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INVESTIGATION OF THE INFLUENCE OF NON-TRADITIONAL RAW MATERIALS ON THE RHEOLOGICAL PROPERTIES OF DOUGH IN THE PRODUCTION OF GLUTEN-FREE PASTA

Anar Kabylda[1*], Fariza Sagyntay[2], Auelbek Iztaev[2], Nurzhan Muslimov[1]

[1]Astana Branch of Kazakh Research Institute of Processing and Food Industry LLP, Al-Farabi 47, 010000 Nur-Sultan, Republic of Kazakhstan
[2]Almaty Technological University, Tole bi str., 100, 050000 Almaty, Republic of Kazakhstan

[*]e-mail: anara121579@gmail.com

Abstract

The nutritional value of food is one of the most important factors determining the health of the population. Based on the importance of the health of the nation for the development and security of the country, the concept of state policy in the field of healthy nutrition of the population of Kazakhstan has been defined, which provides for a set of measures aimed at creating conditions that meet the needs of various segments of the population in a rational, healthy diet, taking into account traditions, habits and the economic situation. In the pasta market, a small segment is occupied by dietary and functional products, enriched pasta and products with a high nutritional value of no more than 1%. In this regard, the purpose of this study is to use non-traditional raw materials and food additives for the production of gluten-free pasta with a high content of vitamins and minerals.

In this work, the materials for the study were: buckwheat and chickpea flour of the Shortandinskaya coarse-grained variety, produced in the scientific and production center of the grain farm named after A. I. Barayev of the Republic of Kazakhstan, corn flour produced in the AL and KS Firm LLP of the Republic of Kazakhstan, using high-grade corn starch produced in the Zharkent Starch Plant of the Republic of Kazakhstan. Based on the experimental data obtained, three recipes for gluten-free pasta based on corn, chickpea, and buckwheat flour have been developed. To maximize the rheological properties of the pasta dough, it is recommended to introduce 25% starch into the dough formulation, which will increase the nutritional value of finished gluten-free pasta without significantly worsening the rheological properties of the dough. Rheological properties were determined using an alveograph (GOST 51415-99, ISO 5530-4-91). Water absorption using a farinograph (GOST 51404-99, ISO 5530-1-97).

During the study, 3 recipes were obtained. Rheological properties are possessed only by a control test sample based on flour of the first grade, which is explained by the fact that the protein fraction of wheat is mainly represented by gliadin and glutenin, insoluble in water, a distinctive feature of which is low solubility in water, therefore they can bind water in the test, swell and form gluten in a limited way. The results of experimental data showed that when starch is added to the pasta dough formulation, the value of the elasticity index increases from 15 to 25%, and the percentage of starch increases to 35%.

Thus, to improve the rheological properties of pasta dough, it is recommended to add 25% starch to the dough formulation, which increases the nutritional value of the finished product without significantly worsening the rheological properties of the dough. The resulting products will have high consumer properties and a homogeneous structure.

***Key words**: Gluten-free flour, Gluten-free pasta, Non-traditional raw materials, Nutritional value, Rheological properties.*

1. Introduction

In the policy of healthy nutrition, much attention is paid to the physiology of nutrition. Along with a balanced amino acid composition and high protein digestibility, foods should contain complex carbohydrates, and ballast substances (dietary fibers) that ensure the normal functioning of the digestive organs [1, 2, and 3].

In this regard, the current trends in the development of pasta production are of interest for the use of glue-free (gluten-free) raw materials for the production of dietary pasta. This raw material consists of some cereals (buckwheat, rice, corn, barley, sorghum, oats, etc.), triticale flour, and old deformed bread. Some of them simultaneously contribute to increasing the biological and nutritional value of products. These types of additives provide savings of the main raw materials, contribute to its effective use [4 - 8].

In traditional technology, durum wheat varieties are used as raw materials for the production of pasta, which are chemically "poor" in important nutrients. In this regard, the nutritional value of pasta can be increased by introducing natural ingredients such as corn, millet, buckwheat, barley or oats, as well as other cereals, the chemical composition of which differs significantly from traditional raw materials. Therefore, the production of pasta based on non-traditional raw materials is one of the promising areas of creating functional products.

Thus, pasta made from non-traditional raw materials, in comparison with other types of flour products, have a number of advantages: high digestibility of basic nutrients, high consumer properties (each category of people can satisfy their taste needs), long shelf life, low cost and accessibility for any population group. However, such products are not produced in our country, and manufacturers are forced to use flour made from soft wheat, the protein of which affects the small intestine of a person suffering from celiac disease [9 - 12].

The main grain crops that have the potential for use in the pasta industry are: oats, barley, rice, sorghum, corn, etc. These cultures are distinguished by their rich chemical composition, as well as the ratio of amylose and amylopectin, pasteurization temperature and granule size.

In this regard, the use of flour of various cereals and legumes is a promising direction in the development of gluten-free pasta production, while their various combinations make it possible to give new varieties of pasta therapeutic and preventive properties, and the consumption of new pasta allows you to give a functional status in the prevention of chronic diseases. That's why the purpose of this study is to use non-traditional raw materials and food additives for the production of gluten-free pasta with a high content of vitamins and minerals.

2. Materials and Methods

In this work, the materials for the study were: buckwheat and chickpea flour of the Shortandinskaya coarse-grained variety, produced in the scientific and production center of the grain farm named after A. I. Barayev of the Republic of Kazakhstan, corn flour produced in the AL and KS Firm LLP of the Republic of Kazakhstan, using high-grade corn starch produced in the Zharkent Starch Plant of the Republic of Kazakhstan. Based on the experimental data obtained, three recipes for gluten-free pasta based on corn, chickpea, and buckwheat flour have been developed. To maximize the rheological properties of the pasta dough, it is recommended to introduce 25% starch into the dough formulation, which will increase the nutritional value of finished gluten-free pasta without significantly worsening the rheological properties of the dough.

The determination of the operating modes of technological equipment, as well as the development and adjustment of the pasta production recipe depend on the rheological properties of the dough [13].

The main technological properties that determine the efficiency of the technological process of pressing gluten-free pasta dough are elastic soft-plastic properties: viscosity, plasticity and extensibility of the dough. In this regard, the rheological properties of pasta made according to a recipe developed on the basis of non-traditional raw materials have been investigated. It is obvious that the prepared mixture is characterized by low values of the studied properties. In this regard, starch was introduced into the formula to give the dough the best elastic-plastic properties, to bind all the components included in the mixture.

We determined rheological properties of flour by alveograph (GOST 51415-99, ISO 5530-4-91). The essence of the method consists in kneading a dough of constant humidity and a solution of sodium chloride, after which the dough is installed in a special compartment of the alveograph, where, when blowing balls out of the dough, the stretching of the dough is determined and an automatic graph with curves showing the rheology of flour is created.

Determination of water absorption and rheology of flour was performed by using a farinograph (GOST 51404-99, ISO 5530-1-97). The study was carried out on a Brabender farinograph - Germany. The principle of operation consisted from mixing the dough in a mixer, adding the necessary amount of water to obtain the desired consistency.

By the farinograph we investigated: the absorption of water in the device, formation time and the stability of the dough, dough degree of thinning, and the degree of quality according.

3. Results and Discussion

Unconventional mixtures for the production of a promising range of pasta based on unconventional raw materials have been developed in accordance with the results of automated calculation using software for the development of formulations of composite mixtures based on flour from whole grains of cereals and legumes.

Formulation development in accordance with the methodology as a result of the calculation with the help of an automated system MS excel, the following calculation formulations were produced:

- Recipe №1: wheat - 0%; barley - 0%; corn -33.33%; buckwheat - 33.33%; chickpeas - 33.22%; protein - 18.028% (difference in protein 4,248); starch - 60.256%; fiber - 8.076% (difference in carbohydrates - 0.008000000000267); fats - 8.61% (difference in oils - 9.27); ash - 3.664%;
- Recipe №2: wheat - 0%; barley - 0%; corn - 50%; buckwheat - 16.667%; chickpeas -16.667%; protein - 17.824% (difference in protein - 3.654); starch - 63.076%; fiber - 6.684% (difference in carbohydrates - 0.029999999985); fats-8.348% (difference in oils - 7,692); ash - 2,946%.
- Recipe №3: wheat - 0%; barley - 16.0%; corn - 41%; chickpeas - 31.7%; buckwheat - 27.3%; millet - 0%; protein - 18.5%; starch - 56.7%; fiber - 13.23%; fats - 7.76%; ash - 5.34%.

In the course of experimental studies, the elasticity of the dough was studied, characterized by the maximum resistance of the dough plate when blowing into bubbles (P, mm). The extensibility of the test was investigated, characterized by the maximum volume of the resulting test (L, mm). Along with the strength indicators of flour, it is necessary to take into account the data of alveograms characterizing the P/L ratio (elasticity and elasticity) of the dough. The actual work spent on the deformation of the test when blowing an experimental test sample into a bubble (W, EA) is determined. Swelling index of the experimental test plate (G) was measured. The coefficient of elasticity (Ie,%), which is characterized by the tensile resistance of the dough during deformation on two axes, is determined.

Experimental data showed that the plates of pasta made from non-traditional raw materials had the worst rheological properties, which were recognized not only by the alveo consistency of Chopin, which is explained by the high content of water-soluble protein fraction. The structure of the dough is tiny, it disintegrates even with insignificant values of deformation. Rheological properties are possessed only by a control test sample based on flour of the first grade, which is explained by the fact that the protein fraction of wheat is mainly represented by gliadin and glutenin, insoluble in water, a distinctive feature of which is low solubility in water, therefore, in the test they can bind water, swell and form gluten in a limited way. The results of experimental studies to determine the rheological properties of the control test sample are shown in Table 1.

Table 1. Rheological properties of first-grade flour dough (control sample)

Indicator	Control (Wheat flour of the I-th class)
Elasticity of the test P, mm x H_2O	137
Dough stretching, L, mm	84
Actual work, W, E. A.	455
Ratio of elasticity to tension, P/L	1.63
Coefficient of elasticity, Ie, %	68.9

Further, experimental studies were conducted aimed at improving the rheological properties of pasta made from non-traditional raw materials. Starch in the amount of 15, 25, and 35% was introduced to optimize the rheological properties of pasta dough and improve the quality of finished products. The results were compared with a control sample of first-grade flour dough. The results of the study are presented in Tables 2 - 4.

Table 2. Rheological properties of pasta dough, recipe №1

Indicator	Introduction of starch, %		
	15	25	35
Elasticity of the test P, mm x H_2O	181	253	188
Dough stretching, L, mm	81.4	38.5	103.6
Actual work, W, E. A.	132	193	330
Ratio of elasticity to tension, P/L	13.66	17.01	7.09
Coefficient of elasticity, Ie, %	12.4	9.3	29.5
Flour moisture content, %	8.47	8.3	8.2

Table 3. Rheological properties of pasta dough, recipe №2

Indicator	Introduction of starch, %		
	15	25	35
Elasticity of the test P, mm x H_2O	121	238	168
Dough stretching, L, mm	40.0	41.01	40.1
Actual work, W, E. A.	79	162	162
Ratio of elasticity to tension, P/L	16.59	22.33	19.81
Coefficient of elasticity, Ie, %	92.9	9.1	36.2
Flour moisture content, %	10.38	8.09	8.12

Table 4. Rheological properties of pasta dough, recipe №3

Indicator	Introduction of starch, %		
	15	25	35
Elasticity of the test P, mm x H_2O	96	162	103
Dough stretching, L, mm	92.4	42.2	29.5
Actual work, W, E. A.	129	164	124
Ratio of elasticity to tension, P/L	8.91	8.07	6.01
Coefficient of elasticity, Ie, %	61.6	11.2	40.0
Flour moisture content, %	8.05	8.2	7.7

3.1 Dough elasticity

In the process, the dough undergoes deformation and exhibits properties such as viscosity, plasticity, strength, which play an important role in the production technology of bakery products. The elasticity of the test is the ability of the body to fully restore its original shape or volume after rapid removal of the load, manifested with small and short-term loads [14 - 18]. The results of experimental data showed that when starch is added to the pasta dough recipe, the value of the elasticity index increases from 15 to 25% and the percentage of starch increases to 35%. The results of experimental data showed that when starch is added to the pasta dough recipe in an amount of 15 to 25%, the values of the elasticity index increase, and a further increase in the percentage of starch to 35% reduces the values of the elasticity index, and this is explained by the fact that an excessive amount of starch introduced should consume more water, and its deficiency gives the dough an easily collapsing, tearing structure.

3.2 Tightening the test

The greatest changes were observed in recipe №1 and №2, where the minimum and maximum stretching values corresponded to the introduction of 25% starch. And in recipe № 3, there is a tendency to a slow decrease in the extensibility values of pasta dough made from non-traditional raw materials.

Thus, according to the results given in the recipe № 1 for stretching during deformation, pasta is characterized by maximum resistance to the test.

3.3 Specific works

It is known that the plasticity and elasticity of the dough are characterized by the specific work expended on the deformation of the dough when blowing an experimental test sample into a bubble. As a result of the conducted experimental studies, numerical values of the specific working index of pasta dough from non-traditional raw materials with the addition of starch (W.E.A.) were determined, which is associated with an increase in the starch content from 15 to 25% (and the indicator "real work" according to recipe № 3 increases to 35%). Flour mixture of cereals and legumes on experimental test plates led to an increase in the specific work on the deformation of the dough. This indicator can be directly related to the energy costs of pressing pasta dough in the preparation of new types of gluten-free pasta.

3.4 Coefficient of elasticity

Analysis of the presented Tables showed that the introduction of starch additives from 15 to 25% leads to a decrease in the elasticity coefficient of pasta dough made from non-traditional grain and legume raw materials. The structure of the dough is shallow; it breaks with insignificant values of deformation. The plasticity of the test differs significantly from the plasticity of the control sample. An increase in the percentage of starch in the prepared dough to 35% increases the values of the elasticity coefficient. As a result of the research, the effect of starch on the change in the rheological properties of pasta dough made from non-traditional grain and legume raw materials was revealed. In flour mixtures with the addition of 15% and 25% starch, an increase in elasticity was observed, a further increase in starch to 35% reduces elasticity and worsens other rheological characteristics of the pasta dough.

4. Conclusions

- In order to improve the rheological properties of pasta dough, it is recommended to add 25% starch to the dough recipe, which increases the nutritional value of the finished product without significantly worsening the rheological properties of the dough. Thus, the resulting products will have high consumer properties and a homogeneous structure.
- The test formation time, according to experimental data, for recipe № 1 is 9.2 minutes; for recipe № 2 - 6.0 minutes; for recipe № 3 - 1.8 minutes.
- The stability of the test corresponded to the following values: for recipe № 1-11.8 min; for recipe № 2 - 5.0 min; for recipe № 3 - 0.5 min.
- The degree of dilution of the dough: Recipe № 1 - 70 units; Recipe № 2 - 163 units; Recipe № 3 - 257 units.
- Test dilution time: for formulation № 1 - 9.3 min; for formulation № 2 - 6.1 min; for formulation № 3 - 1.8 min.
- The degree of quality according to the farinograph: Recipe № 1 - 93 units; Recipe № 2 - 61 units; Recipe № 3 - 18 units.
- According to the data presented, pasta dough prepared according to recipe № 1 has the best technological properties, i.e. low water absorption, but high dough formation time, the dough has high stability, low dilution and high quality values in accordance with the farinograph.

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