Investigation of the degree of grinding of the composite grain mixture

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Abstract. Determining the degree of grinding of a functional multicomponent mixture of cereals and legumes is an important indicator of the flour-grinding properties of the constituent components of the recipe for the production technology of flour culinary products. The degree of grinding affects the structure of the flour and the uniformity of the crumb products. The selection of grain components of the recipe was carried out on the basis of the amino acid composition of cereals, legumes and spicy aromatic raw materials. A number of grindings of the raw components of the grain mixture were performed: lentils, peas, millet, pearl barley, spelled, oats, coriander, black pepper, or beans, rye, buckwheat, millet, lentils, spelled, pine nut shells, salt, coriander, black pepper and others compositions. The technological parameters of torn and grinding systems are determined and the indicators of the obtained processing components are characterized: flour, dunst and bran. Grinding schemes for five multicomponent grinding mixtures have been developed, including the preparation of basic and intermediate products. In addition to the composite flour obtained on all technological systems, bran was selected on the V tattered system and from the 3rd to the 7th grinding system, as well as hard and soft dunst. The passage from I-V torn systems is the finished product in the form of flour with a particle size of less than 132 microns. After grinding at all 7 stages of grinding systems, bran is obtained. The passage of 1-7 grinding systems produces a finished product in the form of flour from a composite grain mixture with a particle size of less than 132 microns. As a result of grinding and scattering through a sieve of 2500 microns, the following was obtained: for a mixture of 1NS - 3.2%, for a mixture of 2DS-2 - 1.8%, for a mixture of 3VS-2 - 2.0%, for a mixture of 4DS-3 - 1, 0% and for the mixture 5VS-3 - 1.9%, and when scattered through a sieve of 132 microns, it was obtained: for the mixture 1NS - 19.2%, for the mixture 2DS-2 - 18.0%, for the mixture 3VS-2 - 17 .4%, for the mixture 4DS-3 - 20.6% and for the mixture 5VS-3 - 19.8%. Investigated multicomponent samples: 4DS-3; 3VS-2; 5VS-3: 2DS-2; 1HC according to the results of expert opinions can be recommended for industrial processing of composite grain mixtures into flour as food additives balanced in amino acid composition. The use of the developed technological scheme of grinding makes it possible to obtain the required granulometric composition of flour used in baking flour culinary products. In the presence

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of large fractions inside the functional mixture, it leads to inclusions that are clearly reflected in the crumb of buns, which is negatively evaluated by consumers.

1 Introduction

At present, the direction that allows the use of ready-made flour functional mixtures in the manufacture of flour culinary products is promising. This will facilitate not only the work of bakers, but also the entire logistics chain from obtaining raw materials, forming grinding batches, grinding, developing innovative recipes and producing high-quality flour culinary products. This is especially true in mini-bakeries, where a limited number of personnel, small capacities and a minimum of space are employed, but with a need to produce a wide, constantly updated assortment [1].

Ant_Z (2012) proposed to include sugar flour, sugar flour molasses, sugar flour and milk molasses, sugar flour, fruit meal and others prepared by spray drying in the mixture for flour products. These also include natural whey and natural whey derivatives (whey concentrates). Secondary dairy products are waste products from the production of cottage cheese, cheese and casein. Whey, regardless of the method of its production, misses 50% of milk solids, including carbohydrates, proteins, mineral salts, milk fat, vitamins. Whey has over 200 compounds, just like milk, making it a complete food.

Fruit and vegetable powders are in demand in the baking industry and the public catering system. They are obtained by drying various types of fruits and vegetables after obtaining juices. The most common raw material for powders is apple pomace. When pressing 1 ton of apple mass, the juice yield is 600 - 650 kg, and the cake - 300 - 350 kg. Raw waste with a mass fraction of moisture of 76-77% is immediately subjected to drying in tunnel or spray dryers to a residual moisture content of 7-8%. Then the dried pomace is additionally crushed and sieved through a sieve with a mesh diameter of 0.4 mm. The powder passed through a sieve is a commodity, it is packed in kraft bags with a polyethylene liner, and sent through a sieve to feed livestock. According to physical and chemical indicators, apple powder must meet the following standards. Humidity must be at least 8%, the mass fraction of the total sugar content is not less than 25%, the mass fraction of mineral impurities is not more than 0.01%, the ash content, insoluble in 10% hydrochloric acid, is not more than 0.01%, the mass fraction of metal impurities is not more than 0.0003% [2].

The use of a multicomponent composition in the manufacture of grinding batches will allow balancing the composition of the grinding mixture for the main nutrients [3].

Examples of raw materials used for grinding batches, as noted by Caroline Banton (2023), may include corn, grain, forest resources, natural gas, and minerals. Raw materials are used in a variety of products and can take many different forms. These are the input goods or stocks that businesses need to produce their products. Plant materials come from seeds or plants, including fruits, nuts, flowers, vegetables, and other components [4].

The works of N.S. Bogoslavsky are devoted to the development of complete schemes for the processing of individual crops. on the processing of wheat grain (2008), Tarasenko S.S. on grinding durum wheat for pasta production (2015), Pankratov G.N. and Kandrokov R.Kh. (2017), who showed the possibility of enriching grains when grinding triticale, Shmalko N.A. and Smirnov S.O. substantiated the possibility of obtaining starchy flakes in the case of grinding amaranth seeds (2018). Brennan M.A., Derbyshire E., Tiwari B.K., Brennan C.S. (2013) showed the features of preparing mixtures for the constituent components of the recipe in the manufacture of snacks, and Ibanoglu S., Ains-worth P., Ozer E. A., Plunkett A. developed grinding batches of various cultures to obtain gluten-free extruded products [3, 5, 18, 19]. In the same direction, the works of Mikhailov O.V. and Korobkova A.N. (2011), showing the possibility of differentiating preliminary operations in the preparation of grain for grinding.

The quality of flour will also be reflected in the degree of preparation of grain for grinding. Belov A.A. and Korobkov A.N. proposed a method for disinfecting grain before grinding it. This technology is based on processing in a microwave electromagnetic field (2015).

Separate innovative technologies also apply to grain processing at low-capacity enterprises. Anisimov A.V., Rudik F.Ya., Zagorodskikh B.P. (2018) developed a grinding scheme for obtaining high-quality flour using cold conditioning, as well as peeling and drying.

At present, innovative directions for the development of advanced technology for processing various grain crops are important [5]. So, Kolpakova V V, Chumikina L V, Arabova L I, Lukin D N and Topunov A F (2016) established the relationship between the functional and technological properties of native and modified wheat gluten and its specific molecular weight in order to develop control methods for adjusting the physicochemical characteristics of protein products and use of the obtained results in technologies for the production of flour culinary products. Methods of analysis of the chemical composition of protein products, protein electrophoresis (PAGE) and DWG modifications were used. To modify the properties of gluten, enzyme preparations were used: endoprotease (Protamex®) and Flavorzyme 500 MG, which contains both endoprotease and endopeptidase at the same time. It has been shown that native flour proteins are inferior in their functional and technological properties to sodium caseinate, soy flour, soy concentrate and egg albumin, therefore their properties are modified by limited proteolysis with a degree of protein hydrolysis of 1.10-3.41%. The data obtained indicate that the duration of hydrolysis can be used to control the properties of gluten: to increase the solubility, foaming ability to the corresponding values shown by egg albumin, and at the same time to reduce water and fat binding capacity and fat emulsification. capacity. The structurally enhanced gluten contains both low molecular weight (less than 40 kDa) and medium molecular weight (40-60 kDa) single chain polypeptides. Among multi-chain peptides with more pronounced foaming ability, the presence of single-chain peptides with low molecular weight (12-16 kDa) seems to be more preferable than polypeptides with medium (27-39 kDa) and high molecular weight (69-108 kDa), which is supposed to use compositions modified gluten for further various applications in the food industry, mainly for the production of confectionery [6].

The quality of flour is formed at all stages of its preparation for grinding. So, Kandrokov R.Kh. and Belova E.R. (2018) investigated the possibility of obtaining the desired quality of spelled flour using hydrothermal treatment. The yield of flour in this case was 87.4-90.0% [7].

A number of authors have studied two schemes for processing triticale grain varieties into high-quality baking flour. The first scheme was reduced and included only the crushing and grinding processes, while the second scheme was more optimal and included the crushing, screening, sizing and grinding processes. A detailed analysis showed the high efficiency of the improved scheme, which involved the use of grate cleaners. Their expediency was determined by the specificity of the break of dunst products on faults I, II, and III. Flour varieties of triticale were obtained by mixing different flows of the central, intermediate and peripheral parts of the endosperm of the triticale grain. According to the reduced scheme, the yield was 40%, and according to the improved technological scheme - 63%. Significant differences were found in absorption during baking, dough kneading time, gluten, viscosity and starch retrogradation of flour. The best baking properties were shown by T-70 and T-80 triticale flours obtained from the central part of the endosperm, both according to simplified and innovative processing schemes. However, the improved scheme proved to be the most effective.

Consumer appeal of ready-to-eat foods is expected to grow rapidly over the next five years as consumers demand high-demand snacks with interesting sensory and textural properties. Extrusion technology is widely used in the production of ready-to-eat cereal snacks due to its ease of operation and ability to produce various textures and shapes that consumers like. Many of the existing ready-to-eat foods are relatively high in sugar and salt, and are therefore considered high-calorie but refined, low in nutrients. However, it is possible to manipulate the nutritional composition of extruded ready-to-eat foods by altering the digestibility of starch and protein, as well as by incorporating bioactive components such as dietary fiber.

The taste parameters of dry breakfasts largely depend on the constituent components of the recipe. IN AND. Stepanov, V.V. Ivanov, A.Yu. Sharikov, D.V. Polivanovskaya and D.V. Semykin (2016), based on the granulometric characteristics of grinding, formed grinding batches that allow obtaining a more delicate structure of the finished extrudate, at the same time, the hardness of the product increases from 6.1 to 9.8 N, which is confirmed by the example of manufactured nutritional snacks acceptable to the consumer.

The technologies developed by Kolpakova V et al. (2016) include: the first is the processing of proteins by heating [8], pressure [9], ultrasound [10], extrusion [11]; the second group includes protein acetylation [12], succinylation [13], phosphorylation [14], treatment with dilute acid [15], the third group of methods includes hydrolysis [16] and deamination [17]. Therefore, a comparative study of the native functional and technological indicators of flour gluten in comparison with other proteins revealed the feasibility of their improvement for future use in foam systems for the production of flour culinary and confectionery products, taking into account their specific rheological properties. The depth of proteolysis for weak gluten, improving solubility, should be achieved with a degree of hydrolysis from 1.76 to 3.41% under the action of endoproteinases and exopeptidases. As for short-tearing gluten, the degree of hydrolysis should be from 1.1 to 2.89% [6],

Developments in the field of improving the range of food products are also carried out using non-traditional vegetable raw materials: quinoa, spelled, bulgur, amaranth groats. Flour-grinding and baking properties of new types of grain raw materials are of interest. The listed raw materials are of interest to both the food concentrate industry and the public catering system. Studies currently being carried out by domestic and foreign scientists make it possible to recommend the use of processed products of a wide range of raw materials in the form of constituent components of a recipe or biologically active additives in the production of the most popular range of high-demand products, especially for the poor, the disabled, large families and other contingents [18 - 21].

The aim of the work is to determine the degree of grinding of a multicomponent composite mixture with the optimal amino acid composition from legume, grain and spicy-aromatic raw materials for use in technologies for the manufacture of flour culinary products.

2 Materials and methods

The developed multicomponent mixtures were used as objects of study: No. 1 with chanterelles, No. 2 with grape seed powder, No. 3 - 5D, 1NS, 2DS-2, 3VS-2, 4DS-3 and 5VS-3, including from 8 to 16 components : lentils, peas, millet, pearl barley, spelled, oats, coriander, black pepper, or beans, rye, buckwheat, millet, lentils, spelled, salt, coriander, black pepper and other options that allow you to balance the amino acid composition as much as possible and enrich it with biologically active substances: vitamins, macro- and microelements, antioxidants, dietary fiber, pigments. All this will allow you to get not only balanced high-quality food, but also an attractive taste and color range of finished products.

The composition of the developed multicomponent mixtures for grinding into flour and determining the degree of grinding of the developed multicomponent mixtures: No. 1 with chanterelles, No. 2 with grape seed powder, No. 3 - 5D, No. 4 - 1NS, No. 5 - 2DS-2, No. 6 - 3VS- 2, No. 7 - 4DS-3, No. 8 - 5VS-3, No. 9 - with zucchini and carrots and No. 10 - with wild berries are shown in table 1.

Table 1. Composition of the developed multicomponent mixtures.

Mixture name	The composition of the formulation components
№1 with chanterelles	Barley 12%, bulgur 10%, sunflower 8%, chanterelle mushrooms 3%, sesame 2%, coriander 1.5%, salt 1.2%, turmeric 1.1%, sugar 0.2%
	buckwheat 36%, oats 22%, lentils 14%, sunflower 10%, millet 7%, grape seed 5%, amaranth 2.5%, hemp 1.1%, salt 1.1%, coriander 0.3%, turmeric 0.3%, sugar 0.3%, oregano 0.2%, allspice 0.2%
№2 with grape seed powder	Zucchini 12%, pearl barley 18%, buckwheat 35%, apple 8%, spelt 6%, carrot 2%, salt 1.10%, bird cherry 1%, blueberry 4%, chokeberry 2%, lingonberry 2%, allspice 0.2 %, tarragon 0.3%, turmeric 0.2%, white sugar 0.2%
№3 - 5D	Beans 39.4%, wheat 16%, mung beans 12%, pearl barley 16%, lentils 6.2%, spelled 6, pine nut shells 4%, salt 1.2%, coriander 0.2%
	barley 18%, wheat 14%, millet 12.7%, lentils 12%, beans 32%, spelt 10%, salt 1.10%, coriander 0.2%
№4 - 1NS	Wheat 26%, lentils 12.5%, peas 18%, millet 12%, barley 12%, spelt 6%, oats 13%, coriander 0.2%, black pepper 0.2%, salt 0.1%
No. 5 - 2DS-2	Buckwheat 30%, wheat 18.5%, millet 12%, peas 18%, barley 10%, spelled 6%, rye 5%, coriander 0.2%, black pepper 0.2%, salt 0.1%
No. 6 - 3 / BC-2	Фасоль 30%, пшеница 12,5%, пшено 15%, горох 18%, перловка 10%, полба 6%, рожь 8%, кориандр 0,2%, черный перец 0,2%, соль 0,1%
No. 9 - with zucchini and carrots	buckwheat 35%, barley 18%, rye 13%, zucchini 12%, sunflower 8%, emmer 6%, sesame 2%, carrot 2%, salt 1.10%, tarragon 0.3%, allspice 0.2%, coriander 0.2% , sugar 0.2%
No. 10 - with wild berries	quinoa 36%, oats 28%, millet 12%, rye 12%, blueberries 4%, chokeberry 2%, sea buckthorn 2%, cranberries 2%, salt 1.1, sugar 0.5%, oregano 0.15%, tarragon 0.15%, allspice 0.1%

Grinding of grain components was carried out using a grinding and sorting unit RSA-4-2 and laboratory sieving with replaceable sieves with hole diameters: 2.5 mm; 1.6mm; 1.2mm; 0.63 mm; 0.45 mm and 0.132 mm.

3 Results and discussion

All components of the recipe have different densities, and it is rather difficult to foresee possible torn and grinding systems and their sequence of technological operations and the fractions obtained during crushing and grinding. As a result of the research, a grinding scheme was developed for the proposed variants of grain mixtures, selected on the basis of the amino acid composition, which is as close as possible to the "ideal" protein.

The grinding of the initial composite grain mixtures was carried out according to the developed laboratory technological scheme, consisting of five tattered and seven grinding systems. After grinding the initial composite grain mixtures on the 1st tattered system, the first waste product enters the second tattered system, the 2nd and 3rd waste products are combined and go to the 1st grinding system. The 1st waste product after grinding on a roller machine of the 2nd torn system enters the 3rd torn system, the 2nd and 3rd go to the 1st grinding system for grinding. The 1st downstream product after grinding on the 3rd torn system enters the 4th torn system, the 2nd and 3rd downstream products go to the 1st grinding system. The 1st waste product after the IV-th torn system enters the roller machine of the V-th torn system, the 2nd and 3rd waste products are sent to the 1st grinding system. The 1st waste product after the V-th torn system is bran and is sent to the bran hopper, the 2nd and 3rd waste products go to the 1st grinding system.

After grinding on the roller machine of the 1st grinding system, the 1st, 2nd and 3rd waste products are combined and sent to the 2nd grinding system. The 1st waste product of the 5th grinding system is the bran, which is sent to the bran hopper, and the 2nd and 3rd waste products enter the 6th and 7th grinding system. The waste products after the 7th grinding system are bran and are sent to the bran hopper.

The passage of all 7 grinding systems produces a finished product in the form of finely ground flour with a particle size of less than 132 microns.

The degree of grinding of the composite grain mixture is shown in table. 2.

Table 2. The degree of grinding of the composite grain mixture.

Departure from the sieve, microns	1NS, %	2DS-2, %	3/VS-2, %	4/DS-3, %	5/VS-3, %
2500	3,2	1,8	2,0	1,0	1,9
1600	9,0	8,2	6,6	2,9	7,0
1200	25,6	26,2	25,4	21,0	24,1
630	15,6	18,9	18,2	17,6	17,0
450	9,0	10,3	10,8	11,0	10,3
132	18,4	16,6	19,6	25,9	19,9
Pass through sieves 132 microns	19,2	18,0	17,4	20,6	19,8

Analysis obtained in table. 2 data shows that the maximum amount of waste product from a 2500 μm sieve is from 1.0 to 3.2%, the waste product from a 1600 μm sieve is from 2.9 to 9.0%, the waste product from a 1200 μm sieve is from 21 up to 26.2%, end product from a sieve of 630 microns - from 15.6 to 18.9%, end product from a sieve of 450 microns - from 9.0 to 11.0%, end product in the form of finely ground flour obtained through a sieve 132 microns in size, ranged from 16.6 to 25.9%.

Grinding schemes for five multicomponent grain combined mixtures, consisting of cereal, oil, spicy aromatic raw materials, of various chemical compositions, due to which it is possible to obtain the required amino acid composition, have been developed. The scheme includes obtaining the main and intermediate products from the V-grain, from the III to VII grinding system - bran, as well as hard and soft dunst. 1 pass with I-V torn systems is the finished product in the form of flour with a particle size of up to 132 microns, as well as bran production at all stages of the grinding system. The passage 1-7 of the grinding system is flour with a particle size of up to 132 microns. As a result of grinding and scattering, the following was obtained from a sieve of 2500 microns: for a mixture of 1NS - 3.2%, for a mixture of 2DS-2 - 1.8%, for a mixture of 3VS-2 - 2.0%, for a mixture of 4DS-3 - 1 .0% and for a mixture of 5VS-3 - 1.9%. It was also obtained that when dispersed through a sieve of 132 μm, the passage of crushed particles was for the following compositions: 1NS mixture - 19.2%, for 2DS-2 mixture - 18.0%, for 3VS-2 mixture - 17.4%, for 4DS mixture -3 - 20.6% and for a mixture of 5BC-3 - 19.8%. Investigated multicomponent samples of leguminous and spicy-aromatic components in the composition of 4DS-3; 3VS-2; 5VS-3: 2DS-2; 1HC after grinding into flour and separation of bran can be recommended for industrial use as a food additive balanced in amino acid composition for the production of flour culinary products.

The optimal concentration of additives in the formulations of shanezhka, cheesecakes, gates, buns, Ossetian pies from 15 to 25%, which is 20%, was established, at which the greatest number of excellent points was obtained.

4 Conclusion

Thus, according to the results of the studies, it was found that the highest yield of intermediate grinding products of the presented five grinding composite grain mixtures is obtained on coarse-forming I-V-th tattered systems with a particle size range of fractions of 157–250 microns.

Studies have established the size of the intermediate fraction, which is more than 450 microns, which was the maximum in comparison with other fractions released during the grinding process. This is an important factor in the development of grinding batches, especially when grinding multicomponent grain mixtures with different densities (legumes, grains, oilseeds) and other crops..

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