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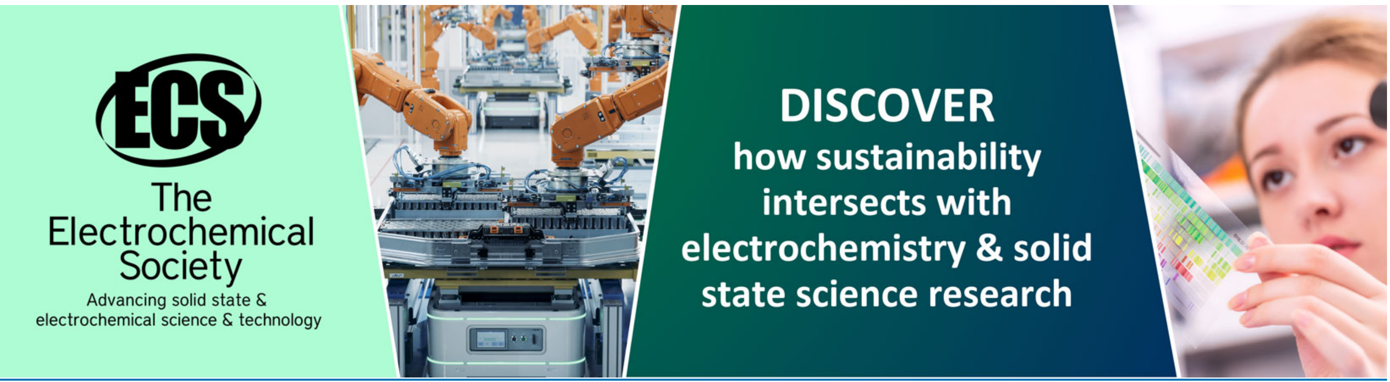

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Technology of grain dispersion in the production of flourless bread

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Abstract. The paper presents technical solutions aimed at increasing the efficiency of the technological process of dispersion of germinated wheat seeds by the method of gradual reduction of the size of grinding particles to the size determined by the technology for the production of flourless bread, and the wheat seeds supplied for dispersion do not undergo a technological operation to remove the fruit and seed shells. The author's resource-saving technology and a new developed highly efficient technological equipment are described, which provide for a multiple effect on germinated wheat seeds due to a step-by-step change in the working technological gap. The developed device consists of a variator connected by gears with movable plate-shaped rotors rotating at different angular speeds and having grinding elements installed in a staggered manner. The adjustable gap between the movable disc-shaped rotors is provided by centrifugal forces and changes in the impact force of the grain mass being crushed against the walls of the cylindrical body for final crushing and obtaining the required uniform particle size of the dispersed material. The comparison of the developed and existing technologies for grain dispersion showed that in modern technological machines that provide for multiple mechanical action of the working body on the grain, finely ground fractions with a low content of dietary fibre are formed. The developed technical means are intended to be introduced into the production schemes of bakery shops specializing in the production of high-quality products. It has been established that the use of the developed author's resource-saving technology for dispersing a grain mixture provides an increase in the total yield of a milled homogeneous grain mass with an increased yield of dietary fibre up to 92%, while using three connected successive grinding zones with rotary grinding elements provides a given fractional composition of the resulting homogeneous grain mass up to 97 %.

1. Introduction

Crops are the most important food source for humans. Since they are the main source of high-value vegetable protein and ballast substances vital for a rational human nutrition, namely dietary fibre.

Whole wheat grain consists of outer and fruit shells, aleurone and subaleuron layers (bran), starchy endosperm and embryo. The starchy endosperm of wheat makes up about 75–80% of the grain weight, while the contribution of germ and bran to the total weight can vary by grain and variety. As noted by [1], at present there is a steady decrease in the content of ballast substances in modern human nutrition, according to foreign and Russian scientific sources, it has been established that the daily intake of ballast substances is 10-15 g per person, but in reality, in modern food products their amount is understated to 1.3.

To increase the consumption of ballast substances, modern nutrition technologies provide for the widespread use of widespread whole grain products in the diet of the population, which contain unique phytochemicals, supplementing those found in fruits and vegetables when consumed together. There are various types of rye and wheat flour milling, which are mainly used for the preparation of bread and pastries [7].

According to existing technologies, flour used for the production of whole grain products is obtained from moistened grain by soaking the grain to maximum swelling until it loses its baking properties with an increased accumulation of active substances (vitamins, antioxidants, enzymes, macronutrients, trace elements, oligosaccharides), which makes it a very valuable raw material for food, pharmaceuticals, diets, etc. chemical composition of flour from different cereals [3].

To obtain whole grain mass in order to enrich bakery products with ballast substances, the process of grain dispersion is widely used, i.e., grinding it to a homogeneous mixture with a given degree of grinding of the ingredients.

According to [4], as a result of the use of the dispersion process, there is a significant decrease in the coefficient of internal friction and an increase in the specific surface area of the processed material during interaction, essentially creating gradients of the rates of internal deformations in the micro- and macro-volumes of the product. The water content greatly affects the mechanical properties of the wheat grain. Dry grains are brittle and easy to grind and require less energy to grind. An increase in water content causes an increase in the ductility of the core and more energy is required for grinding. However, changing the mechanical properties of the kernel by adding water is usually done by grinding the wheat grain. Moisturizing the kernel prior to grinding is essential and promotes endosperm breakdown, even if it makes the bran more resistant to breakdown. It was found that with a moisture content of wheat grain of 16-17%, the most optimal grinding mode is observed.

Modern equipment and technologies for grain dispersion provide for the mechanical action of the working body on the crushed grain with high energy consumption for the technological operation, while it is crushed into different fractions with the loss of dietary fibre in finely ground fractions [2].

2. Problem statement

It has been established that for a rational diet of a modern person, it is necessary to consume up to 15 g of dietary fibre per day per person, which is not provided by the consumed foodstuffs.

Whole grain products are the most promising, since during their production the grain is refined into a homogeneous mass rich in dietary fibre. To increase the norms of consumption of ballast substances due to the modernization of modern equipment and technology for grinding grain crops, it became necessary to develop new resource-saving technological equipment for grain processing enterprises.

3. Research questions

During the study, the following questions were considered:

- Determine the stages of dispersion;
- Develop the design of the dispersant to ensure uniformity of the output of the fractional mixture.

4. Purpose of the study

The scientific goal of this work was to develop a dispersant to ensure a uniform yield of dietary fiber in a homogeneous grain mixture by gradually reducing the fractional composition of the crushed mass.

Experimental work provides for the substantiation of the technical parameters of its operation under the conditions necessary to intensify the grinding of grain and increase the content of dietary fiber in a homogeneous grain mass.

5. Research methods

At the initial stage of research, a comparative analysis of existing and developed technologies for dispersing wheat grain was carried out to determine design differences and reveal the inefficiency of existing equipment. To increase the efficiency of the technological process of grain dispersion in the production of grain bread and the development of new equipment, the results of patent research carried out on the Russian and foreign information bases were used. The development of the prototype was carried out using modern means of mathematical and computer modelling of technological processes.

Tests of an experimental sample of resource-saving technology were carried out in the laboratory conditions of the Institute of Food Production on the basis of the normative documents "Tests of agricultural machinery. Test program and methods".

6. Findings

The disperser includes a cylindrical body 1 with loading 2 and unloading 3 nozzles, in which the upper disc-shaped rotor 4 with grinding elements 5 fixed on it and located with the convex part 6 upward, and the lower disc-shaped rotor 7 with fixed on it with grinding elements 8 and located with the convex part 9 downward. The disperser is equipped with a device 10 for changing the gap 11 between the rotors 4 and 7, the grinding elements 5 and 8 on the respective rotors 4 and 7 are staggered, and the shaft 12 of the rotor 4 and the shaft 13 of the rotor 7 are interconnected through the corresponding gears 14 and 15 by a variator 16. The shaft 13 of the rotor 7 is connected by the gear 17 to the drive motor 18. The rotor 4 is connected to the shaft 13 by rods 19.

The disperser works as follows. The material to be dispersed enters the device through the feed nozzle 2 and rods 19 into the cavity between the rotors 4 and 7. The rotating rods 19 pre-grind the material. Under the action of centrifugal forces, material particles move to the periphery of rotors 4 and 7 and enter the working area with grinding elements 5 and 8. The installation of the grinding elements 5 and 8 on the respective rotors 4 and 7 in a staggered manner excludes the exit of unprocessed material. The crushed material, after passing through the grinding elements 5 and 8, exits through the gap 11 between the rotors 4 and 7, rotating at different angular speeds, undergoing additional grinding. Adjusting the gap 11 between the rotors 4 and 7 by the device 10 allows you to obtain the desired degree of crushing. The material to be dispersed passes through the gap 11 under the action of centrifugal forces, which are greatest at the periphery of the rotors 4 and 7. Rotation of rotors 4 and 7 with different angular velocities, as well as the possibility of changing the ratio of these angular velocities by the variator 16, provide a high degree of dispersion due to the abrasion of material particles. When leaving the rotors 4 and 7, the material hits the walls of the cylindrical body 1 and is additionally crushed. The dispersed material leaves the housing 1 through the discharge nozzle 3. Thus, the material to be dispersed passes through four stages of dispersion with the possibility of adjusting this process. The kinematic diagram of the "dispersant" is shown in figure 1, the novelty of which is confirmed by the patent of the Russian Federation No. 2686213 [6].

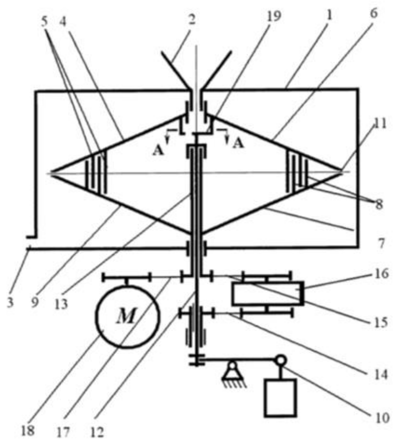

Figure 1. Kinematic diagram of the disperser.

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7. Conclusion

A comparative analysis of existing technologies for grinding grain using the dispersion process on existing equipment showed that the developed author's resource-saving technology disperses grain by multi-stage action on grain with rotary grinding elements in three zones with sequential movement of the ground grain up to homogeneous mass.

A comparison of the developed resource-saving technology with the used technology of active action of rotary grinding elements specially designed in three grinding zones is carried out.

According to the developed proprietary technology, the total yield of the crushed homogeneous grain mass increases with an increased yield of dietary fibre up to 92%, while due to the use of three connected successive grinding zones with rotary grinding elements, a given fractional composition of the obtained homogeneous grain mass is provided up to 97 %.

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