Technological innovations in bread production in the Arctic

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Abstract. The conditions and factors determining the need to develop technological innovations for food production in the Arctic zone of the Russian Federation are considered. An innovative technology of separated cleaning and electro-hydraulic grinding of grains, electrocontact baking of bread and bakery products is proposed. The composition and principles of the combined device for grinding grain and bread production are disclosed. The principles of technological operations using technological equipment for the production of whole grain bread are formed. The directions of further research on food production, optimizing food storage are determined and recommendations are given on the food supply of the population in remote areas, as well as in emergency situations, natural disasters, and in quarantine conditions.

1. Introduction
Reducing the level of reserves of natural resources and, above all, hydrocarbon raw materials in many countries of the world requires the development of new oil and gas fields. In this regard, the problems of searching and developing sources of raw materials in the Arctic zone become very relevant. However, despite the large hydrocarbon reserves on the Arctic shelf, their production is complicated by difficult environmental and climatic conditions and the lack of infrastructure for carrying out prospecting, exploration and development of oil and gas fields. Along with the lack of transport communications, the complexity of organizing life support systems, the task of food support for the work of search parties, exploration parties, and shift teams is not unimportant. Based on this, the organization of work requires the justification of food security measures involved in the development of new deposits of small groups of specialists acting independently.

2. Problem statement
In this case, the common problems are the development of individual diets, food production technologies in the difficult climatic conditions of the Arctic, ways of storing and transporting food and source components. Innovative activity in this direction should be aimed at the development of whole grain bakery products, as well as devices for their production at low temperatures. This is due to the fact that bakery products are an essential component in the daily diet and make up 35–40% of its calorie content. In addition, bread and bakery products belong to food products with short shelf life, which does not allow to create their stocks with delivery from bakeries to the mainland [1].
3. Materials and methods

The technology of separated cleaning and electro-hydraulic grinding of grains, electrical contact baking of bread and bakery products is proposed for the production of bread and bakery products [2].

The essence of the technology is to use the physical effect of ultrasonic treatment of water, grain, yeast suspension, electro-hydraulic grinding of grain and mixing the ingredients under thermostatic pressure and vibration. The technology is based on the methods of separated grain cleaning from impurities, its electrohydraulic grinding and electrical contact baking of bread and bakery products at low ambient temperatures. This provides a number of advantages over traditional bread production technology.

Firstly, when using whole grain as an initial component, the process of transportation and storage of raw materials is greatly simplified. With this method, it is not necessary to create special conditions for the storage and transportation of flour.

Secondly, the application of the physical principles of electrohydraulic shock for grain grinding directly in the process of bread production eliminates the cost of creating, maintaining and operating technological equipment for the production of flour.

Thirdly, the proposed technology is based on the use of the physical effect of ultrasonic water treatment, as well as electro-hydraulic mixing of the ingredients under thermostatic pressure and vibration, which allows to accelerate the production of bread and bakery products.

To implement this technology, compact technological equipment has been developed - a combined device for grinding grain and bread production (CDGG). A schematic diagram of the device is shown in figure 1 [3].

![Figure 1](image)

**Figure 1.** Combined device for grinding grain and bread production: 1 - water tank; 2 - grain hopper; 3 - separator; 4 - saline dispenser; 5 - yeast suspension doser; 6 - container; 7 - sieve; 8 - aperture; 9 - mixer; 10 - technological pipe; 11 - thermostat; 12 - electrotenes; 13 - grinding chamber; 14 - electric discharge tube; 15 - slide; 16 - electric contact heater; 17 - knife; 18 - packaging machine; 19 - case; 20 - electrode; 21 - container for water; 22 - wire; 23 - electric generator; 24 - source of pulse voltage.

The operation of the combined device is based on the use of physical principles of forced grain segregation for cleaning it, followed by electro-hydraulic grinding in order to obtain pulp. Subsequently, turbulent kneading, mixing of the ingredients and electrical contact baking are performed. Figure 2 shows the principles and procedures for the use of SURF in the proposed technology.
Figure 2. Principles of performing technological operations using CDGG.

CDGG kit allows you to implement the following processes: aerohydrotreating of grain and its processing by infrared radiation; electro-hydraulic grinding of grain; pulsating progress of the dough inside the process pipe and mixing it with the ingredients; fermentation in the process of multifactor intensifying effect of vibration; electrocontact bread baking; slicing bread products with a vibrating knife and packing them in shrink film [8-10]. The schematic diagram of the combined device for grinding grain and bread production CDGG is presented in Figure 3.

Combining the processes of grain grinding and the direct production of bakery products in one device based on the use of physical principles of forced grain segregation for cleaning it with subsequent electrohydraulic grinding, as well as turbulent mixing and mixing of ingredients and electrical contact baking, allows for insignificant mass-dimensional characteristics (weight 0.3 t, volume 1.5 m³) and sufficiently low power consumption for the operation of the proposed device. At the same time, CDGG can be used both in stationary dining rooms and small-sized mini-bakeries, and in the field. The device can operate in semi-automatic mode, is easy to maintain and economical in energy consumption (up to 6 kW).

The method of cleaning grain needs clarification. Grain cleaning is carried out in an electrostatic separator, the work of which is reduced to forced segregation of whole grain. Subsequently, the grain is processed by infrared radiation, which can significantly improve the quality and microbiological parameters of bakery products with a high content of dietary fiber. When a high voltage is applied between the central electrode and the cylinder through which the grain enters, electrostatic forces arise that easily separate the husk, shells, flakes, dust, feeble weed seeds and the whole grain, since the latter is 3-10 times heavier and is not delayed by the separator. Preliminary infrared processing of grain before crushing regulates the activity of amylolytic enzymes, stabilizes the rheological properties of dough semi-finished products and improves the quality of grain bread [4-7].
The process of grinding grain is uniform, which is unattainable with mechanical grinding. The duration of the pulse (exposure) supplied by the source of the pulse voltage at each microexplosion corresponds to 10–100 μs, the shear strain rate of the material reaches 300 m / s and more, the pressure in the grinding chamber must be regulated over a wide range from tens of kg / cm2 to 1000 kg / cm2 and more. The grain, colliding between itself and the walls of the grinding chamber, is converted into a flour pulp that is lighter in density. A significant portion of the shell cellulose is degraded to starch and sugars. This increases the nutritional value of bread products. With the arising pressures, microorganisms (bacteria, fungi) are destroyed, that is, the pulp is sterilized. It allows to use grain without washing and steaming. The absence of other types of fermentation and the increased amount of carbohydrates provide good conditions for the fermentation of baker's yeast in the dough. Pulsations in the dough accelerate their reproduction.

The pulsating pulp stream at the exit of the grinding chamber creates a periodic vacuum. This ensures a uniform supply of yeast suspension and saline. The pulsating dough sharply reduces its viscosity, providing the use of a static mixer of ingredients (yeast suspension, saline with the resulting pulp).

The fermented dough is continuously arriving into a multi-channel electrical contact heater, which is fixed at the second end of the process pipe, where bread is baked. Electrocontact baking of bread allows preserving biologically valuable substances of raw materials and preventing the formation of indigestible and dangerous compounds (polycyclic carbohydrates, in particular benzopyrene), typical for traditional radiation-convection baking. This effect is achieved due to the temperature regime of baking in the range from 94–95 °С, while with radiation-convection baking the temperature reaches 270 °C. To obtain a crispy crust at the outlet of the electric contact heater in a conductive way, the bread crust overheats with electrodes made of metal with high electrical resistance in a ceramic shell (metal bread does not touch).
The baked bread can be of any shape (square, rectangular, round or semicircular), depending on the shape of the pipe of the electric contact heater. Baking bread ranged from 3 to 10 minutes, depending on the salt content in the dough.

4. Results and discussion

The novelty of the technological solution consists in the fact that, compared to the existing ones, the technology allows to speed up the production process, improve quality, reduce the number of staff and energy consumption based on electromagnetic baking of bakery products, electro-hydraulic grinding of grain and technology of separated cleaning of impurities.

The practical significance of the technology is to ensure the preservation of the useful properties of grain in each technological operation of production, reduce the cost of transportation and storage of raw materials, reduce the number of units of technological equipment used and personnel, as well as the duration of the production of bakery products. The process of grinding grain is uniform, which is unachievable with mechanical grinding. A significant part of the cellulose of the shell is destroyed to starch and sugars, which increases the nutritional value of bread products and its whiteness. When pressure arises, microorganisms, spores and molds are destroyed, i.e. sterilization of the pulp occurs. This allows you to use the grain without washing and steaming. The absence of other types of fermentation and the increased amount of carbohydrates provide good conditions for yeast in the test, and pulsations in the test accelerate the reproduction of yeast.

5. Conclusion

Along with reducing the time spent on the production of bread and bakery products according to the proposed technology, their biological value is increasing, and the possibility of producing whole grain bread products at low temperatures is also ensured. The production of bread by the proposed method is characterized by low cost, high adaptability, which makes it possible to widely use this method in the food supply system of small groups of specialists in conditions of significant distance from stationary life support facilities in the Arctic zone.

The considered advantages of the proposed method indicate that further research should be aimed at developing methods for the production of canned and concentrated types of food for catering in the Far North and the Arctic zone; optimization of food storage, modernization of technical equipment at low temperatures, improvement of technological equipment for cooking, development of scientifically based recommendations on the introduction of new technical solutions in the food supply processes of the population in remote areas, as well as in emergency situations, natural disasters, quarantine measures.

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