, bakery, and pastry //Journal of culinary science & technology. – 2013. – Т. 11. – №. 1. – С. 56-65.
8. Voinea L., Popescu D. V., Negrea M. T. Good practices in educating and informing the new generation of consumers on organic foodstuffs //Amfiteatru Economic Journal. – 2015. – Т. 17. – №. 38. – С. 488-506.
9. Noorfarahzilah M. et al. Applications of composite flour in development of food products // International Food Research Journal. – 2014. – Т. 21. – №. 6. – С. 2061.
10. Catterall P., Cauvain S. P. Flour milling //Technology of breadmaking. – Springer, Boston, MA, 2007. – С. 333-369.
11. Рибалка О.І. Якість пшениці та її поліпшення / Логос. Київ, 2011. 496
12. Duyvejonck A. E. et al. Relative contribution of wheat flour constituents to solvent retention capacity profiles of European wheats //Journal of Cereal Science. – 2011. – Т. 53. – №. 3. – С. 312-318.
13. Prabhasankar P., Rao P. H. Effect of different milling methods on chemical composition of whole wheat flour //European Food Research and Technology. – 2001. – Т. 213. – №. 6. – С. 465-469.
14. Yu, X. R., Zhou, L., Zhang, J., Yu, H., Gao, D. R., Zhang, B. Q. et. al. (2015). Comparison of Structural Development and Biochemical Accumulation of Waxy and Non-waxy Wheat Caryopses. Cereal Research Communications. 2015. Vol. 43 (2). P. 307–317.
15. Xurun, Y., Heng, Y., Zhang, J., Shao, S., Zhou, L., Xiong, F. & Wang, Z. Comparison of endosperm starch granule development and physicochemical properties of starches from waxy and non-waxy wheat. International Journal of Food Properties. 2015. Vol. 18. P. 2409–2421.
16. Лебеденко, Т. Е. Технологія хлібопекарського виробництва. Практикум / Освіта України. Одеса, 2014. 392 с.
17. Іоргачова К.Г., Макарова О.В., Гордієнко Л.В., Коркач Г.В. Практикум по технології кондитерських виробів / за ред. К.Г. Іоргачової. Одеса. 2011. 208.
18. Iorgachova K., Makarova O., Khvostenko K. (2018). Prospect of the new types of wheat flour usage in the production of the refined sugar-free hardtacks. Vol. 24 (5). P. 225-235.
19. Luyten, H., Plijter, J.J., Vliet, T.V., 2004. Crisp/crunchy crusts of cellular foods: a literature review with discussion. Journal of Texture Studies 35 (5), 445–492

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INNOVATIVE APPROACHES IN THE FORMATION OF COMPOUND FEED RECIPES FOR DECORATIVE BIRDS AND SINGING BIRDS AND TECHNOLOGY OF COMPOUND FEED PRODUCTION FOR THEM

Abstract

The share of compound feeds for unproductive pets in the compound feed markets of the world is growing every year. In Europe, decorative and songbird birds are the third largest pet population (cats and dogs being numbers one and two, pectively), according to FEDIAF data, with 51.87 million decorative birds in all of Europe (37.23 million of those in the European Union) in 2019.

Decorative and songbirds need complete feeding to maintain life and health. Today, owners of decorative and songbirds have a wide range of ready-made food, which allows them to make the right choice of appropriate feeding regime for their pets. Analyzing the market of feed for decorative and songbirds, we saw that a significant part of it is imported feed, while the range of domestic feed in the Ukrainian market is very small and does not always meet market requirements and can not compete. However, the presented compound feeds can hardly be called complete, as they are mainly different types of feed mixtures, which include, depending on the price category, different types of components: from cereals and ending with different nuts and dried fruits.

Compound feed should contain all the components necessary for energy production, growth, tissue regeneration, as well as to regulate metabolism. Complete feed for decorative and songbirds must contain a certain amount of all nutrients and biologically active substances. Factors such as age, general health, breeding season, growth, molting, housing conditions and even the season should also be considered.

To date, there are a number of issues that need to improve our knowledge of the nutrient and biologically active needs of each species of decorative and songbird, including the characteristics of feed materials, the amount of energy, digestibility of feed and the content of nutrients and biologically active substances.

In this regard, it is necessary to study each class of nutrients and biologically active substances and features of the formation of compound feed recipes, taking into account the need for decorative and songbirds. To study in detail the functional purpose of nutrients and biologically active substances, symptoms that occur in the body of decorative and songbirds in their absence or excess in the feed, as well as their sources and minimum needs of birds during reproduction, growth and maintenance of healthy birds.

To meet the forage needs of decorative and songbirds when kept in captivity, one of the most effective methods is to create complete feed by using innovative technologies (for example, in the form of crumbs or a blend of crumbs obtained by extrusion). This will provide an opportunity to meet both the behavioral and feeding needs of birds.

Keywords: decorative and songbirds, nutrients and biologically active substances, recipe, innovative technologies, extruded complete feed for decorative and songbirds.

Introduction

The share of compound feeds for unproductive pets in the compound feed markets of the world is growing every year. Finished industrial feeds become the only balanced source of nutrients and biologically active substances in their diet [1].

Petfood Industry 2019 estimated the global pet feed market at $ 91 billion (annual growth of 6.5 %). The world leader is the United States. Last year, American pets ate almost $ 37 billion worth of food and treats, which is 7.3 % more than in 2018. The appetites of European furriers are a bit more modest. According to analysts at European Pet Food Industry (the federation covers 18 countries in Western and Eastern Europe), feed sales in the region over the past three years increased by an average of 2.6 %, which in 2019 reached a level of € 21 billion. The Ukrainian market does not exceed UAH 6.0 – 6.5 billion, but grows by 20 – 30 % annually [2].

In Europe, decorative birds are the third largest pet population (cats and dogs being numbers one and two, pectively), according to FEDIAF data, with 51.87 million decorative and songbirds birds in all of Europe (37.23 million of those in the European Union) in 2019. 28.57 million small mammals (10.63 million in the EU), 15.54 million aquaria (10.63 million in the EU; overall equating to roughly 300 million ornamental fish) and 9.43 million reptiles (7.91 million in the EU) round out the top pet types in Europe [3, 4].

Like all living things, decorative and songbirds need complete food to maintain life and health. Compound feed should contain all the components necessary for energy production, growth, tissue regeneration, as well as to regulate metabolism. Components of feed that perform these functions are called nutrients, the main of which are proteins, fats, carbohydrates and biologically active substances (vitamins and minerals). Properly balanced feed for decorative and songbirds should contain a certain amount of all nutrients and biologically active substances. Factors such as age, general health, breeding season, growth, molting, housing conditions and even the season should also be considered [5, 6].

Today, owners of decorative and songbirds have a wide range of ready-made feed, which allows them to make the right choice of appropriate feeding regime for their pets [7]. Analyzing the market of feed for decorative and songbirds, we saw that a significant part of it is imported feed, while the range of domestic feed in the Ukrainian market is very small and does not always meet market requirements and can not compete [8]. However, the presented feed is difficult to call complete, as it is mainly different types of feed mixtures, which include, depending on the price category, different types of components: from cereals and ending with different nuts and dried fruits.

To date, there are a number of issues that need to improve our knowledge of the nutrient and biologically active needs of each species of decorative and songbird, including feed characteristics, energy content, feed digestibility and nutrient and bioactive content. To meet the feeding needs of birds when kept in captivity, one of the most effective methods is to create a complete feed.

Purpose and objectives of the analysis

The aim was to study each class of nutrients and biologically active substances and features of the formation of compound feed recipes, based on needs of decorative birds and songbirds.

Results and its discussion

Consider the requirements for the amount of energy for decorative birds and songbirds when kept at home, during reproduction, during the growing season; needs of adult birds, during growth and molting in proteins and amino acids; needs for fats and essential fatty acids; carbohydrates; vitamins and minerals.

Energy needs when kept at home. The main source of energy in the diet of grain birds is carbohydrates, mainly in the form of starch. In addition, fats are a highly concentrated source of energy. For example, young squash pigeons meet their energy needs by consuming the fats contained in goiter's milk. If there are not enough carbohydrates or fats in the diet, proteins can be used as an energy source. The body of the bird regulates the consumption of food by providing the necessary amount of energy. Poultry studies have shown that if the energy content of the diet increases, for example, by increasing the fat content of the feed, the bird reduces feed intake to compensate for this. If no changes have been made to the other components, a nutrient deficiency develops. Conversely, when the energy value of the feed is reduced, its consumption increases, so that the bird meets its energy needs as needed. However, if the diet contains very little energy, the ability to regulate consumption can be neglected, as the limiting factor is the capacity of the gastrointestinal tract. In the table 1 shows the metabolic energy needs for some species of decorative and songbirds.

Table 1 – Metabolic energy needs for some species of decorative and songbirds

Birds	Weight range, g	Age requirement, kJ/day
Cockatoo Nymphicus hollandieus	80-100	110-130
Wavy parrot	50-70	78-100
Canary	20-30	40-55
Zebra amadin	15-20	32-40

Since the energy content of most cereal mixtures for budgies is about 1.75 MJ per 100 g, theoretically, the bird should eat about 4-6 g/day to meet their energy needs. It should also be borne in mind that the energy absorption of seeds is normally about 90 %. Studies have shown that the average budgerigar consumes 8 to 12 g of seeds per day, which is equivalent to 500-1000 individual seeds [5, 9, 10].

Energy needs during reproduction. The average weight of a budgerigar egg is 2.5 g, each gram contains about 5.5 kJ of energy. Therefore, one budgerigar egg contains approximately 16.5 kJ. If there are an average of five eggs in the clutch, the hatched male may need an additional 80 kJ of energy during the laying of eggs. In addition, because males need energy to form eggs, the amount of energy increases. Obviously, more food needs to be consumed to compensate for the increased needs. During the period of egg laying and hatching, energy consumption remains relatively constant: 231 – 252 kJ/day. However, when the chicks begin to hatch, there is a tremendous increase in energy needs of the parent pair. At peak joint feed intake, birds absorbed from 483 to 505 kJ per day (2 adult birds and 3 chicks) [5, 9, 10].

Energy needs for growth. At hatching from an egg the chick of a wavy parrot weighs approximately 1,5 g, and by the tenth day of life its weight makes already approximately 20 g. In order to gain this phenomenal growth rate, as well as for the full development of plumage, a young bird needs a lot of energy. The chicks spend most of the energy they consume to grow. This ranged from 62 to 73 % in chicks at the age of 1-3 days. This proportion gradually decreases as the chicks develop, but for the entire period from hatching until they become independent, an average of 11 % of the daily energy supply is spent on growth. Therefore, adult birds should receive additional food so that they can provide their chicks with the necessary nutrients. On average, the need for food during the rearing of chicks doubles, and will return to baseline only after the last chick leaves the nest [5, 9, 10].

Influence of temperature. Birds maintain a body temperature of 41-42 °C, which is usually much higher than the ambient temperature, which requires

energy. The energy needed to maintain a constant body temperature depends on the difference between normal body temperature and ambient temperature. This means that in a cold environment, birds must use an effective mechanism to conserve heat, and feed consumption will be maximum. Also, when the ambient temperature is high, more heat should be expended. Birds lower their body temperature by evaporating from the surface of the airways and skin. However, it is not very effective and in hot conditions the reduction of heat release is often achieved by reducing feed consumption. With increasing temperature, feed consumption decreases by about 1.5 % for each °C compared to normal temperature [5, 9].

Fats and essential fatty acids. Fats play two main roles in feeding birds: they are a concentrated source of energy and perform various metabolic functions, as well as promote the absorption of fat-soluble vitamins. Birds are sensitive to the level of fat in the feed and regulate their metabolism, preventing excess energy. This is achieved by maintaining a constant level of feed intake in order to meet the needs of other nutrients by metabolizing fats with less efficiency. Thus, the overall effect is expressed in maintaining a constant mass, not in building it. However, birds that receive diets high in fat are obese. In addition, the consumption of large amounts of fat can cause diarrhea, as well as the formation of insoluble soaps. This makes minerals such as calcium and iron inaccessible to birds. Some cockatoos, which consume only sunflower seeds, are obese and often have lipomas. This is observed in the pink-breasted cockatoo and emphasizes the importance of the diet based on mixtures of seeds.

It is generally believed that linolenic acid is the most essential fatty acid for decorative and songbirds, so it helps to eliminate all the symptoms of deficiency of essential fatty acids. The first sign of a deficiency of essential fatty acids in chicks is a slowdown in growth, which may occur during the first week of feeding a diet with this deficiency. This is accompanied by damage to membrane structures, leading to skin diseases [5, 11]. The skin becomes rough, scaly, its permeability increases, which leads to rapid water loss. If birds do not receive essential fatty acids, they are affected by plumage, reduced utilization of nutrients, reduced resistance to disease, and sometimes the bird dies. In adult birds, this is rare, so the bird's body has a high ability to maintain reserves of essential fatty acids. Studies in poultry suggest that approximately 2 % of metabolic energy should come in the form of linolenic acid. This corresponds to approximately 0.9 % of the diet containing 12.5 MJ/kg. It is possible that during molting periods in adult birds the need for feed fats increases significantly. The membranes of epithelial cells involved in the formation of feathers contain a large amount of fat component, which must come with food. One source of linolenic acid is flaxseed [5, 12, 13].

The needs of adult birds in protein. Birds need proteins to form and develop body tissues and to maintain its structure. In addition, birds utilize proteins to form and maintain a healthy plumage, claws and beak. Studies on budgies have shown that the minimum need for feed protein is 10 %. Work with birds of the rowan family (adult field sparrows) confirmed that the concentration of feed protein, equal to 8 – 9 %, is sufficient to maintain weight, nitrogen and energy balance. However, this figure is probably less than the need for optimal growth, development and tissue repair (eg, reproduction, development of chicks, molting process). The results of a study of pigeons showed that birds during the breeding season need a protein content in the diet, at the level of 18 %.

In addition, protein needs depend on feed intake. Thus, everything that affects feed intake, ie energy content in the diet or ambient temperature, has a side effect on the optimal level of protein in the diet. There is no advantage in the bird's consumption of high-protein feed, as the energy costs of deamination, uric acid formation and excretion are very high. Further, overload of the excretory capacity of the kidneys can lead to hyperuricemia. Further deposition of urate crystals in the kidneys can cause clinical symptoms and cause death. In addition, there may be an association between excessive protein content in the feed and hypertrophied growth of the beak and claws in birds with cellular retention [5, 11].

Protein needs have both quantitative and qualitative aspects. As for the first, the feed should contain a sufficient amount of protein to obtain replacement amino acids or nitrogen for their synthesis. From a qualitative point of view, feed proteins should be a source of amino acids that the bird's body can not synthesize at all or can not synthesize quickly enough – essential amino acids. In addition to the essential amino acids that mammals and chicks need, they probably need a feed source of glycine and proline needed to ensure maximum growth and development.

To effectively utilize dietary proteins, it is important to maintain an optimal balance between amino acids. Ideally, the diet should meet the need for all amino acids, not including excess protein or individual amino acids. When using a diet low in protein, which causes a moderate deficiency of all amino acids, there is an increase in feed intake. This is an attempt by the bird to compensate for the lack of diet, which leads to obesity. An even more noticeable reaction is observed if only one or two amino acids are present in the diet at abnormally low or high concentrations. Under natural conditions, deficiency of certain amino acids is rare. However, cage keeping of birds and feeding a narrow set of seeds or grains can cause a deficiency of some amino acids, in particular lysine and methionine, the content of which is low in some seeds, such as safflower seeds and peanuts [5, 12, 13].

The need for protein for growth. Requirements for rapid growth and development mean that young birds have increased protein needs. If we take into account the growth rate, we see that the protein needs of chicks are much higher than those of adult birds. Newly hatched budgerigar chicks double in weight in two days and then continue to grow rapidly until they are thirty days old. In addition to the huge weight gain, birds develop full plumage. However, the optimal level of protein in the diet has yet to be established. When the protein content is at least 25 %, the chick develops much better. The fluid formed in the goiter of budgerigars,

which is intended for feeding chicks, contains from 24 to 26 % protein relative to dry matter, which leads to the conclusion that this level is optimal for budgies that have just hatched. After a few days, protein requirements are reduced, and studies in squash pigeons have shown that at this stage the conditions for optimal growth and development are achieved when the protein content in the diet is 18 %. Studies of chicks of small Australian crested cockatoos (Nymphicus hollandicus) have shown that to maintain maximum growth, the diet should contain 20 % protein. Subsequent studies have suggested that the minimum lysine requirements are 0.8 %. Modern research on canary chicks leads to the conclusion that the protein content in the feed should be 16.5 – 21.9 %. Excess protein in the diet (23 %) inhibited the growth of older chicks mentioned by the Australian cockatoo, so it would be unwise to overload the diet.

The amino acid needs of developing chicks are different from the needs of adult birds. In addition to 10 essential amino acids, decorative birds and songbirds need glycine and proline for optimal development. Glycine is an integral precursor of uric acid this is one of the reasons why the bird has high requirements for the content of this amino acid in the diet. In addition, glycine is the main component of collagen and feathers (table 2). Thus, a deficiency of this amino acid immediately affects the development of chicks. If to get the right amount of glycine you have to give the chicks an increased amount of food, the serine in the liver can be converted into glycine. However, since the rate at which the chick synthesizes glycine is less than the rate at which it is used, it is useful to introduce appropriate supplements into the diet. A similar situation occurs in the case of proline. This is the main component of collagen and feathers, which explains the importance it has for the development of chicks. Glutamate is a common precursor of proline, and therefore it is often called a "semi-essential" component of the diet of chicks [5, 12, 13].

Table 2 – The main amino acid protein of budgerigar feathers

Amino acid	Content in protein, %
Glutamic acid	7,72
Cystine	7,45
Proline	7,26
Valine	5,41
Leucine	5,30
Glycine	4,60
Aspartic acid	4,54
Arginine	4,27
Serine	4,12
Alanine	4,07

The need for protein and amino acids during molting. The plumage creates a heat-insulated layer in birds, and also acts as a water-repellent coating and promotes flight. The formation of follicles is observed during the development of the embryo, but later the feathers of birds more than once during life fall out and recover. At the age of four months, the budgie experiences its first moult. In Western Europe, the main annual moult occurs in autumn. It begins when the temperature drops and usually lasts six to eight weeks. The pattern of molting is the same as that of canaries and finches.

Feathers 85 – 97 % consists of protein, and almost all protein is represented by keratin. Thus, the amino acids of the diet play an important role in the development of plumage. The main amino acids involved in the synthesis of keratin are methionine and cystine.

Cystine is a component of keratin, methionine is important as a precursor to cystine. Studies have shown that during the period of rapid development of plumage, the maximum feeding efficiency is achieved if cystine is at least half of the sulfur-containing amino acids in the diet. As the feathers grow, the nutritional value of cystine decreases. Thus, during the molting period it is reasonable to include in the diet of both rapeseed and white millet, which contain many of these amino acids. There are other amino acids that are important for healthy plumage, including lysine and arginine. Lysine is also required for pigmentation, which is probably due to its role in the formation of melanin. In addition, there is evidence of a link between the lack of feed arginine and the plucking of feathers by birds.

Birds that lose their feathers either due to disease or plucking have higher feed needs, which allows them to compensate for this effect. In addition to the need for amino acids for the growth of new feathers in birds with incomplete plumage, there is increased heat loss. This leads to an increase in metabolic rate by more than 60 % with an even increase in energy needs for heat generation and plumage recovery. Energy consumption by birds that have lost their plumage is more than 85 % higher than that of birds with normal plumage (at 22 °C). It should be noted that at this time the birds should be fed mainly grain with high energy value, such as oats or oilseeds [5, 12, 13].

Interaction of amino acids. The interaction of glycine – serine and glutamate – proline reveal the importance of analyzing the role of amino acid needs in the diet. For adult birds, the interaction between sulfur-containing amino acids, which are integral components of feathers, is important. Thus, given the interactions between methionine and cystine, the minimum feed requirement for methionine is expressed as the need for both of these amino acids. Also for chicks feed need for glycine is determined by the total content of glycine and serine in the diet. The situation is complicated by the fact that the need for feed glycine increases under the influence of low concentrations of methionine, arginine or B vitamins [5, 12, 13].

Carbohydrates. The main function of all carbohydrates consumed by decorative birds and songbirds is a direct source of energy. The enzymes of the digestive tract of birds are as effective in breaking down starch as the enzymes of other animals. However, birds have a more limited ability to digest polysaccharides of non-starchy nature, in particular, in birds that have a rudimentary cecum or do not have it at all [5, 12, 13].

Water. Physiologically, birds are less dependent on drinking water than mammals because they excrete nitrogenous excrement in the form of insoluble uric acid rather than urea. As a result, their excrement contains very little water, an average of 32.8 – 6.5 %. However, water remains the most important component of feeding. It plays the role of a transport medium, an environment in which metabolic reactions take place and which is vital for the regulation of the body temperature of birds. Species of birds for which water is of paramount importance are those species whose main part of the diet is dry seeds. Decorative birds and songbirds birds such as budgies, canaries and finches are in constant need of fresh water. Wavy parrots, receiving a diet based on seeds with supplements, consume 3 to 5 ml of water daily. Of all the birds kept in cages, canaries are the most sensitive to the presence of water and in its absence can die in 48 hours. On the other hand, budgies in the process of evolution have the ability to survive in minimal water content, but they also need to give fresh water daily. If the bird does not consume enough water, its manure is meager. In addition, the proportion of fecal masses in the manure increases so much that the manure becomes dark green [5, 13].

Vitamins.

Vitamin A deficiency is commonly found in captive parrots, and most commonly in African grays and Amazons. Clinical symptoms include increased susceptibility to respiratory infections, kidney disease, oral abscesses, reduced hatching and high mortality of chicks at hatching. Birds are able to convert β-carotene feed to vitamin A, but most seeds contain very little. Most of the diseases associated with vitamin A deficiency are caused by the use of unbalanced diets and, especially in parrots, overeating sunflower seeds. Fish oil is a good source of vitamin A as well as iodine, and is often used by poultry farmers as a dietary supplement. However, the use of excessive amounts of additives can lead to a toxic dose of vitamin A, so it is necessary to exercise caution and caution in assessing the proposed amount of vitamin A bird.

The effectiveness of ***vitamin D*** for birds is only one-thirtieth of the effectiveness of vitamin D_3 (cholicalciferol). Vitamin D is essential for the absorption of calcium in the digestive tract and for calcium metabolism in the bones. Insufficient intake of vitamin D with food or UV light for the synthesis of vitamin D from steroids in the skin leads to metabolic bone disease. Symptoms of calcium deficiency the inability of bones and beak to calcify during growth and demineralization of bones in adult birds. In addition, the plumage may be damaged, and with a certain color of the feathers may develop abnormal blackening. During the breeding season, vitamin D deficiency leads to thinning of the egg shell. Hatching of chicks from eggs decreases, embryos have deformed or only partially formed beaks.

Vitamin E deficiency in poultry leads to encephalopathy, exudative diathesis or muscular dystrophy. Symptoms of encephalopathy include loss of coordination, throwing the head, stretching the legs and squeezing the toes. Exudative diathesis is caused by increased permeability of capillaries due to the accumulation under the skin in the chest exudate, which is a derivative of hemoglobin. This exudate has a characteristic green color. Feeding-related muscular dystrophy, especially of pectoral muscles, is observed in combination with vitamin E and selenium deficiency. With vitamin E deficiency, selenium can prevent both exudative diathesis and muscular dystrophy. Small Australian cockatoos with varying degrees of paralysis responded to the addition of vitamin E and selenium. Whole grains contain a sufficient amount of vitamin E, so when keeping birds on a normal diet based on seeds, vitamin E deficiency is rare. Alfalfa and seed germ oils contain a particularly high level of vitamin E, so if necessary can be used as additional sources of this vitamin.

Vitamin K is found in most green leaves and herbs. In addition, intestinal bacteria synthesize vitamin K, which can then be absorbed. Only when antibiotics are used does this non-feed source of vitamin K become unavailable. As a result, vitamin K deficiency is rare.

We do not have published data on the needs of decorative birds and songbirds species in ***B vitamins***. Thus, our knowledge of these needs is based on the results of work performed on poultry and on the symptoms observed in keeping birds on B-deficient diets.

Thiamine (B_1) is found in grains, although pathogens caused by some fungal infections can reduce its amount. Deficiency can occur when infected with specific intestinal bacteria that produce thiaminase, which destroys thiamine before it is absorbed by the bird. Manifestations of deficiency include loss of appetite, general weakness and polyneuritis. The latter symptom develops in chicks at a rapid pace, accompanied by drowsiness, tremor of the head, and in more advanced cases throwing his head back.

The use of deficient rations in the feeding of chicks ***riboflavin (B_2)*** leads to growth retardation and paralysis (with wrapping of the fingers). In cases of minor deficiency, spontaneous recovery may occur. Curable and early stages of the disease. Moderate deficiency can lead to the death of embryos in the middle of hatching and to a reduction in hatching.

Pyridoxine (B_6) and related compounds (*pyridoxal and pyridoxamine*) are common in cereals, so cases of deficiency are rare.

Biotin is also abundant in cereals, so the likelihood of deficiency of this vitamin in birds eating normal diets is low. In birds kept on an experimental diet, specific symptoms of biotin deficiency include foot dermatitis and lesions in the submandibular and eye area. It is unclear whether birds are able to utilize biotin, which is synthesized by the intestinal microflora.

Vitamin B_{12} is not found in plants, but is present in meat, milk and yeast. Birds receive some amount of vitamin B_{12} by absorbing vitamin synthesized by bacterial microflora in the intestine or by ingesting feces (coprophagy). Vitamin B_{12} deficiency leads to anemia and erosion of the muscular stomach, as well as has a devastating effect on the skin and plumage. The process of hatching chicks in conditions of insufficient reserves of vitamin B_{12} may be accompanied by a high mortality rate.

Niacin (*nicotinic acid*) deficiency results in stunted growth, poor plumage, and stomatitis. In chickens, this disease is known as "black tongue", and progressive inflammation of the tongue and esophagus leads to reduced feed intake. Most seeds contain enough niacin, except corn. Because corn also has a low tryptophan concentration, diets high in corn should be supplemented with sources of potential niacin precursors.

Pantothenic acid is important for the growth and integrity of plumage in chickens. In chickens, signs of its deficiency include slow growth, the appearance of "snacks" in the corners of the beak and nostrils, as well as dermatitis of the fingers (biotin deficiency affects primarily the pads on the soles and toes). Wheat and oat grains give a sufficient amount of pantothenic acid.

Choline is found in many feeds and is present in the seeds in an amount sufficient to prevent symptoms of deficiency. Symptoms of deficiency in poultry include growth retardation and limb structure abnormalities. Adult birds are likely to be able to synthesize enough choline to meet their needs, but growing birds and birds need breeding choline sources during the breeding season. As a complicating factor, the need for choline may depend on the level of vitamin B_{12} in the diet.

In birds with ***folic acid*** deficiency there is a growth retardation, poor plumage, loss of feather pigmentation and the appearance of characteristic anemia. The specificity of anemia caused by folic acid deficiency is expressed in a decrease in the number of erythrocytes, which increase in size, their deformation, the content of increased amounts of hemoglobin.

In general, birds do not need feed ***vitamin C***, although there are exceptions to this rule: the Asian bulb Pycnonotus cafer and one species of nectar Aethopyga siparaja. Vitamin C supplements can have a positive effect during physiological stress, for example, during reproduction, molting or growth [5, 11, 14].

Minerals.

Calcium and ***phosphorus*** are important for the development and maintenance of the skeletal structures of birds. In the body of a growing bird, most of the calcium contained in the diet is used to form bones, while in the reproduction of birds, most of the calcium will be used by the female to form the eggshell, which is 98 % calcium carbonate. Partly due to the high growth rate of captive birds, calcium and phosphorus requirements are high. The ideal ratio of calcium and phosphorus (Ca:P) compared to most mammals is also very large (approximately 2:1).

Imbalance in the absorption of calcium and phosphorus (or lack of vitamin D in the diet) in domestic parrots is common and leads to a variety of diseases. Rickets is most often observed. Rickets usually occurs as a result of feeding birds only seeds with a high fat content and low mineral content, and at a low ratio of Ca:P. When feeding seeds with a high oil content, insoluble calcium soaps can interfere with the absorption of calcium in the intestine and further exacerbate the absolute and relative calcium deficiency. To maintain a normal level of calcium in the blood, the calcium contained in the bones of the skeleton goes into a soluble state, which leads to osteomalacia. he result of chronic calcium deficiency is usually secondary forage hyper-parathyroidism, a fairly common disease of parrots. In birds that received a diet with moderate calcium deficiency, clinical symptoms of the disease can develop over years. They usually manifest themselves in the form of loss of appetite, plucking of feathers, weakness and drowsiness. In more severe cases, bone fractures may occur, and some individuals may develop hypocalcemic tetany and convulsions. There is evidence that some species of parrots are more sensitive to calcium deficiency than others. For example, in African gray parrots, hypocalcemia is common.

In practice, a sufficient concentration of calcium in the diet can be ensured by giving the birds shellfish, limestone gravel, cuttlefish shells, as well as direct addition of calcium to the diet. High concentrations of calcium carbonate or calcium phosphate in the diet can give the feed an unpleasant taste, so you need to be careful in dosages. Studies of diets containing 1 % calcium have shown that this amount is sufficient for reproduction in some large species of parrots, the same level is recommended for turnips, to prevent calcium deficiency. On the contrary, it is shown that the content of 0.35 % of calcium is sufficient to ensure the thickness of the eggshell and its conductivity in Australian cockatoos during the breeding season. Some studies have shown that 0.8 % of calcium is a sufficient concentration for budgies during breeding and growth, the real needs may be lower. Usually phosphorus is abundant in the seeds, but only 30 – 40 % is contained in non-phytate form and can be considered as available to the body of birds. If there is a deficiency of phosphorus in the diet, the needs for phosphorus in nervous tissue, cellular structures and enzyme synthesis take precedence over the needs for bone formation. Thus, deficiency always affects the skeleton [5, 11].

Interactions occur between different *trace elements*, which can lead to bioavailability problems (for example, between copper and molybdenum, calcium and zinc, manganese and iodine, mercury and selenium). Therefore, any feed additive must be made taking into account these interactions, otherwise excessive concentrations of one mineral may lead to a deficiency of another.

Minerals can also be used in the body of birds to form colored pigments of plumage and skin. *Copper,* for example, is found in turacin, a pigment that gives feathers a blue color. Hypopigmentation of the plumage can occur with *iron* deficiency.

Iodine deficiency was often observed in budgies when kept on cereals without additives. The result was a decrease in the production of thyroid hormones with an increase in its volume (goiter, current), which, in turn, could lead to difficulty breathing, belching food and loss of activity. Symptoms of deficiency are more common in areas far from the sea, even drinking water contains little natural iodine. Scientists recommend to add 2 μg of iodine to the diet twice a week to prevent thyroid dysplasia in budgies or add 1 % fish oil to the standard diet. Some feeds may contain goitrogenic substances. For example, peanuts contained in peanuts affect the utilization of iodine. High levels of calcium can also exacerbate iodine deficiency by reducing absorption.

Table 3 – The needs of budgies in basic nutrients and biologically active substances

Indicator	Mass fraction
Protein, %	10 – 17
Fat, %	6 – 9
Saccharose, %	3 – 4,6
Cellulose, %	3,5 – 7
Essential amino acids, mg/100 g:	
lysine	1,02
threonine	1,20
methionine	0,80
cystine	0,40
phenylalanine	1,20
tyrosine	1,00
valine	1,50
leucine	0,80
arginine	1,90
histidine	0,70
tryptophan	0,30
Vitamins:	
A, IU/kg	200 – 500
D_3, IU/kg	500 – 800
E	0,20 – 0,60
K	0,20 – 0,40
B_1	0,20 – 0,40
B_2	0,12 – 0,50
PP	0,15 – 0,60
B_6	0,40 – 0,60
B_8	0,10 – 0,24
B_{12}, μg/kg	0,24 – 0,50
Minerals:	
Ca, %	0,90 – 1,30
P, %	0,68 – 0,75
Mg, %	0,015 – 0,02
K, %	0,20 – 0,30
Mn, mg/kg	0,80 – 0,90
Se, mg/kg	0,75 – 1,00
I, mg/kg	0,30 – 0,40
Zn, mg/kg	0,40 – 0,65
Fe, mg/kg	0,78 – 0,85
Cu, mg/kg	0,80 – 1,00

Manganese deficiency causes perose in poultry. Hock joints swell and become denser, the Achilles tendon is displaced relative to the normal state. Peroz was observed in keelless birds and cranes, but there is no data on its presence in rowans and parrots. This is probably due to the fact that they have shorter limbs and less body weight compared to birds that move mainly on land. However, although rowans and parrots do not show clinical signs of manganese deficiency, this does not necessarily mean that their needs are different from those of other birds. Since the seeds have been shown to be low in manganese, it probably makes sense to use appropriate dietary supplements.

Zinc is usually found in excess in most feeds, particularly in seed germs. However, zinc of plant origin is less available to the body of poultry than zinc of animal origin, due to the formation of insoluble zinc-phytate complexes. In addition, the availability of zinc is reduced by calcium, by forming the most insoluble mixed zinc calcium-phytate complex. Signs of marginal or chronic zinc deficiency include anorexia, poor wound healing, skin diseases, scaly paws, and decreased reproductive capacity. Excess zinc can also be dangerous, inhibiting growth and causing anemia. Very high concentrations of zinc are toxic [5, 11].

In the table 3 the needs of budgies in the main nutrients and biologically active substances are given [5, 10-13].

Based on the above, taking into account the needs of decorative and songbirds in nutrients and biologically active substances, recipes for complete feed were calculated. A method of production of compound feeds for decorative birds and songbirds in the form in the form of crumbs or a blend of crumbs obtained by extrusion [15]. This will allow them to meet both behavioral and feed needs.

Conclusions

On the basis of the conducted scientific researches the requirements concerning quantity of energy for an decorative and songbirds at the maintenance in house conditions, at reproduction, in the period of growth are studied; needs of adult birds, during growth and molting in proteins and amino acids; needs for fats and essential fatty acids; carbohydrates; vitamins and minerals.

The functional purpose of nutrients and biologically active substances, symptoms that occur in the body of decorative and songbirds in their absence or excess in the feed, as well as their sources and minimum needs of birds during breeding, growth and maintenance of healthy birds.

To meet the forage needs of decorative and songbirds when kept in captivity, one of the most effective methods is to create complete feed by using innovative technologies (for example, in the form of crumbs or a blend of crumbs obtained by extrusion). This will provide an opportunity to meet both the behavioral and feeding needs of birds.

REFERENCES

1. *Bordun, T.V. (2014). Stan i perspektyvy rozvytku svitovoho ta ukrainskoho rynku kormiv dlia sviiskykh tvaryn. Khranenye y pererabotka zerna, 5 (182), 22–26.*
2. *Zviriachyi apetyt: pet food industriia pohlynaie rynok: veb-sait. URL: https://www.business.ua/uk/node/11094 (data zvernennia: 07.06.2021).*
3. *Lindsay Beaton. "Other" pets: A small but important segment to watch: veb-sait. URL: https://www.petfoodindustry.com/articles/9566-other-pets-a-small-but-important-segment-to-watch (data zvernennia: 07.06.2021).*
4. *Yehorov, B.V., Bordun, T.V. (2016). Naipopuliarnishi tvaryny-kompanony v Ukraini. Zbirnyk tez tedopovidei 76 naukovoi konferentsii vykladachiv akademii. Odesa: ONAKhT, 4–6.*
5. *Kniga o kormlenii domashnih zhivotnyh (1997). Pod red. A. Burgera. Moskva: Biainformservis, 182.*
6. *Iehorov, B.V., Bordun, T.V. (2020). Osoblyvosti protsesu travlennia dekoratyvnoi ptytsi. Zbirnyk tez dopovidei 80 naukovoi konferentsii vykladachiv akademii. Odesa: ONAKhT, 29–31.*
7. *Kazakova, V.A. (2011). Popugai. Vybor, priruchenie, soderzhanie, razvedenie. Rostov na Donu: Vladis; Moskva: RIPOL klasik, 352.*
8. *Bordun, T.V., Mardar, M.R., Yevdokymova, H.I., Kulesha, V.I. (2015). Sanitarna yakist kombikormiv dlia khvyliastykh papuh. Khranenye y pererabotka zerna, 11-12, 54–56.*
9. *Jenciklopedija vladel'ca pticy: veb-sajt. URL: http://www.mybirds.ru/groups/popug/feeding/ (data zvernennia: 11.06.2021).*
10. *Peron, F., Grosset, C. (2014). The diet of adult psittacids: veterinarian and ethological approaches. Journal of Animal Physiology and Animal Nutrition, 98, 403–416. DOI: 10.1111/jpn.12103.*
11. *Kvinten, D. (2011). Bolezni dekorativnyh ptic. Moskva: «Akvarium Print», 208.*
12. *Top 5 Nutritional Needs Of Parrots: veb-sait. URL: https://birdsupplies.com/pages/top-5-nutritional-needs-of-parrots (data zvernennia: 15.06.2021).*
13. *A guide to Avoiding Nutritional Disease in Pet Parrots https://mbgvet.com/wp-content/uploads/2021/07/Avoiding-Nutritional-Disease-in-Pet-Parrots.pdf (data zvernennia: 15.06.2021).*
14. *Nutritional Requirements for Psittacines (Parrots) by Jeannine Miesle: veb-sait. URL: https://www.beautyofbirds.com/nutritionalrequirementsofparrots (data zvernennia: 15.06.2021).*
15. *Bordun, T.V. (2017). Ispol'zovanie processa jekstrudirovanija pri proizvodstve kombikormov dlja dekorativnoj pticy i gryzunov. Tehnika i tehnologija pishhevyh proizvodstv: tezisy dokladov XI Mezhdunarodnoj nauch. tehn. konferencii. Mogilev: MGUP, 268.*

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ІННОВАЦІЙНІ ПІДХОДИ ПРИ ФОРМУВАННІ РЕЦЕПТІВ КОМБІКОРМІВ ДЛЯ ДЕКОРАТИВНОЇ ТА СПІВУЧОЇ ПТИЦІ І ТЕХНОЛОГІЇ ЇХ ВИРОБНИЦТВА

Анотація

З кожним роком зростає частка комбікормів для непродуктивних домашніх тварин на комбікормових ринках світу. Згідно з даними FEDIAF, декоративна та співуча птиця є третьою за величиною популяцією домашніх улюбленців (коти і собаки, відповідно, номери 1 і 2), 51,87 млн декоративних птахів у всій Європі (37,23 млн з них в Європейському Союзі) у 2019 році.

Декоративна та співуча птиця потребує повноцінної годівлі для підтримки життя та здоров'я. На сьогоднішній день власники декоративної та співучої птиці в своєму розпорядженні мають широкий асортимент готових кормів, що дозволяє їм зробити правильний вибір відповідного режиму годівлі їх улюбленців. Аналізуючи ринок комбікормів для декоративної та співучої птиці, побачили, що суттєву його частину займають комбікорми імпортного виробництва, в той час як асортимент вітчизняних комбікормів на ринку України дуже малий і не завжди відповідає вимогам ринку та не витримує конкуренції. Проте, представлені комбікорми важко назвати повнораціонними, так як це в основному різні види кормових сумішей, до складу яких входять, у залежності від цінової категорії, різні види компонентів: починаючи із зернових – і закінчуючи різними горіхами та сухофруктами. Комбікорм повинен містити всі компоненти, необхідні для вироблення енергії, росту, регенерації тканин, а також для регулювання обміну речовин. Повнораціонний комбікорм для декоративної та співучої птиці повинен містити у визначеній кількості всі поживні та біологічно активні речовини. Слід також враховувати такі фактори, як вік, загальний стан здоров'я, період розмноження, росту, линьки, умови утримання і навіть пору року.На сьогоднішній день є ряд питань, які потребують удосконалення наших знань про потреби у поживних та біологічно активних речовинах для кожного виду декоративних та співучих пта-

хів, включаючи особливості кормової сировини, кількості енергії, перетравності корму і вмісту в ньому поживних та біологічно активних речовин.

У зв'язку з цим необхідно вивчити кожен клас поживних та біологічно активних речовин і особливості формування рецептів комбікормів з урахуванням потреби в них декоративної та співучої птиці. Детально вивчити функціональне призначення поживних та біологічно активних речовин, симптоми, які виникають в організмі декоративної та співучої птиці при їх недостачі або надлишку в кормі, а також їх джерела і мінімальні потреби птиці у період розмноження, росту та підтримання організму здорової птиці.

Щоб задовольнити кормові потреби декоративної та співучої птиці при їх утриманні в неволі, одним з найефективніших методів є створення повнораціонних комбікормів шляхом застосування інноваційних технологій (наприклад, у вигляді крупки або суміші крупок, одержаної шляхом екструдування). Це дасть можливість забезпечити задоволення як поведінкових так і кормових потреб птахів.

Ключові слова: декоративна та співуча птиця, поживні та біологічно активні речовини, рецепт, інноваційні технології, екструдований повнораціонний комбікорм для декоративної та співучої птиці.

ЛІТЕРАТУРА

1. *Бордун Т.В. Стан і перспективи розвитку світового та українського ринку кормів для свійських тварин. Хранение и переработка зерна. 2014. № 5 (182). С. 22–26.*
2. *Звірячий апетит: pet food індустрія поглинає ринок: веб-сайт. URL: https://www.business.ua/uk/node/11094 (дата звернення: 07.06.2021).*
3. *Lindsay Beaton. "Other" pets: A small but important segment to watch: веб-сайт. URL: https://www.petfoodindustry.com/articles/9566-other-pets-a-small-but-important-segment-to-watch (дата звернення: 07.06.2021).*
4. *Єгоров Б.В., Бордун Т.В. Найпопулярніші тварини-компаньони в Україні. Збірник тез тедоповідей 76 наукової конференції викладачів академії. Одеса: ОНАХТ, 2016. С. 4–6.*
5. *Книга о кормлении домашних животных / под ред. А. Бургера. Москва: Биоинформсервис, 1997. 184 с.*
6. *Єгоров Б.В., Бордун Т.В. Особливості процесу травлення декоративної птиці. Збірник тез доповідей 80 наукової конференції викладачів академії. Одеса: ОНАХТ, 2020. С. 29–31.*
7. *Казакова В.А. Попугаи. Выбор, приручение, содержание, разведение. Ростов на Дону: Владис; Москва: РИПОЛ класик, 2011. 352 с.*
8. *Бордун Т.В., Мардар М.Р., Євдокимова Г.Й., Кулеша В.І. Санітарна якість комбікормів для хвилястих папуг. Хранение и переработка зерна. 2015. № 11-12. С. 54–56.*
9. *Энциклопедия владельца птицы: веб-сайт. URL: http://www.mybirds.ru/groups/popug/feeding/ (дата звернення: 11.06.2021).*
10. *F. Peron, C. Grosset. The diet of adult psittacids: veterinarian and ethological approaches. Journal of Animal Physiology and Animal Nutrition. 2014. Vol. 98. P. 403–416. DOI: 10.1111/jpn.12103.*
11. *Д. Квинтен. Болезни декоративных птиц. Москва: «Аквариум Принт», 2011. 208 с.*
12. *Top 5 Nutritional Needs Of Parrots: веб-сайт. URL: https://birdsupplies.com/pages/top-5-nutritional-needs-of-parrots (дата звернення: 15.06.2021).*
13. *A guide to Avoiding Nutritional Disease in Pet Parrots https://mbgvet.com/wp-content/uploads/2021/07/Avoiding-Nutritional-Disease-in-Pet-Parrots.pdf (дата звернення: 15.06.2021).*
14. *Nutritional Requirements for Psittacines (Parrots) by Jeannine Miesle: веб-сайт. URL: https://www.beautyofbirds.com/nutritionalrequirementsofparrots (дата звернення: 15.06.2021).*
15. *Бордун Т.В. Использование процесса экструдирования при производстве комбикормов для декоративной птицы и грызунов. Техника и технология пищевых производств: тезисы докладов XI Международной науч. техн. конференции. Могилев: МГУП, 2017. С. 268.*

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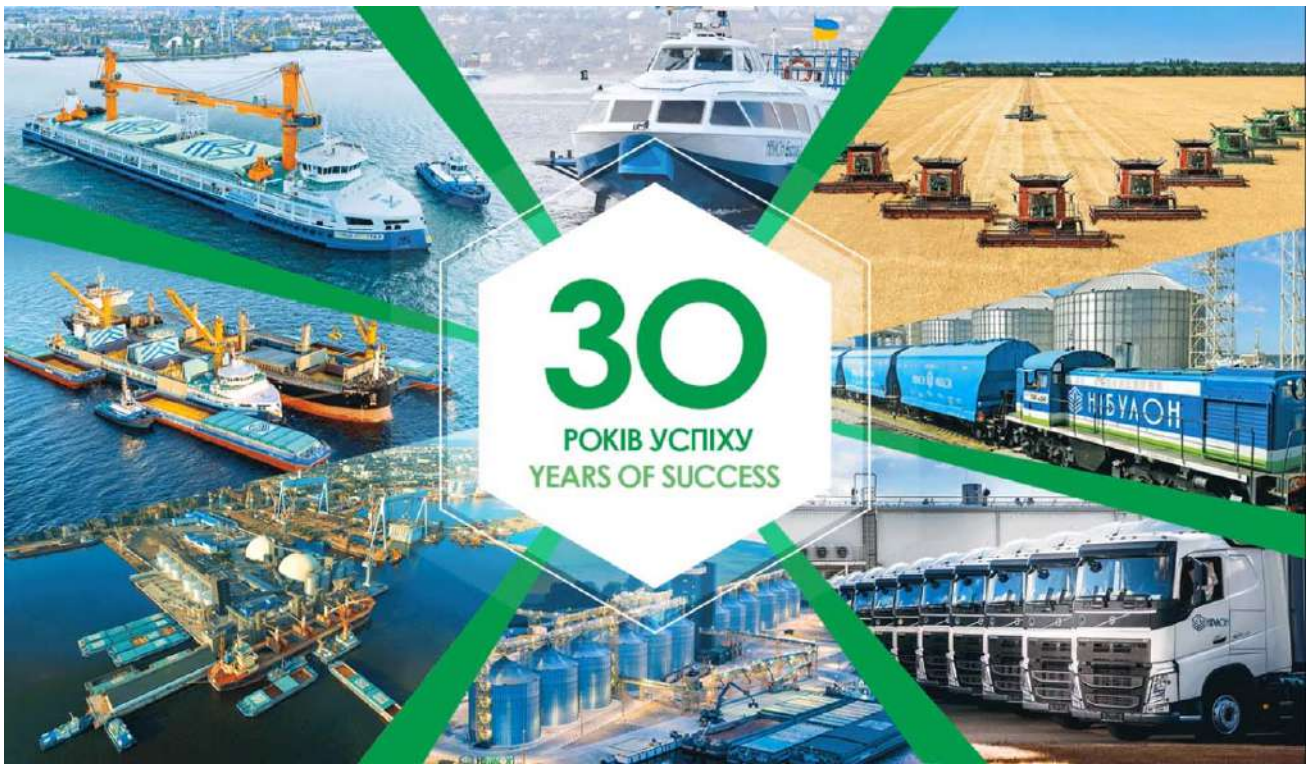

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THE ANTIDISBIOTIC EFFECT OF OIL CAKE FROM HIGH OLEIC SUNFLOWER SEEDS IN RATS WITH EXPERIMENTAL DYSBIOSIS

Abstract

The work shows the relevance of the use in feeds production of means for correcting the microbiome. It is shown that the use of probiotic and prebiotic preparations increases the zootechnical efficiency of feed products, contributes to an increase in the amount of livestock and poultry products and forms its quality and safety. The expediency of using oil cake from high oleic sunflower seeds in the production of feed products has been substantiated from the point of view of ensuring the nutritional value of products and a positive effect on the norm of the flora of farm animals and poultry.

Experimental dysbiosis in rats was reproduced with lincomycin. Oilcakes from linoleic and high oleic sunflower seeds were added to the diet in an amount of 10%. The experiment lasted 18 days. The activity of urease, lysozyme, elastase was determined in the mucous membranes of the digestive tract (oral, small and large intestine), and the degree of dysbiosis was calculated.

The therapeutic and prophylactic effect of oil cake from high oleic sunflower seeds on the development of inflammatory and dystrophic processes in the digestive system of rats under experimental dysbiosis was established. Studies have established an increase in the activity of elastase, urease, a decrease in the activity of lysozyme in rats with experimental dysbiosis. It was found that the consumption of high-oleic sunflower oil cake has a significantly greater therapeutic and prophylactic effect in comparison with the linole-type sunflower oil cake, since it reduces the level of elastase by 23-45%, urease by 13.5-58% in the mucous membranes of the digestive tract. An increase of 25-94% in the activity of lysozyme in animals with experimental dysbiosis was established when using oil cake from high oleic sunflower. It was found that the consumption of oil cake from high oleic sunflower seeds reduces the degree of dysbiosis in all tissues, especially in the small intestine (5 times).

It was found that with dysbiosis in the digestive system, inflammatory-dystrophic processes develop as a result of a decrease in the level of nonspecific immunity. It was found that the consumption of oil cake from the seeds of high oleic sunflower has an antidisbiotic effect and, as a consequence, mucosoprotective effect.

Key words: feeds, cake, high-oleic sunflower, digestive system, dysbiosis, inflammatory processes.

Introduction

Numerous studies have established that probiotic and prebiotic preparations improve intestinal function and normalize the digestion of feed in farm animals and poultry, increasing the zootechnical efficiency of diets. Colonization of the gastrointestinal tract with beneficial microflora helps to reduce the negative impact of pathogenic or opportunistic microorganisms, maintain optimal acidity of the environment, prevent dysbiosis, stimulate local and general immunity factors, reduce the amount of antibiotics and drugs used in animal husbandry and [1].

Topical issues in feed production are the substantiation of the composition and formulation of products, taking into account its effect on the normal flora of farm animals and poultry.

With the press method of processing sunflower seeds, almost 60% of cake is formed with a content of 9 to 15 % fat and more than 30% protein. The use of cake in the composition of mixed fodders significantly increases the content of protein and fat.

Recently, they began to grow high oleic varieties and hybrids of sunflower [2, 3], containing in the fat composition a large amount (80 ... 90 %) of valuable oleic acid (C18: 1, ω -9), a low amount (less than 10 %) of linoleic acid (C18: 2, ω -6) and a small amount (up to 5%) of palmitic acid (C16: 0), harmful to the body [4]. It was found that high-oleic sunflower hybrids contain more protein than high-salt varieties [5].

The aim of this work was to determine the effect of oil cake from high oleic sunflower seeds on the development of dysbiosis in the digestive system of rats. For comparison, a cake from the seeds of a common sunflower of the linoleic type was used.

Materials and methods of research.

In the work, 20 Wistar rats (males, 2-2.5 months, live weight 193 ± 13 g) were used, which were divided into 4 levels of the group: 1st control, which received a standard diet [6]; Groups 2, 3, 4 received the antibiotic lincomycin at a dose of 70 mg / kg with drinking water for the first 5 days to reproduce the experimental dysbiosis [7]. Rats of the 3rd group received 10 % of linoleic-type sunflower oil cake with food (replacement of 10 % wheat grain), and rats of the 4th group received 10 % high-oleic sunflower oil cake with food (replacement of 10 % wheat grain).

The fat content in macus from sunflower seeds of the linoleic type was 9.1 %, the content of linoleic acid was 54.5% of the total fatty acids. The fat content of the macaus of the high oleic sunflower was 8.9 %, the oleic acid content was 84.6%. The analysis of the fatty acid composition of the oil cake was carried out in accordance with [8].

The duration of feeding was 18 days.

The animals were euthanized on the 19th day of the experiment under thiopental anesthesia (20 mg / kg) by total bleeding from the heart. The liver and mucous membranes of the cheeks (oral cavity (OOM)), small and large intestines were isolated, after washing them with cold 0.9 % NaCl solution.

In tissue homogenates, the activity of the proteolytic enzyme elastase [9], the activity of the bacterial enzyme urease [9], the activity of the antimicrobial enzyme lysozyme [9] were determined, and the degree of dysbiosis was calculated according to A.P. Levitsky [9].

The experimental results were subjected to standard statistical processing [10].

Results and discussion.

Table 1 presents the results of determining the activity of elastase in the mucous membranes of the digestive system of rats, which is a marker of inflammatory-dystrophic processes [9] and the activity of the bacterial enzyme urease.

As can be seen from the data, in all studied tissues of rats with dysbiosis, the level of elastase increases: in the oral mucosa by 20 %, in the small intestine by 57 %, in the large intestine by 70 %.

In rats that consumed linoleic sunflower cake, elastase activity decreased slightly in the mucous membranes of the mouth and small intestine (only by 3-5 %) and significantly (by 31 %) in the mucous membrane of the large intestine.

In rats that consumed oil cakes from high oleic sunflower seeds, the activity of elastase in the OAS decreases by 23 %, and in the mucous membrane of the small intestine by 45 %, in the mucous membrane of the large intestine, a decrease of 5%.

From the data obtained on the activity of urease in the studied tissues, it can be seen that the level of this enzyme in rats with dysbiosis increases in the OAS by 168 %, in the mucous membrane of the small intestine by 280 % and in the mucous membrane of the large intestine by 197 %.

Consumption of oil cake from linoleic sunflower seeds somewhat reduces the level of urease, however, $P > 0.05$. Only the addition of oil cake from high oleic sunflower to the diet significantly reduced the activity of urease: in the OAS by 41 %, in the small intestine by 58 %, in the large intestine the level of this enzyme decreased by 13.5 %.

Table 2 shows the results of determining the activity of the antimicrobial enzyme lysozyme in the tissues of rats with experimental dysbiosis. It can be seen that in all tissues the level of lysozyme decreases, especially in the colon - by 51%.

Consumption of oil cake from ordinary sunflower (linoleic type) had little effect on the level of lysozyme, while the addition of oil cake from high oleic sunflower to the diet significantly increases the activity of lysozyme: in the small intestine by 94 %, in the large intestine.

From the results of determining the degree of dysbiosis in the digestive system of rats, it can be seen that the degree of dysbiosis in the OAS increases by almost 3 times, and in the intestine by 5-6 times, provided that the antibiotic lincomycin is used.

As can be seen from the data obtained (Table 2.), the consumption of oil cake from sunflower seeds of the linoleic type reduces the degree of dysbiosis, but it is reliable only in the OSS. Consumption of oil cake from high oleic sunflower seeds reduces the degree of dysbio-

sis in all tissues, especially in the small intestine (5 times).

Thus, the data obtained have shown that in animals with dysbiosis, damage to the digestive system is observed (inflammatory-dystrophic processes). This is evidenced by an increase in the activity of the biochemical marker of inflammation, the enzyme elastase. An increase in bacterial seeding of the mucous membrane of the digestive tract is evidenced by an increase in the activity of urease.

Table 1- The effect of sunflower seed cake on the activity of elastase and urease in the digestive system of rats with experimental dysbiosis

№	Group	Elastase			Urease		
		Oral mucosa , μkat /kg	mucous membrane of the small intestine, μkat /kg	mucous membrane of the colon, μkat /kg	Oral mucosa, μkat /kg	mucous membrane of the small intestine , μkat /kg	mucous membrane of the colon, μkat /kg
1	Control	54.6±6.1	1.04±0.06	44.3±3.3	0.13±0.03	1.28±0.31	1.28±0.16
2	Experimental dysbiosis (ED)	65.7±5.3 P>0.05	1.63±0.05 P<0.01	76.3±2.2 P<0.01	0.34±0.004 P<0.05	5.14±1.85 P<0.05	3,8±0.57 P<0.05
3	ED + sunflower seed cake linoleic type	63.3±10.84 P>0.3 P1>0.5	1.55±0.08 P<0.01 P1>0.3	52.8±9,1 P>0.05 P1<0.05	0.25±0.04 P>0.05 P1>0.05	4.99±0.59 P<0.05 P1>0.3	3.3±0.57 P>0.05 P1>0.3
4	ED+ high oleic sunflower seed cake	48.7±6.9 P>0.3 P1>0.05 P2>0.05	0.85±0.03 P<0.05 P1<0.001 P2>0.001	48.0±3.3 P>0.3 P1<0.01 P2>0.35	0.20±0.04 P>0.05 P1<0.05 P2>0.3	1.92±0.75 P<0.05 P1<0.05 P2>0.05	3.28±0.31 P<0.05 P1>0.3 P2>0.5

Note: P - in comparison with group 1
P1 - in comparison with group 2
P2 - in comparison with group 3

Table 2 - Influence of oil cake from sunflower seeds on the activity of lysozyme and the degree of dysbiosis in the digestive system of rats

№	Group	Lysozyme, units / kg			Degree of dysbiosis, units		
		Oral mucosa , μkat /kg	mucous membrane of the small intestine , μkat /kg	mucous membrane of the colon , μkat /kg	Oral mucosa , μkat /kg	mucous membrane of the small intestine , μkat /kg	mucous membrane of the colon, μkat /kg
1	Control	189±16	275±35	522±28	1.00±0.12	1.00±0.27	1.00±0.15
2	Experimental dysbiosis (ED)	178±8 P>0.1	191±32 P>0.05	297±5 P<0.01	2.87±0.39 P<0.01	5.39±0.88 P<0.001	5.57±0.84 P<0.01
3	ED + sunflower seed cake linoleic type	166±19 P>0.3 P1>0.3	213±17 P>0.05 P1>0.3	290±20 P<0.01 P1>0.05	1.75±0.23 P<0.05 P1<0.05	4.69±0.91 P<0.001 P1>0.3	4.96±0.77 P<0.01 P1>0.3
4	ED+ high oleic sunflower seed cake	194±10 P>0.3 P1>0.05 P2>0.05	414±14 P<0.01 P1<0.01 P2<0.01	364±20 P<0.01 P1<0.01 P2<0.05	1.9±0.27 P>0.05 P1<0.05 P2>0.3	0.93±0.28 P<0.05 P1<0.01 P2<0.01	3.66±0.59 P<0.05 P1>0.05 P2>0.05

Note: P - compared with group 1
P1 - compared with group 2
P2 - compared with group 3

The reason for the development of pathological phenomena in the digestive system may be a significant decrease in the level of nonspecific immunity, an indicator of which is the enzyme lysozyme. As our research has shown, the consumption of high oleic sunflower meal can significantly affect the state of the digestive system in conditions of dysbiosis. Normalization is due to an increase in the activity of lysozyme and a decrease in the level of inflammatory-dystrophic processes.

The benefits of oil cake from high oleic sunflower seeds are most likely due to the presence of a large amount of oleic acid, which is an antioxidant [11] and stimulates endogenous biosynthesis of ω3 PUFA (polyunsaturated fatty acids) [12], as a result of which inflammatory processes are inhibited in the body. regeneration [13, 14]. The established ability of high oleic sunflower cake to neutralize the negative manifestations of the antibiotic and restore homeostasis in the "microbe - human" system allows us to recommend its use as a component of feed products not only as a source of protein, but as a component with functional properties, in particular antidisbiotic.

Further research is advisable to establish the biological value, functional properties of oil cake from high oleic sunflower and substantiate the methods of effective use in the production of feed products.

Conclusions.

1. In conditions of dysbiosis, inflammatory and dystrophic processes develop in the digestive system.

2. The use of drugs that normalize the intestinal microbe of farm animals and poultry in the production of feed products can significantly increase its zootechnical efficiency, contributing to an increase in the amount of products obtained and the quality and safety of the latter.

3. Consumption of oil cake from high oleic sunflower seeds has an antidisbiotic effect and, as a result, mucosoprotective effect.

REFERENCES

1. *Mohamed Zommiti Probiotics and Prebiotics in Animal Feed / Mohamed Zommiti, Mounir Ferchichi // Probiotics and Prebiotics in Foods, Elsevier, 2021. – pp.233-261.*
2. *Levitsky A. P. Fatty food, fatty acids, Healthy sunflower olive / A. P. Levitsky, I. L. Potapova // Intern. Journ. Food a Nutrition Sciences. – 2015. – v. 4, iss. 3. – P. 15-20.*
3. *Levic'kij A.P. Rol' visokooleïnovoï sonyashnikovoï oliï u virishenni problemi zhirovogo zabezpechennya sil's'kogospodars'kih tvarin ta ptici / A.P. Levic'kij, A.P. Lapins'ka, I.V. Hodakov // Zernovi produkti i kombikorma. – 2016. – T. 62, №2. – C.38-43*
4. *Levickij, A. P. Razvitie kolita u krys, poluchavshih vysokopal'mitinovye pishchevye zhiry / Levickij, A. P., Bocharov, A. V., Hodakov, I. V., Markov, A. V. // Visnik mors'koï medicini. – 2019. –№ 2 (83). – C.84-91.*
5. *Bezverhaya, N. S. Sravnitel'naya harakteristika dvuh biotipov gibridnogo podsolnechnika s razlichnym zhirnokislotnym sostavom zapasnyh lipidov / Bezverhaya, N. S., Il'chishina, N. V., Efimenko, S. G., SHCHebakov, V. G. // Izvestiya vysshih uchebnyh zavedenij. Pishchevaya tekhnologiya. – 2010. –№ 2. – S. 17-19.*
6. *Levickij A.P. Metody eksperimental'noj stomatologii / Levickij A.P., Makarenko O.A., Dem'yanenko S.A. // Uchebno-metodicheskoe posobie. – Simferopol': Tarpan, 2018. – 78 s.*
7. *Patent Ukraïni na korisnu model' № 31012 MPK. A61P 31/00 Sposib modelyuvannya disbiozu (disbakteriozu) / Levic'kij A.P., Selivans'ka I.O.; Cisel's'kij YU.V.UA); Pochtar V.M. Rozsahanova L.M. Gulavs'kij V.T. zayavl. 22.10.2007 opubl., 25.03.2008 Byul.№ 6.*
8. *Levickij A.P. Metody issledovaniya zhirov i masel / Levickij A.P., Makarenko O.V., Hodakov I.V. – KP «OGT», 2015. 32 .*
9. *Levickij A.P., Makarenko O.A., Selivanskaya I.A. i dr. Fermentativnyj metod opredeleniya disbioza polosti rta dlya skrininga pro- i prebiotikov: Metod. rekomendacii. – K.: GFC, 2007. – 22 s*
10. *Truhacheva N. V. Matematicheskaya statistika v mediko-biologicheskih issledovaniyah s primeneniem paketa Statistica. – M.: GEOTAR-Media, 2012. – 384 s.*
11. *Titov V.N. Metodicheskie voprosy i diagnosticheskoe znachenie opredeleniya perekisnogo okisleniya lipidov v lipoproteinah nizkoj plotnosti. Oleinovaya zhirnaya kislota kak biologicheskij antioksidant (obzor literatury) / V.N. Titov, D.M. Lisicyn, S.D. Razumovskij // Klinich. lab. diagnostika. – 2005. – №4. – S. 3-10.*
12. *Levickij, A. P. Vliyanie zhirovogo pitaniya na sootnoshenie ω-6 i ω-3 polinenasyshchennyh zhirnyh kislot v nejtral'nyh lipidah pecheni krys / Levickij, A. P., Hodakov, I. V., Selivanskaya, I. A., Dvulit, I. P.// Visnik mors'koï medicini. – 2021. – №2 (91). – S. 64-73.*
13. *Serhan, C. N. Resolvins in inflammation: emergence of the pro-resolving superfamily of mediators / Serhan, C. N., Levy, B. D. // The Journal of clinical investigation. – 2018. –№ 128(7) . – p 2657-2669.*
14. *Dalli, J. Identification and structure elucidation of the proresolving mediators provides novel leads for resolution pharmacology / Dalli, J., Serhan, C. N. // British journal of pharmacology. – 2019. – № 176(8) . – P 1024-1037.*

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АНТИДИСБІОТИЧНА ДІЯ МАКУХИ З НАСІННЯ ВИСОКООЛЕЇНОВОГО СОНЯШНИКА У ЩУРІВ З ЕКСПЕРИМЕНТАЛЬНИМ ДИСБІОЗОМ

Анотація

В роботі показано, актуальність застосування в кормовирбництві засобів для корекції мікробіому. Показано, що застосування пробіотичних та пребіотичних препаратів підвищує зоотехнічну ефективність комбікормової продукції, сприяє збільшенню кількості продукції тваринництва та птахівництва та формує її якість та безпеку. Обгрунтовано доцільність застосування макухи з насіння високоолеїнового соняшника при виробництві комбікормової продукції, з точки зору забезпечення поживної цінності продукції та позитивного впливу на нормофлору сільськогосподарських тварин та птиці.

Експериментальний дисбіоз у щурів відтворювали за допомогою лінкоміцину. Макуху з насіння соняшника лінолевого типу та високоолеїнового додавали до раціону в кількості 10%. Тривалість експерименту становила 18 днів. В слизових оболонках травного тракту (СОПР, тонка та товста кишка) визначали активність уреази, лізоциму, еластази, розраховували ступінь дисбіозу.

Встановлено лікувально-профілактичну дію макухи з насіння високоолеїнового соняшника на розвиток запально-дистрофічних процесів в травній системі щурів за умов експериментального дисбіозу. Дослідженнями встановлено зростання активності еластази, уреази, зниження активності лізоциму у щурів із експериментальним дисбіозом. Встановлено, що споживання макухи високоолеїнового соняшника має значно більшу лікувально-профілактичну дію у порівнянні з макухою соняшника лінолевого типу, оскільки дозволяє знизити рівень еластази на 23-45%, уреази на 13,5-58% в слизових оболонках травного тракту. Встановлено збільшення на 25-94% активності лізоциму у тварин з експериментальним дисбіозом за умови споживання макухи з високоолеїнового соняшника. Встановлено що споживання макухи з насіння високоолеїнового соняшника знижує ступінь дисбіозу в усіх тканинах, особливо у тонкій кишці (в 5 разів).

Встановлено, що за умов дисбіозу в травній системі розвиваються запально-дистрофічні процеси, як результат зниження рівня неспецифічного імунітету. Встановлено, що споживання макухи з насіння високоолеїнового соняшника здійснює антидисбіотичну дію і, як наслідок, мукозопротекторну дію.

Ключові слова: корми, макуха, високоолеїновий соняшник, травна система, дисбіоз, запальні процеси.

ЛІТЕРАТУРА

1. *Mohamed Zommiti Probiotics and Prebiotics in Animal Feed / Mohamed Zommiti, Mounir Ferchichi // Probiotics and Prebiotics in Foods, Elsevier, 2021. – pp.233-261.*
2. *Levitsky A. P. Fatty food, fatty acids, Healthy sunflower olive / A. P. Levitsky, I. L. Potapova // Intern. Journ. Food a Nutrition Sciences. – 2015. – v. 4, iss. 3. – P. 15-20.*
3. *Левицький А. П. Роль високоолеїнової соняшникової олії у вирішенні проблеми жирового забезпечення сільськогосподарських тварин та птиці / А. П. Левицький, А. П. Лапінська, І. В. Ходаков // Зернові продукти і комбікорма. – 2016. – Т. 62, №2. – С.38-43*
4. *Левицкий, А. П. Развитие колита у крыс, получавших высокопальмитиновые пищевые жиры / Левицкий, А. П., Бочаров, А. В., Ходаков, И. В., Марков, А. В. // Вісник морської медицини. – 2019. –№ 2 (83). – С.84-91.*
5. *Безверхая, Н. С. Сравнительная характеристика двух биотипов гибридного подсолнечника с различным жирнокислотным составом запасных липидов / Безверхая, Н. С., Ильчишина, Н. В., Ефименко, С. Г., Щебаков, В. Г. // Известия высших учебных заведений. Пищевая технология. – 2010. –№ 2. – С. 17-19.*
6. *Левицкий А.П. Методы экспериментальной стоматологии / Левицкий А.П., Макаренко О.А., Демьяненко С.А. // Учебно-методическое пособие. – Симферополь: Тарпан, 2018. – 78 с.*
7. *Патент України на корисну модель № 31012 МПК. A61P 31/00 Спосіб моделювання дисбіозу (дисбактеріозу) / Левицький А.П., Селиванська І.О.; Цисельський Ю.В.UA); Почтар В.М. Розсаханова Л.М. Гулавський В.Т. заявл. 22.10.2007 опубл., 25.03.2008 Бюл.№ 6.*
8. *Левицкий А.П. Методы исследования жиров и масел / Левицкий А.П., Макаренко О.В., Ходаков И.В. – КП «ОГТ», 2015. – 32 с.*
9. *Левицкий А.П., Макаренко О.А., Селиванская И.А. и др. Ферментативный метод определения дисбиоза полости рта для скрининга про- и пребиотиков: Метод. рекомендации. – К.: ГФЦ, 2007. – 22 с*
10. *Трухачева Н. В. Математическая статистика в медико-биологических исследованиях с применением пакета Statistica. – М.: ГЭОТАР-Медиа, 2012. – 384 с.*
11. *Титов В.Н. Методические вопросы и диагностическое значение определения перекисного окисления липидов в липопротеинах низкой плотности. Олеиновая жирная кислота как биологический антиоксидант (обзор литературы) / В.Н. Титов, Д.М. Лисицын, С.Д. Разумовский // Клинич. лаб. диагностика. – 2005. – №4. – С. 3-10.*
12. *Левицкий, А. П. Влияние жирового питания на соотношение ω-6 и ω-3 полиненасыщенных жирных кислот в нейтральных липидах печени крыс / Левицкий, А. П., Ходаков, И. В., Селиванская, И. А., Двулит, И. П.// Вісник морської медицини. – 2021. – №2 (91). – С. 64-73.*
13. *Serhan, C. N. Resolvins in inflammation: emergence of the pro-resolving superfamily of mediators / Serhan, C. N., Levy, B. D. // The Journal of clinical investigation. – 2018. –№ 128(7) . – p 2657-2669.*
14. *Dalli, J. Identification and structure elucidation of the proresolving mediators provides novel leads for resolution pharmacology / Dalli, J., Serhan, C. N. // British journal of pharmacology. – 2019. – № 176(8) . – P 1024-1037*

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MODERNIZATION OF THE MACHINE FOR HYDROTHERMAL TREATMENT OF GRAIN

Abstract

The purpose of hydrothermal processing of grain is to change its initial technological properties in the direction of stabilization and maintaining them at the optimal level for the further process of processing it into the final product - flour or cereals. The use of devices of continuous action allows the steaming process to become more efficient, while hydrothermal treatment occupies a special place in the technology of processing cereals, obtaining them high consumer properties. The analysis of designs of devices of continuous action, shows that the most widespread have devices of horizontal type where the main working body of the steamer has functions of transportation and hashing. This design allows to achieve uniformity of steaming during processing of the product. To achieve a flexible change in the exposure of steaming, it is proposed to introduce a two-stage variator in the drive of the working body, which will significantly change the steaming time and use the apparatus for steaming more different crops, and to ensure a constant set steam pressure the design of which allows to carry out these operations without pressure losses. In the two-stage version of the variator, the rotation from its drive shaft by means of a V-belt is transmitted to the intermediate shaft, and from it by means of an additional V-belt to the main working shaft. The gear ratio is adjusted by turning the glasses and their synchronous shift in the axial direction.At the same time there is a simultaneous movement of movable conical disks, transfer of a V-belt and an additional V-belt to other diameters. We use sluice gates with a flat sealing surface and a fluoroplastic gasket to supply grain to the working chamber under pressure and unload it. This design allows the most effective sealing of the working chamber under pressure and to maintain the working pressure within the specified limits, with continuous loading and unloading of the device. The calculations show the feasibility and efficiency of modernization of the steamer by ensuring the tightness of the unloader and the uniformity of the speed of the product processed in the working chamber by using a two-stage gearbox or drive motor with a frequency converter.

Key words: hydrothermal treatment, grain, groats, steaming, calculation, unloader, reducer.

Problem statement

Hydrothermal treatment occupies a special place in the technology of processing cereals and obtaining cereals and their derivatives (flakes, muesli, flour, dietary products, etc.) with high consumer properties.

The analysis of designs of devices of continuous action, shows that devices of horizontal type with the transporting - mixing body have the greatest distribution. This design allows to achieve uniformity of steaming by mixing the product.

The use of continuous devices allows the steaming process to become more efficient.

To achieve a flexible change in the exposure of steaming, it is proposed to introduce a variator in the drive of the transporting body, which will significantly change the steaming time and use the apparatus for steaming more different crops, and to ensure a constant set pressure which allows you to perform these operations without pressure loss.

In the two-stage version of the variator, the rotation from the drive shaft by means of a V-belt is transmitted to the intermediate shaft, and from it by means of an additional V-belt to the ice shaft. The gear ratio is adjusted by turning the glasses and their synchronous shift in the axial direction. At the same time there is a simultaneous movement of movable conical disks and transfer of a V-belt and an additional V-belt to other diameters.

We use sluice gates with a flat sealing surface and a fluoroplastic gasket to supply grain to the working chamber under pressure and unload it. This design allows the most effective sealing of the working chamber under pressure and to maintain the working pressure within the specified limits, with continuous loading and unloading of the device.

1. Description of the functional diagram of the machine.

Before the start of the steamer (Fig. 1) is the connection of the machine to the mains and steam line, then the drive is turned on and the manual valve 7 supplies steam to the vessel 1 to heat it for 5-10 minutes. After warming up the apparatus, the control valve 8 is adjusted depending on the required pressure in the apparatus by moving the loads 9 on the valve lever. The required pressure is monitored by a manometer 6 mounted on the housing 1 of the working chamber. A safety valve 5 is also installed on the housing. Next, steam enters the apparatus through the distribution steam collector 11 and through the nozzles 12. The required drive speed is set depending on the required exposure.

After the steam pressure in the vessel has been adjusted and the required steaming exposure has been established, the feeder 3 and the unloader 4 are switched on and the grain is loaded into the apparatus. The grain enters from the hopper into the loading pipe of the feeder 3, successively filling the cell of the rotating rotor. The cells transfer the grain from the loading pipe to the unloading pipe of the feeder and when the cell coincides with the unloading pipe, the grain is pushed out of the cell into the working chamber by a jet of steam supplied through the cell channel, coinciding with the supply channel on the feeder housing.

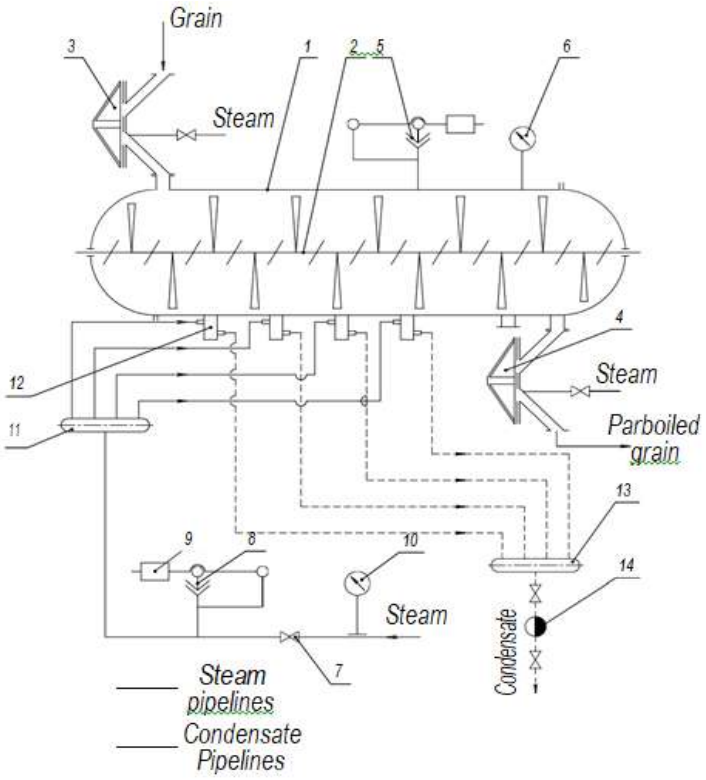

Fig. 1. Functional diagram of the steamer

After emptying the cell from the grain and disconnecting it from the working chamber, the cell through the hole in the sluice body connects to the atmosphere, as a result of which the pressure in it becomes equal to atmospheric and the cell is prepared for the next grain loading.

The grain entering the vessel moves from the loading hole in the vessel to the unloading blade auger 2, along the way subjected to heat treatment with steam, with vigorous stirring of the auger blades and a jet of steam that penetrate the product layer.

At the end of the vessel, the steamed product enters through the discharge pipe into the unloader 4. The operation of the unloader is similar to the operation of the feeder 3.

Condensate through the nozzles 12 and the collector 13 is removed from the apparatus by the condensate drain 14.

2. Technological calculation.

The task of calculation: to determine the geometric dimensions of the steamer housing (Fig. 2), sluice gates (Fig. 3) and the speed of rotation of the blade auger.

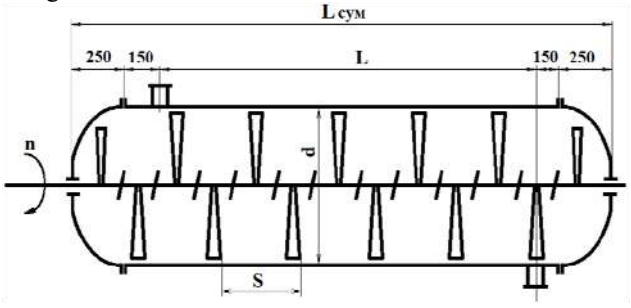

Fig. 2. Steamer's auger body and blade

Data for calculation:

productivity Q= 5 *t/h* =5000 *kg/h*;

body diameter d=*1000mm* ;

maximum and minimum steamer exposure:

t_{max}=*6 min*; t_{min}=*1 min*;

the unloading sluice gate should have productivity on 20% more than loading.

Calculation conditions: volumetric mass of oats γ=500 *kg / m3.*

It is necessary to calculate the geometric dimensions of the body of the steamer and the speed of the blade auger:

The calculation of the volume of the device is on the lightest grain (oats) with a bulk density:

γ = 500 *kg/m3* and by calculating the steaming exposure t = 5 min.

$$V = \frac{Q}{\gamma} \cdot t = \frac{5000}{500} \cdot \frac{5}{60} = 0,835 \ m^3, \quad (1)$$

Taking the filling factor of the vane auger ψ = 0.4 we find the total volume of the housing

$$V_1 = \frac{V}{\psi} = \frac{0,835}{0,4} = 2,1 \ m^3, \quad (2)$$

When the diameter of the body d = 1000mm determine the cross-sectional area of the body

$$F = 0,785 \cdot d^2 = 0,785 \cdot 1^2 = 0,785 \ m^2, \quad (3)$$

The length of the steamer housing from the loading to the unloading pipe

$$L = \frac{V_1}{F} = \frac{2,1}{0,785} = 2,630 \ m = 2680 \ mm, \quad (4)$$

The size of the case taking into account elliptical bottoms (250 mm) and distance from the center of branch pipes to edge of a shell (150 mm), will make:

$$L_{сум} = 2680 + 2 \cdot 250 + 2 \cdot 150 = 3480 \ mm. \quad (5)$$

Determining the parameters of the blade auger

The maximum allowable number of revolutions of the auger

$$n_{max} = \frac{A}{\sqrt{D}} = \frac{65}{\sqrt{1}} = 65 \ r/min, \quad (6)$$

where A=*65* – coefficient for grain; D=*1m* – screw diameter.

The maximum number of revolutions should be at the minimum exposure.

Based on the minimum exposure t_{min}=1 min (60 s), with the length of the steaming section from the loading to the unloading pipe L = 2680 mm, the speed of movement of the material should be

$$v = \frac{L}{t_{min}} = \frac{2,68}{60} = 0,045 \ m/s, \quad (7)$$

The auger must have the maximum speed.

We accept n_{max}=*60 r/min* або *1 r/s.*

From here we determine the pitch of the auger. In one turn, the auger must move the material by 1 step, ie S'=*0,045 m*.

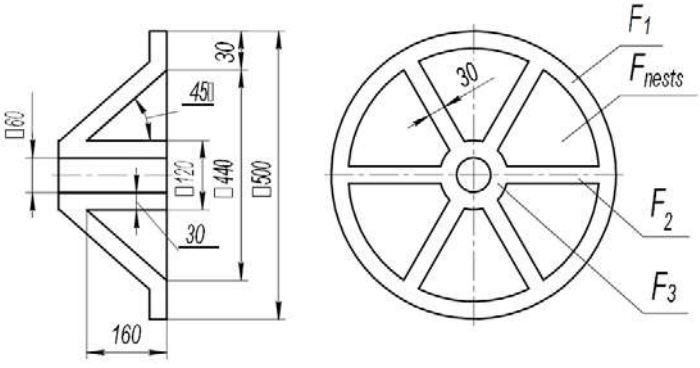

Fig. 3. Sluice gate

For advancement and hashing of the steaming product we accept the blade screw recommended for movement and hashing of sticky products.

Preliminarily, we take the ratio of the area of the vane auger and the area of the solid auger φ = 0.25. Then to maintain the productivity of the auger increase in accordance with the reduction of the area of his step

$$S = \frac{S'}{\varphi} = \frac{0,045}{0,25} = 180\ mm. \quad (8)$$

Increase the step to *S = 280 mm* and get *φ=0,045/0,28=0,161.*

The minimum number of turns of the auger is determined from the ratio of exposures

$$n_{min} = \frac{n_{v.max}}{\frac{n_{max}}{t_{min}}} = \frac{60}{\frac{60}{1}} = 10\ r/min \quad (9)$$

Calculation of the geometric dimensions of the rotors of the sluice gates and their speed:

To supply grain to the working chamber under pressure and unload it, we use sluice gates (Fig. 3) with a flat sealing surface and a fluoroplastic gasket. This design allows the most effective sealing of the working chamber under pressure and to maintain the working pressure within the specified limits, with continuous loading and unloading of the device.

Concerned in advance with the diameter of the rotor of the sluice gate 500 mm, the angle of the cone 450, the number of cells n = 6 and the minimum width of the sealing surfaces of 30 mm determine the capacity of the rotor.

The rotor capacity is calculated as the volume of the truncated cone minus the volume of the hub and partitions h

$$V_{tr.c.} = \frac{1}{12} \cdot \pi \cdot h \cdot (D^2 + D \cdot d + d^2), \quad (10)$$

$$V_{tr.c.} = \frac{1}{12} \cdot 3,14 \cdot 16 \cdot (44^2 + 44 \cdot 12 + 12^2) = 10900\ cm^3 = 10,9\ l.$$

$$V_{cyl.} = \frac{\pi \cdot d^2 \cdot h}{4} = \frac{3,14 \cdot 12^2 \cdot 16}{4} = 1800\ cm^3 = 1,8\ l., \quad (11)$$

$$V_{partitions} = \frac{1}{2} \cdot \left(\frac{D-d}{2}\right) \cdot h \cdot b \cdot n = \frac{1}{2} \cdot \left(\frac{44-12}{2}\right) \cdot 16 \cdot 3 \cdot 6 = 2,3l. \quad (12)$$

Total cell capacity:

$$\sum V = V_{tr.c.} - (V_{cyl.} + V_{partitions}) = 10,9 - (1,8 + 2,3) = 6,8\ l. \quad (13)$$

Based on the productivity of the gateway *Q = 5000 kg / h* for grain with a bulk density *γ = 500 kg / m3 = 0.5 kg / liter,* determine the speed of the loading sluice gate taking into account the cell fill factor *φ=0,8*

$$n_{loa.} = \frac{Q}{\varphi \cdot \sum V \cdot \gamma \cdot 60} = \frac{5000}{0,8 \cdot 6 \cdot 0,8 \cdot 60} = 30,7\ r/min. \quad (14)$$

Since the unloading sluice gate must have a capacity of 20% more than the loading then its speed will be

$$n_{unl.} = 30,7 + \frac{30,7 \cdot 20}{100} = 36,84\ r/min.$$

Conclusion from the calculation:

The length of the body of the steamer from the loading to the unloading pipe L = 2680 mm; the size of the case taking into account elliptical bottoms and distance from the center of branch pipes to edge of a shell Lsum. = 3480 mm; case diameter d = 1000 mm; screw pitch S = 280 mm; the maximum speed of rotation of the blade auger n_{max}*=60 r/min*; the minimum speed of rotation of the blade auger n_{min}*=10 r/min*;

the rotor speed of the loading sluice gate $n_{loa.}$*=30,7 r/min*;

rotor speed of the unloading sluice gate $n_{uol.}$*=36,84 r/min.*

3. Description of the kinematic scheme of the machine.

The task of calculation: to determine the kinematic parameters of the drive of the machine.

Data for calculation:

- the maximum speed of rotation of the blade auger n_{max}*=60 r/min*;
- the minimum speed of rotation of the blade auger n_{min}*=10 r/min*;
- the rotor speed of the loading sluice gate $n_{loa.}$*=30,7 r/min*;
- rotor speed of the unloading sluice gate $n_{uol.}$*=36,84 r/min.*

Terms of calculation:

the rotational speed of the rotor of the electric motor of the blade auger drive $n_{дв.ш}$=1460 *r/min*; the rotational speed of the rotor of the motor of the feeder drive $n_{дв.п}$=960 *r/min*; speed of rotor of the electric motor of the drive of the unloader $n_{дв.р}$=960 *r/min*;

In the drive of the vane screw we use a variator of the VC type with an initial speed $n_{в.\ min}$*= 300 r/min;* $n_{в.\ max}$ *=1800 r/min.*

4. Kinematic calculation.

To obtain the required speed on the auger shaft, we use a reducer of the RCD type with a gear ratio of ip = 31.5.

Determine the gear ratio of the chain drive

$$i_c = \frac{n_{v.min}}{n_{min} i_p} = \frac{300}{10 \cdot 31,5} = 0,952, \quad (15)$$

$$i_c = \frac{n_{v.max}}{n_{max} i_p} = \frac{1800}{60 \cdot 31,5} = 0,952. \quad (16)$$

We accept a chain with a step t = 38,1 mm and the number of teeth of the leading star Z1 = 25, then the number of teeth of the driven star will be

$$Z_2 = Z_1 \cdot i_c = 25 \cdot 0,952 = 23. \quad (17)$$

Specify the speed of the auger shaft

$$n_{min} = \frac{n_{v.min}}{i_c i_p} = \frac{300}{0,952 \cdot 31,5} = 10\ r/min. \quad (18)$$

$$n_{max} = \frac{n_{v.max}}{i_c i_p} = \frac{1800}{0,952 \cdot 31,5} = 60\ r/min. \quad (19)$$

The feeder is driven by an electric motor with a rotational speed $n_{en.n}$=960 *r/min*. To obtain the required speed on the feeder shaft, we use a reducer of the RCD type with a gear ratio of ip = 31.5.

Specify the speed of the feeder

$$n_{loa.} = \frac{n_{en.n}}{i_p} = \frac{960}{31,5} = 30,4\ r/min.$$

The feeder is driven by an electric motor with a rotational speed

$n_{дв.р}$=960 *r/min*. Since the unloader must have a capacity of 20% more than the feeder, we use a reducer type RCD with a gear ratio of ip = 25.

Specify the speed of the unloader

$$n_{unl.} = \frac{n_{en.n.}}{i_p} = \frac{960}{25} = 38{,}4\ r/min.$$

Conclusion from the calculation:

The blade auger is driven by an electric motor with a rotational speed

$n_{en.n}$ =1460 *r/min*, through a variator of the VC type with an initial speed $n_{v.\,min}$= *300 r/min;* $n_{v.\,max}$ =*1800 r/min* with the control range 6, through a reducer of the RCD type with a gear ratio ip = 31.5 and a chain drive with a gear ratio ic = 0.952 (the number of teeth of the chain drive Z1 = 25; Z2 = 23).

The feeder is driven by an electric motor with a rotational speed $n_{en\,n}$=960 *r/min*, through a reducer of the RCD type with a gear ratio i_p=*31,5*.

The unloader is driven by an electric motor with a rotational speed $n_{en\ n}$=960 *r/min*, through a reducer of RCD type with a gear ratio of ip = 25.

Maximum blade speed n_{max}=*60 r/min*;

Minimum blade speed n_{min}=*10 r/min*;

Frequency of rotation of a rotor of a loading sluice gate $n_{loa.}$=*30,4 r/min*;

Frequency of rotation of the rotor of the unloading sluice gate n_{unl} =*38,4 r/min.*

Thus, the calculations show the feasibility and efficiency of modernization of the steamer by ensuring the tightness of the unloader and the uniformity of the speed of the product processed in the working chamber by using a two-stage gearbox or drive motor with frequency converter.

REFERENCES

1. *Technological equipment predpriyatiy otryasli (grain processing enterprises): учебник /L.A. Glebov, A.B. Demsky, VF Vedenev and others - M .: DeLi print, 2006, -816p.*
2. *Technological equipment of flour and cereal enterprises: a textbook / O.I.Gaponyuk, L.S. Soldatenko, LG Grosul et al. - Kherson: Oldi-plus, 2018. - 752p.*

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МОДЕРНІЗАЦІЯ МАШИНИ ДЛЯ ГІДРОТЕРМІЧНОЇ ОБРОБКИ ЗЕРНА

Анотація

Мета гідротермічної обробки зерна - зміна його вихідних технологічних властивостей у напрямку стабілізації та підтримці їх на оптимальному рівні для подальшого процесу переробки його в кінцеву продукцію - борошно чи крупу. Застосування апаратів безперервної дії дозволяє процес пропарювання стати більш ефективним, при цьому, гідротермічна обробка займає особливе місце в технології переробки круп'яних культур, отримання ними високих споживчих властивостей. Аналіз конструкцій апаратів безперервної дії, показує, що найбільшого поширення мають апарати горизонтального типу де основний робочий орган пропарювача має функції транспортування і перемішування. Така конструкція дозволяє досягти рівномірності пропарювання за час обробки продукту. Для досягнення гнучкої зміни експозиції пропарювання пропонується в складі приводу робочого органу ввести двоступінчастий варіатор, який дозволить суттєво змінювати час пропарювання і застосовувати апарат для пропарювання більш різних культур, а для забезпечення постійного заданого тиску пари в апараті пропонується для завантаження і вивантаження апарату застосовувати шлюзові затвори, конструкція яких дозволяє виробляти ці операції без втрат тиску. При двоступінчастому виконанні варіатора обертання від його ведучого валу за допомогою клинового ременя передається проміжному валу, а від нього за допомогою додаткового клинового ременя – основному робочому валу. Регулювання передавального відношення здійснюється при повороті склянок і їх синхронному зсуві в осьовому напрямку. При цьому відбувається одночасне переміщення рухомих конічних дисків, переклад клинового ременя і додаткового клинового ременя на інші діаметри.Для подачі зерна у робочу камеру під тиском і розвантаження його застосовуємо шлюзові затвори з плоскою ущільнюючою поверхнею і прокладкою із фторопласта. Така конструкція дозволяє найбільш ефективно герметизувати робочу камеру під тиском і забезпечити підтримку робочого тиску в заданих межах, при безперервному завантаженні та розвантаженні апарату. Проведені розрахунки показують доцільність і ефективність модернізації пропарювача за рахунок забезпечення герметичності роботи розвантажувача і рівномірності швидкості руху продукту, що обробляється в робочій камері, шляхом застосування двоступінчастого редуктора або приводного електродвигуна з частотним перетворювачем.

Ключови слова: гідротермічна обробка, зерно, крупа, пропарювання, розрахунок, розвантажувач

ЛІТЕРАТУРА

1. *Технологическое оборудование предприятий отрясли (зерноперерабатывающие предприятия): учебник / Л.А. Глебов, А.Б. Демский, В.Ф.Веденев и др.- М.: ДеЛи принт, 2006,-816с.*
2. *Технологічне обладнання борошномельних і круп'яних підприємств : підручник / О.І. Гапонюк, Л.С. Солдатенко, Л.Г. Гросул и др. – Херсон : Олді-плюс, 2018. – 752с.*

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ФАКУЛЬТЕТ
ТЕХНОЛОГІЇ ЗЕРНА І ЗЕРНОВОГО БІЗНЕСУ

ХАРЧОВІ ТЕХНОЛОГІЇ

Освітні програми:

- Технології та управління зерновим бізнесом;
- Технологія зберігання зерна та елеваторний бізнес;
- Технології та управління кормовим бізнесом;
- Технології та управління хлібопекарним і кондитерським бізнесом.

ПІДПРИЄМНИЦТВО, ТОРГІВЛЯ ТА БІРЖОВА ДІЯЛЬНІСТЬ

Освітня програма:

- Міжнародна торгівля зерном;

ГАЛУЗЕВЕ МАШИНОБУДУВАННЯ

Освітня програма:

- ІТ конструювання та обслуговування обладнання (Зернопереробної галузі).

Працевлаштування:

- Керівниками харчових та зернових підприємств (елеваторів, борошномельних, круп'яних, комбікормових заводів, кондитерських фабрик, хлібозаводів);
- Керівниками агропромислових підприємств;
- Керівниками машинобудівних заводів, комерційних структур технічного сервісу;
- Керівниками торгівельних, зерноторгівельних компаній та їх підрозділів;
- Керівниками підприємств малого бізнесу;
- Керівниками біржових структур та їх підрозділів;
- Фахівцями-аналітиками з дослідження товарних ринків і бірж;
- Технологами, головними інженерами, завідуючими лабораторіями, менеджерами з якості;
- Брокерами на товарних біржах;
- Фахівцями з логістики;
- Експертами з зовнішньоекономічних питань;
- Експертами з оцінки та прогнозування діяльності зерноторгівельних підприємств та ін.

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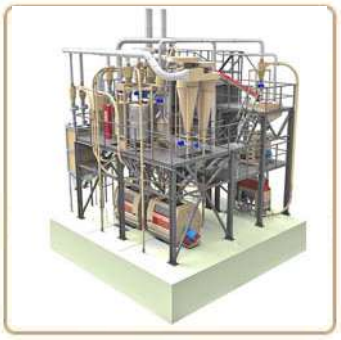
ЗЕРНООЧИСТНЕ ОБЛАДНАННЯ

ТЕХНОЛОГІЧНЕ

ЛАБОРАТОРНЕ

ЗЕРНООЧИСНІ КОМПЛЕКСИ

КРУПОЗАВОДИ



МЛИНИ

ТРАНСПОРТНЕ

АСПІРАЦІЙНЕ

САМОПЛИННЕ

16
РОКІВ ДОСВІДУ РОЗРОБОК І ВПРОВАДЖЕННЯ

200
НАЙМЕНУВАНЬ УСТАТКУВАННЯ, ЩО ВИПУСКАЄТЬСЯ

3000
ПРАЦЮЮЧИХ ВИРОБНИЦТВ У СВІТІ