Determining the optimal modes of the technological process of obtaining dietary flour from oat grain

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Abstract. The article covers the results of study on determining the optimal modes of obtaining dietary flour from oat grains for the nutrition of little children and patients with dietetic disease. At first, the influence of the working space between the grooves of the milling machine on the yield of oat flour has been studied. The influence of the size of milled oat products on the quality of the finished product (flour that does not require cooking) was studied by changing the amount of starch and water-soluble substances in it, and optimum modes for the production of oat flour that does not require cooking, e.g. the amount of ground particles of 500…710 mcm in size is not more than 20.0%, the amount of particles of 150…355 mcm in size is 40.0%, the amount of particles smaller than 150 mcm is not less than 40.0%, etc. have been determined. The proposed technology allows obtaining ecologically clean products and protect the environment from pollution. The application of the obtained results in production allows increasing the type of dietary food products.

1 Introduction

Complete satisfaction of the demand of population of our republic for food products and fundamental improving the supply in this sector is one of the most urgent issues. In the successful solution of these tasks, it is necessary to pay special attention to the important aspects of storing and processing grain products.

Flour and cereals are the foundation for the preparation of countless food products. Because of their consumption, a person satisfies the need for 30…50% of protein and 20…40% of various necessary biological substances. Flour contains fibrous substances due to crushed coats, which affect the release of various slags in the digestive tract and improve the physiological functions of the intestines [1].

Continuity of supply the population of our republic with quality bread, pasta products, cereals, young children and dietary food products is one of the main tasks. The technology of making flour for young children's food from local oat grains grown in the Republic of Uzbekistan has been studied very little.

Oat is used to produce grinded groats, crumpled groats, flattened groats and oatmeal. Oat products are distinguished from other cereal products by their high calorie content. Due to

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the presence of sticky substances in the products obtained from oat grain, they have nutritional properties. These products contain a large amount of vitamins (thiamine, riboflavin, niacin) and several trace elements [2].

Compared to other cereal grains, oat grain has more hulls, and the film content is 25-30% and higher. Round-shaped, whole-grain, low-film oat has the best technological properties [3]. The amount of small oat grains passed through a 1.8x20 mm sieve in the mass of oat grain should not exceed 5%. Because oat, which has a large amount of small grains in its composition, the output of cereal is low. The fruit, seed coat and aleurone layer of oat kernel is very thin, and together they make up 9-11% of the grain mass [4].

Cooking of many types of traditional groats produced in the cereal industry requires a long time. For example, pearl barley groat is cooked for 1.5…2.0 hours, and oat groat is cooked for more than 1 hour. Cooking food from such cereals requires a large amount of energy [5].

The use of hydrothermal treatment slightly reduces the duration of cooking of cereals, but this reduction is noticeable when using hard modes of steaming. Steaming in such strict modes is not applicable for many types of groats. Due to the use of hard modes of steaming, the color of the groats obtained from rice and peas is yellow, and the yield of broken groats from oats increases [6].

Flattened oat groat is produced by crumpling high-quality or first-grade groats on groove mills. The number of riffles cut on the surface of the grooves is 6...8 pieces per 1 cm, their slope is 3%, the speed ratio is 1:1 and the speed is 2.5 m/s. When using grooves, the groats are not only lightly flattened, but the riffles also cut off the remaining fruit and seed coats and separate them from the kernel, because of which it becomes easier for the kernel to absorb water during cooking [7]. After grinding, the surface of the kernel is left with traces of riffles on both sides.

In order to reduce the amount of broken groats, they are evaporated in continuous motion evaporators at a steam pressure of 0.05...0.1 MPa before flattening. In order to separate the broken kernels from the groat, it is sieved on sieves with a diameter of 2.0 mm, then the broken kernel is separated by blowing twice in aspirators, and after separation from metal-magnetic waste, it is transferred to the hopper of finished products [8].

Because of flattening the groats, their cooking time can be significantly reduced. In the process of packing, the structure of the kernel is partially destroyed, the surface of the pieces expands and the thickness decreases. This accelerates the effect of water and heat on the groats. [9].

Secondary raw materials formed during the production of cereals are used mainly for fodder purposes and nominally do not represent an environmental hazard.

Discharge of sewage at groat plants do not occur a problem. Water-heat treatment of grain is used in oat plants. This operation consumes a small amount of potable water, but results wastewater discharge. Grain plants discharge only domestic wastewater [10].

All equipment of grain processing enterprises is equipped with a high-capacity aspiration system. Aspiration systems create a vacuum inside machines and mechanisms, preventing the release of dust into industrial premises to ensure their explosion safety and sanitation, while a small part of the dust is removed in air separating aspirators. Dusty sediments are sent to cyclones and filters for cleaning. The precipitated heavy fraction is removed from the aspiration system through sluice gates, and the purified air is released into the atmosphere. In aspirators with a closed air cyclone, the purified air is returned to the working area. Based on the foregoing, cereal enterprises do not belong to the main air pollutants [11].

2 Methods

Quality indicators of oat grain (moisture, amount of grainy mixture, amount of impurities, ash content, and volumetric weight) were determined based on standards.

Moisture determination was conducted according to GOST 82041-82.

Grain moisture is determined as the ratio of water content to its total mass.

Ash content. Conducted according to GOST 10847-64.

Ash content of grain is determined by burning in muffle furnaces at high temperatures with and without accelerators. The method of determining the ash content without accelerators is considered the main one and is used in arbitration cases.

The recalculated ash content in relation to absolute dry substance is determined in percent by the following formula:

$$X = \frac{1000 \cdot G}{g(100 - W)};$$

where: G is the absolute weight of ash, g;

g is the weighted sample of ground grain

W is grain moisture, %

The amount of starch in grain and groats is determined by Evers' polarimetric method.

The amount of starch is calculated using the following formula.

$$X = \frac{L \cdot 100 \cdot 100 \cdot 100}{LD \cdot P \cdot l \cdot (W - 100)} \cdot 0.3469;$$

Where: X is the amount of starch in the flour;

L is the angle of rotation

P is the amount of flour sample, g

l is the length of the polarimeter tube, dm.

W is the moisture content of the substance under study, %

LD is the relative rotation angle of dextrin.

0.3469 is the value of the coefficient passing from the circular scale indicator of the polarimeter to the normal scale of the saccharimeter (1 division of the normal scale is equal to 0.3469).

3 Results and discussion

Oat groats produced from the harvest of oat grain in 2021 was used for scientific research.

Quality indicators of oat groats are given in Table 1.

Table 1. Quality indicators of oat groats.

No.	Quality indicators	Amount, %
1	Moisture	11.6
2	Good quality kernel including broken groats	99.2 0.56
3	Non-flaked grain	0.1
4	Waste including: mineral waste damaged	0.02 - 0.0 0.0
5	Baking flour	0.06

The analysis of Table 1 shows that the quality indicators of oat groats meet the standard requirements, only one indicator does not meet the standard requirements for non-flaked grain.

The quality indicators of oat groats (moisture, granular mixture, dirty mixture) were determined based on standards.

In order to weigh ordinary oatmeal, high-grade oatmeal was cleaned of dirt and grainy waste. Refined oat groats were crushed in one grinding and three grinding systems and flour was separated on 27k and 38k sieves. In this case, the influence of the working distance between the grooves of the milling machine on the yield of oatmeal was determined (Table 2).

Table 2. The effect of the working space between the grooves of a groove mill on the yield of flour.

Systems	Working space between the grooves, mm	Yield of flour, sieved on 27k sieve, %
I groat system	0.45	12.4
1 g.s.	0.30	21.6
2 g.s.	0.15	20.7
3 g.s.	0.10	19.1
Total		73.8
I groat system	0.35	17.5
1 g.s.	0.15	22.9
2 g.s.	0.10	22.1
3 g.s.	0.08	25.3
Total		87.8
I groat system	0.20	25.9
1 g.s.	0.10	25.8
2 g.s.	0.08	28.6
3 g.s.	0.06	18.6
Total		98.9

The analysis of Table 2 shows that the highest yield of ordinary oatmeal (98.9%) is obtained in the following modes, i.e., when the working space between the grains is set to the following parameters when grinding flour from oat groats on a groove mill:

In I groat system – 0.20 mm; 1 g.s. – 0.10 mm;

2 g.s. – 0.08 mm; 3 g.s. – 0.06 mm.

In order to obtain dietary oatmeal that does not require cooking, oat groats were milled in a groove mill to standard requirements (the amount of product remaining on a 27-kapron sieve is not more than 2%, the amount of products that passed through a 38-kapron sieve is not less than 60%). Then oatmeal was mixed with water in a ratio of 1:4 and heated at 45 °C for 60 minutes. The resulting suspension was dried in a valet drier (the temperature of the shaft surface is 140...150 °C). The moisture content of the dried product is 6...7%. The dried product was then milled again to standard requirements in a groove mill.

Table 3. Coarseness (dispersity) of ground oat groats.

Sieve No.	Sieve hole size, mcm	The amount of products that did not pass through the sieve according to the number of sieve, %				
		No. 1	No. 2	No. 3	No. 4	No. 5
8ПА-300 46РА-60 sieved leaflet	950	-	-	-	1.2	13.5
10.3РА-280	710	-	-	5.6	15.9	19.8
14РА-200	500	-	0.9	12.4	21.4	20.6
19.5РА-160	355	-	12.5	15.9	17.4	17.2
27РА-120	250	1.9	25.3	13.2	16.6	8.8

46PA-600	150	27.2	22.3	10.7	3.6	4.0
Unsifted on 46PA-60 sieve	Less than 150 μm	70.9	39.0	42.1	23.9	16.0

Oat groats was milled at different sizes to reduce the energy required to mill the oat groats and to determine the effect of milled product size on the quality of non-cooking oatmeal. The size of the ground products was analyzed using sieves. The obtained results are presented in Table 3.

Non-cooking flour was prepared from the samples of oat products ground to different sizes listed in Table 3. The size of the product in the No.1 sample corresponds to the standard requirements. The size of the products in the remaining samples is much larger than required.

When obtaining groats from oat grain, because of separating the coat and grinding, the fruit and seed coat, partially aleurone layer, and husk of the grain are removed. Because of this, substances that cannot be digested by the human body, such as cellulose, hemecellulose, etc., are removed from the grain. The amount of starch, protein, water-soluble substances and vitamins in oat kernel increases.

The main part of water-soluble substances in grain consists of nitrogenous compounds (amino acids, water-soluble protein) 11…51%, carbohydrates (sugar, dextrin) 39…82% and mineral substances. Non-cooked flour was obtained from oat groats ground to various sizes.

The influence of the size of milled oat products on the quality of the finished product (non-cooking flour) was determined by the change in the amount of starch and water-soluble substances in it. The amount of starch and water-soluble substances in the non-cooking flour made from ground oats in samples No.1...No.5 is shown in Table 4

Table 4. Amount of starch and water-soluble substances in non-cooking oatmeal, %.

Sample No.	**Amount of substances,%**	
	starch	**water-soluble substances**
1.	68.3	9.3
2.	67.6	9.5
3.	67.7	9.8
4.	68.2	7.7
5.	69.9	6.2

The analysis of Table 4 shows that the amount of starch is uniformly reduced and the amount of water-soluble substances is uniformly increased in non-cooking flours made from ground oat groats in samples No. 1, No. 2, and No. 3. The amount of water-soluble substances in non-cooking flours prepared from samples No. 4 and No. 5 is slightly increased. This is due to the increase in the coarseness of ground oat groats in samples No. 4 and No. 5.

In the production technology of dietary non-cooking flours, the milled cereal product is intensively treated with water and heat. In this case, the nutritional properties of the flour are greatly improved, and time and energy are not required to cook the flour. Dietary non-cooking flour is mixed with water or milk at a temperature of 45-55 °C to form a ready-made porridge.

In the production of non-cooking oatmeal for young children food, it is treated with water and heat. This affects its consumption properties, that is, the cooking time, appearance, color, taste and smell of finished flour change.

Nutritional properties of ordinary and non-cooking oatmeal are shown in Table 5.

Table 5. Consumption properties of oatmeal.

No.	Product name	Cooking time, min.	The color	The taste	The smell	Consistency
1.	Ordinary oatmeal	6	Yellowish pink	Good	Peculiar	The same
2.	Non-cooking oatmeal	Does not require cooking	Yellowish pink	Good	Peculiar	The same

The analysis of Table 5 shows that to prepare porridge from ordinary oatmeal, it is necessary to cook the flour for 6 minutes. In order to make porridge from non-cooking oatmeal, boiled water should be cooled to a temperature of 40-45 °C and oatmeal should be mixed in a ratio of 1:5.

The color, taste, smell and consistency of porridges made from ordinary and non-cooking oatmeal have good indicators.

4 Conclusions

Obtained results allow recommending the following size of ground oat groats for the production of non-cooking oatmeal: similar to the size of sample product No. 3, that is, the amount of ground particles with a size of 500...710 mcm is not more than 20.0%; the amount of particles with a size of 150…355 mcm is 40.0%, the amount of particles with a size smaller than 150 mcm is not less than 40.0%.

In the production of non-cooking oatmeal, it is not advisable to increase the size of the ground oat groats from the specified size, because this does not affect the improvement of the consumption properties of the obtained finished product.

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