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Study of Barley Grain Processing by Steam Pressure and Ultra-High Frequency Drying

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Abstract: In this study, a modern, energy-efficient, and resource-saving technology for the production of early-ripening cereals from the grain of the local barley variety "Istak" was developed. Analysis of the main nutrients, vitamins, minerals, and amino acids in the grain showed that the "Istak" variety has high biological value. Compared to wheat, it is characterized by the predominance of the amino acids trionine, silicon, and niacin. In the technological process, the grain was subjected to steam treatment at a pressure of 0.3 MPa with subsequent microwave drying at a frequency of 2.45 GHz and a power of 600 W/kg. Thanks to this, 84.2% of early-maturing cereals were obtained in the product composition, microbiological safety was ensured, and energy consumption was reduced by 3 times compared to the traditional method. It has been shown that the energy consumption in the proposed technology is 0.7 kW/h, which is significantly more efficient than the traditional method. This process ensures the microbiological safety of the product and allows for the preservation of nutrients. Based on the research results, the effectiveness of this technological method in processing local barley has been proven, and thanks to its implementation in practice, the possibility of providing the population with high-quality, energy-rich, and biologically rich early-ripening products has been created.

Keywords: Barley grain, instant cereal, "Istak" barley variety, microwave drying, steam processing, nutritional value, mineral substances, amino acids, energy efficiency, microbiological safety.

Introduction:

The process of rapidly preparing groats from barley grain is one of the important directions of research aimed at efficient use of plant resources. From this point of view, the conducted research on obtaining special flour and cereals from barley not only contributes to increasing the efficiency of its industrial production, but also opens up new prospects in the field of functional nutrition aimed at organizing special nutritional diets.

When processing barley grain, it is important to isolate optimal components for special food rations. For this purpose, based on the study and analysis of the chemical composition of barley grain, a number of substances with functional properties have been identified. The important properties of the identified substances for human health have also been scientifically substantiated.

Barley stems and grains are mainly used for fodder purposes for livestock. It should be noted that due to today's ecologically unfavorable climatic conditions, the decrease or loss of yields of fodder grain crops grown on irrigated lands requires efficient use of existing raw material sources.

METHODS

The organoleptic indicators of barley flour were studied based on GOST 26574-85. Its moisture content was determined by GOST 13586.5-93, and the protein content by the Kjeldahl method, in accordance with GOST 10846-91. The oil content was assessed according to GOST 29033-91 using the Sokhlet extraction method, and the water content was assessed according to GOST 9404-88 by drying at 105°C.

The amount of dietary fiber was studied according to GOST 31675-2012. The total nutritional value (caloric value) was determined by calculation method based on 4 kcal per 1 g of protein and carbohydrates, 9 kcal per 1 g of fat.

RESULTS AND DISCUSSIONS

For the purpose of using barley grain for food purposes, the autumn grain varieties listed in the state register: "Noyob" and "Istak" varieties were studied. As a result, an analysis of the functional composition of grain, which is important for the human body, was carried out, and it was substantiated that the "Istak" variety is the optimal variety of barley for drought resistance compared to the "Noyob" variety, and to obtain quick flour and groats, the physicochemical, technological, and biochemical properties of this grain variety were studied.

Table 1

Chemical composition and nutritional value of the "Noyob" and "Istak" varieties of barley grain (100 g).

Composition	Istak	Rare
Proteins. gr	10,3	9,2
Fats. gr	2,4	2,0
Carbohydrates. gr	56,4	51,2
Water gr.	14,0	14,0
Food fibers. gr	14,5	15,1
Nutritional value. Kcal	288	271

According to the analysis of Table 1, the superior "Istak" variety of barley in terms of nutritional value was selected as the optimal variety for the research object and its nutritional composition was substantiated.

Barley groats are a difficult-to-flow and brittle product, steam-pressure treatment is considered effective, the upper shell of barley grain under steam pressure becomes soft, elastic, and does not crumble when pressed on smooth rollers.

Using steam directly in the groat production processes in the proposed technology is advisable for optimizing energy-intensive stages such as bleaching, shell separation, and grinding.

Therefore, it is not advisable to obtain early-ripening groats from barley grain from bleached barley, as this leads to the formation of large quantities of grain and flour shards, which negatively affects the quality and cost of the finished product. We aimed to carry out the processes of processing barley grain grown in local conditions based on the sequence shown in Figure 1.

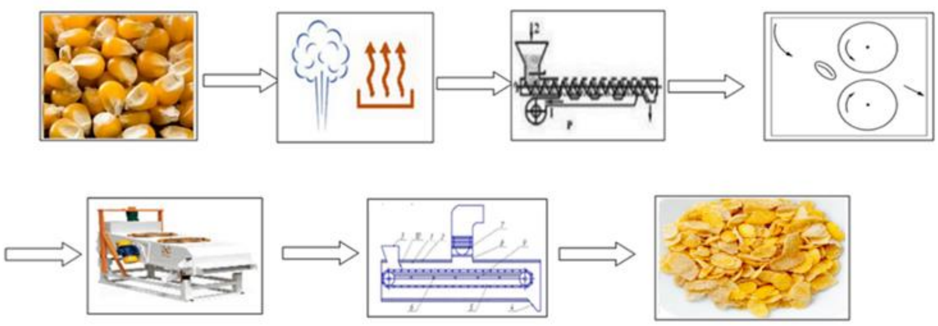


Figure 1. Block diagram of the proposed barley grain processing process

The pre-cleaned barley grain was processed in a vortex moisturizing unit at a steam pressure of 0.3 MPa for 5 minutes to facilitate separation of the husk and reduce the firing stage time, and then directed to the firing stage.

After this, it was standardized to obtain grains with the following parameters. In this case, the barley grain was given a moisture content of 26% and simmered for 14 hours.

Then it was processed at a steam pressure of 0.3 MPa for 10 minutes. The barley grain exiting the evaporation chamber was dried to a moisture content of 18%.

After removing up to 10% of barley grain shells with softened shells that have not lost core strength but have reduced brittleness (plasticized), the mixture was directed for crushing on smooth rollers with a rotation speed ratio of 1:1 and an interval of 0.2 mm.

The resulting grain was dried to a moisture content of 10-11% and standardized by sorting in a control separator.

The quality indicators of early-ripening barley grain obtained using the proposed new method were determined.

Evaporation moistens and heats the grain, plasticizes the kernel, makes it less brittle, and minimizes grinding during hulling and grinding. Plasticization of the nucleus also occurs as a result of some chemical changes: for example, part of the starch gelatinizes, forming a small number of dextrins with adhesive properties.

Drying after evaporation largely dehydrates the outer membranes, which lose moisture, become more brittle, and are easier to remove during the separation process. Additionally, deformation changes occurring in grain components during evaporation and drying lead to shell movement. Furthermore, drying the grain led to a decrease in the number of adhering shells during grinding.

In the pieces of grain obtained using the proposed new technological method, the following indicators were determined: the yield of large-fraction grain pieces was determined by the amount passed through a 4.5 mm sieve. The yield of grain and flour fragments during the production process was determined by the number of particles that passed through the sieve on a 3 mm sieve.

In the proposed new method, in the technological process of obtaining early-ripening groats from the "Istak" variety of barley grain, the grain was pre-moistened to a moisture content of 26% and processed at a steam pressure of 0.3 MPa for 10 minutes, and then the groats were obtained by pressing to a thickness of 2 mm on a two-shaft machine. After this, drying was carried out on a microwave installation with a power of 600 W/kg, a frequency of 2.45 GHz for 2 minutes to a moisture content of 10-15%. In the composition of the obtained product, the proportion of coarse, early-ripening grains was 84.2%, fine-grained grains - 5.8%, and shells formed during bleaching - 10%.

When conducting experiments, the total amount of electricity consumed to obtain 1 kg of early grain was 0.07 kW/h. This indicator demonstrates the energy efficiency of the technological process and confirms the optimality of the modern UHF drying method compared to traditional methods, the results are presented in Table 2 below.

Table 2.

Selected modes and parameters for the proposed new method of rapidly preparing groats from the Istak barley variety.

Grain name	Given humidity in GTI %	Steam pressure and processing time, MPa/min.	UHF 600 W/kg/min drying GHz/min	Amount of separated shell, %	Quantity of early grain, %	Amount of received efective grain, %	Energy consumption for obtaining 1 kg of grain, kW/h
Barley	26	0,3/10	2,45/2	10	84,2	5,8	0,7

According to the analysis of Table 3.1.6, in the technological process of obtaining early-ripening groats from barley grain using the traditional method, the grains were pre-moistened to a moisture content of 26% and processed at a steam pressure of 0.3 MPa for 10 minutes, and the groats were formed by pressing to a thickness of 2 mm on a two-shaft machine.

After this, an infrared drying of 2.5 µm at 3 kV/h was carried out, drying to a moisture content of 10-11% for 10 minutes. In the composition of the obtained product, the share of large early-ripening panicle was 72.0%, fine-grained panicle - 20%, and shells formed during bleaching - 8%.

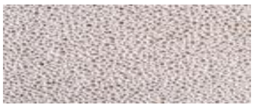
When conducting experiments, the total amount of electricity consumed to obtain 1 kg of early grain was 2 kW/h. This indicator justifies the optimality of the microwave drying method compared to traditional methods due to the high energy consumption of the technological process. Table 3.1.3.

According to the analysis of Table 3.1.7, the optimal drying frequency at ultra-high frequency and at 2.45 GHz for 120 seconds was determined, and it was established that the optimal electrical energy voltage is 600 watts per 1 kg of product. In this case, the influence of the established parameters of microwave drying on nutrients and the microbiological activity of the product was taken into account.

At the same time, during the steaming process under 0.3 MPa pressure, the temperature in the chamber reached 140-145°C, which, in turn, leads to almost complete disinfection of the finished product. The thermal temperature of the steam supplied over a short period of time does not significantly affect the nutrients, as it is carried out in a humid environment. Optimal parameters of microwave drying are also substantiated in practical experiments based on the theoretical data presented above.

Table 3.

Research on the selection of optimal parameters of the microwave drying method in the production of instant cereals.

Parameters	Example 1	Example 2	Example 3
Microwave frequency. GHz	3,0	2.65	2.45
Power density. W/g	1.5–6	1.5–6	1.5–6
Validity period. sec.	30–120	30–120	30–120
Temperature range. °C	80–120	80–120	80–120
Initial humidity (%)	26	26	26
Actual humidity (%)	4–5	7–8	10–11
Degree of reduction of microbes. 105 times, that is, a decrease of 100,000 times, survived by 0.001%.	$> 10^5$	$> 10^5$	$> 10^5$
Optimal porosity capacity (W/kg)	800	700	600
Porosity of early-ripening barley (g/cm3)	**600–700** 	**550–720** 	**600–650** 

The chosen microwave drying method for rapidly cooking grains, unlike other drying methods, also effectively affects the porous texture and microbiological activity of the product.

The following table shows the indicators of microbiological activity.

Table 4

Microbiological indicators of early cereals obtained during the drying process

Sample	Microbiological indicators					
	Determined forms of microorganisms					
	KMAFANM (Mesophilic aerobic and facultative anaerobic microorganisms) COE/gram		coliform bacteria group COE/gram		Yeast and mold fungi COE/gram	
	Fact.	Norm	Fact.	Norm	Fact.	Norm
Grain moisture content, up to 11-12%	Not detected	1×10^4	in 1 gram of product nothing found	in 1 gram of product not allowed	in 1 gram of product nothing found	Yeast 10. Mold 50.

Analysis of Table 4 shows the absence of general mesophilic aerobic and facultative anaerobic microorganisms in food products. This indicator is important when assessing the degree of microbiological contamination of the product.

COE/g (colony-forming unit/gram) is taken as the unit of measurement. CFU/g indicates how many colonies of living microorganisms are present in each gram of the product.

These indicators are the main criteria for determining the safety, quality, and shelf life of products. When barley grain was processed at a steam pressure of 0.3 MPa for 10 minutes and dried at an ultra-high frequency (600 W/2.45 GHz), the highest quality grains were obtained. Based on the obtained effective results, a new technology for obtaining early-ripening barley groats has been developed.

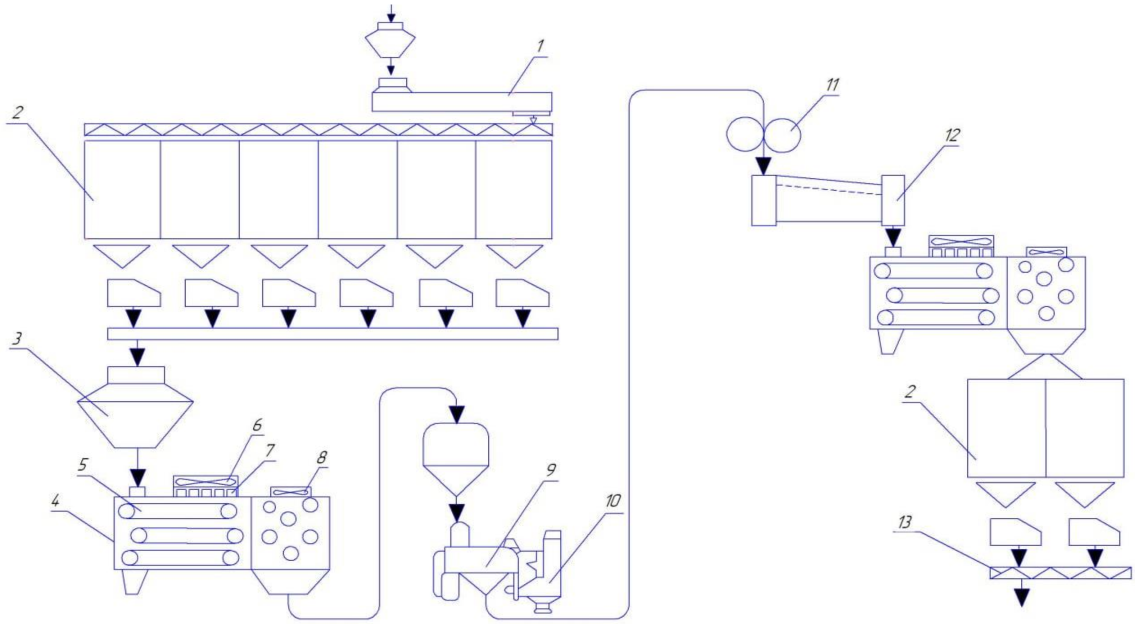


Figure 2. Technological scheme for obtaining quick-prepared groats from barley grain.

1-moistening apparatus, 2-tamps, 3-evaporator, 4-first-stage microwave drying unit, 5-kapron mesh conveyor, 6-ventilator, 7-magnetic tap, 8-cooler, 9-whitening equipment, 10-separator, roller machine, 12-separator, 13-finished product conveyor.

CONCLUSION

As a result of the conducted research, a new, efficient, and energy-saving technology for obtaining early-ripening barley grain from the "Istak" barley variety has been developed. During the research, the chemical, biochemical, and physico-technological properties of the barley grain were thoroughly studied, particularly revealing that this variety is rich in high nutritional value, valuable functional substances, vitamins, and minerals.

In the new technology, barley grain was pre-treated with steam under 0.3 MPa pressure, which ensured softening of the husk, plasticization of the kernel, and reduced grinding. After this, the grain was dried in an SVC (super high-frequency) unit at a power of 600 W/kg at a frequency of 2.45 GHz for 2 minutes. This method allowed for the extraction of 84.2% of large-fractional early-ripening grain, 5.8% of small-fractional grain, and 10% of shell.

Compared to traditional drying methods, the energy consumption for obtaining 1 kg of grain in the new method is only 0.07 kW/h, which indicates the high efficiency of the technological process. Drying fully ensured the microbial safety of the product and did not negatively affect the nutrients.

The microbiological analysis results showed the absence of KMAFANM, BGKP, yeast, and mold fungi. This is an important factor in ensuring the quality, safety, and shelf life of products.

Based on the obtained results, a new technological scheme for producing early-ripening groats from barley grain has been developed and recommended for implementation in production. This approach allows for the production of food products with high biological value based on local raw materials.

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