Development of a new generation instant pasta based on gluten-free raw materials and dietary fiber

A P Nechaev, T B Tsyganova, S N Butova, J V Nikolaeva, V V Tarasova and D A Smirnov

Moscow State University of Food Production, 11, Volokolamskoe sh., Moscow, 125080, Russian Federation

E-mail: ztatianaz@yandex.ru

Abstract. The production of instant pasta from non-conventional raw materials using dietary fibers is a promising field of development of both instant pasta and gluten-free food products intended for people who keep special diets. This paper considered the possibility of producing instant pasta from non-conventional wheat gliadin- or protein-free raw materials having similar properties (secaline, hordein, avenin). Rice, buckwheat and soy flour were chosen as the raw materials for the study. The study included laboratory works to identify structure-forming agents and plasticizers, as well as their optimum doses and ratios thus simulating the properties of wheat gluten in pasta prepared according to the traditional formula. The choice of food additives was based on the analysis of their influence on physical and chemical properties of semi-finished and finished products, as well as on manufacturing technology. Instant pasta prepared from gluten-free raw materials using structure-forming agents was characterized by better dry matter ratio, transferred to cooking water during brewing, higher protein content and lower fat content in finished products compared to instant pasta made from wheat flour. The maximum dosage of instant pasta made of non-traditional raw material of dietary fiber (inulin) is established, which does not have a negative impact on technological and consumer quality parameters of semi-finished and finished products.

1. Introduction
Recent decades are characterized by the decline in the level of physical activity of a large group of the population due to changes in their lifestyle. This causes the imbalance in energy and food consumption [1].

The nutrition structure is changing thus increasing the share of refined products with higher energy value. Such nutrition leads to a shortage of certain macro- and micronutrients, the physiological need for which slightly changes. In this regard, the creation of food products with increased food value and reduced energy value is an important and relevant task for the food industry [2].

The nature of nutrition affects all biological characteristics of the human body, primarily its physical and mental health. Food products acts as the sources of energy, participate in all metabolic processes, serve as a plastic material for human body tissues [3].

Increased pace of life of citizens led to an increase in the popularity of instant products, which are convenient to use and require less time for preparation. Their preparation is convenient both at home and outside it, so such products are widespread among the population. Such products also include instant pasta, which is popular in Russia [4].
Pasta, like bakery and flour confectionery products, form the main component of the population diet. Instant pasta formula consists of main and additional raw materials. The main raw materials include high-grade and first-grade bakery wheat flour, high-grade and first-grade soft vitreous wheat flour, and drinking water. However, not everyone can eat such products due to diseases related to hereditary genesis. These include celiac disease, an inherited disease caused by digestive disorders due to the damage to the small intestine by food products containing a certain protein – gliadin (gluten) in wheat and similar proteins of cereal crops in rye (secaline), barley (hordein), oat (avenin) [5, 6].

Gluten-free dieting is the only therapeutic agent for people suffering from celiac disease. Therefore, the use of non-conventional gluten-free raw materials in technologies such as instant pasta production with additional enrichment of finished products with dietary fibers is a relevant and urgent task corresponding to modern trends [7].

Innovations are characterized by continuous development of production in two basic directions:
— technological production with the use of mechanization, automation, electronization for the preparation of products with set quality indicators alongside with simultaneous intensification of production and reduction of energy costs;
— assortment production with the use of raw materials with set characteristics, including non-conventional, thus ensuring the creation products with balanced composition for different groups of the population [8].

One of the directions of food engineering related to gluten-free flour products involves the design of products based on natural vegetable-based gluten-free raw materials (gluten-free cereals, legumes, nuts, etc.). In this case, it is necessary to create gluten-free flour products, when dealing with modeling of bakery properties of gluten-containing wheat flour, i.e. simulation of structure-forming properties of gluten contained in these types of raw materials [9].

A promising direction aimed at expanding the range of flour products is the use of non-conventional raw materials. Biological and nutritional values change with the change of product composition. Pasta production with the addition of non-conventional raw materials such as rice flour, buckwheat flour and soy flour is becoming ever more popular [7].

One of the ways to improve the quality and expand the range of products and wheat flour is the use of vegetable-based enriching additives in their technology. In order to create the necessary structure of semi-finished and finished products, it is necessary to use structure-forming agents. Most often food hydrocolloids are used in similar technologies. The use of several structure-forming agents at once causes the synergistic effect [10, 11].

The creation of dietary fiber compositions is quite promising due to their different physiological effects on the human body, as well as different technological properties [12].

Thus, the creation of instant pasta technology using gluten-free raw materials and the use of food hydrocolloids is an important and relevant task.

2. Purpose of the study
Not enough attention has been paid to the use of gluten-free raw materials in instant pasta technology, as well as their enrichment with dietary fibers, therefore this research trend seems quite relevant. On the basis of the above, the purpose of the study is to develop a formulation and technology of instant pasta products based on non-conventional gluten-free raw materials enriched with dietary fibers having increased nutritional value.

3. Object of the study
The objects of the study included soybean, buckwheat, rice flour; Fibruline XL inulin; VIVAPUR MC A 4M methyl cellulose; GRINDSTED XANTHAN 200 xanthan gum; GRINDSTED Guar 225 guar gum; Akucell AF 2985 carboxymethyl cellulose sodium salt; Verolec LASENOR soy lecithin; PREGEFLO CH-40 modified starch.
4. Materials and methods

4.1 Methods of studying raw material properties

The moisture content of flour was determined by vacuum-oven method in SESH-3M according to GOST 9404-88, the acidity of flour was determined according to GOST 27493-87 and the procedures given in the laboratory guide [13].

The content of raw fiber in flour was determined by removing acid-alkali soluble substances from the product and determining the weight of the residue conventionally taken as fiber according to GOST 13496.2-91.

The organoleptic indicators of flour were determined by methods specified in GOST 27558-87.

The starch content in flour was determined by polarimetry according to GOST 10845-98.

The protein content of flour was determined by the Kjeldahl’s method according to GOST 10846-91.

The fat content of flour was determined by the Soxhlet extraction according to GOST 29033-91.

4.2 Methods of preparation of semi-finished and finished pasta products

Instant pasta was prepared using methods based on the technique described in the study guide [6].

4.3 Methods of studying the properties of semi-finished and finished pasta products

The dough moisture content was determined by forced drying to constant mass using PIVI-1 device according to the procedure given in the laboratory guide [13].

The quality of dough sheeting was determined according to the current requirements given in book [6].

The moisture content of instant pasta was determined by drying the batch weight in SESH-3M according to GOST 31749-2012 and the method given in the laboratory guide [14].

The strength of briquettes was determined using ST-1M Structure meter.

The extraction of lipids from instant pasta and their quantitative determination were carried out using fexIKA vario control extractor according to GOST 29033-91.

The preparation time and condition of instant pasta after preparation were determined according to GOST 31749-2012.

5. Results and discussion

According to the traditional formula, instant pasta products are made from patent or light wheat flour. All types of wheat flour are characterized by a relatively high content of gluten, which is an important structural component of dough. The flour used in the production of pasta must have good elasticity gluten, shall not be sticky and have high stretch factor. The optimum content of gluten in flour shall be within 26-32% to ensure high quality of finished products [6].

In developing a formula of instant pasta based on gluten-free raw materials, which include buckwheat, soybean, rice and corn flour, it was decided to study the possibility of using some of the most common structure-forming agents in food industry to simulate the properties of wheat gluten. Xanthan gum, guar gum, methyl cellulose, sodium carboxymethyl cellulose were chosen as stabilizers and thickeners.

Instant pasta made according to traditional technology was chosen as a control sample [6]. Technological, physicochemical and organoleptic indicators were studied in the control sample to compare it with instant pasta samples made from non-conventional raw materials.

According to the literature review, the content of protein and starch in the used flour has a great influence on the structure of dough and pasta [4].

For the preparation of instant pasta from non-conventional raw materials, the proportions of flour mixture containing rice, buckwheat and soy flour were calculated, which were characterized by the similar content of protein and starch of patent wheat flour used for the preparation of the control sample.
According to the performed studies, the introduction of thickeners and stabilizers into the formula of instant pasta products from non-conventional raw materials increased the deep-fat frying of semi-finished product samples and improved physical-chemical and technological parameters of semi-finished and finished products. The dependence of the frying duration of pasta samples on the number of introduced structure-forming agents is shown in Figure 1.

![Figure 1. Effect of thickeners and stabilizers on the duration of deep-fat frying](image)

The study showed direct and nonlinear dependence of the frying time of instant pasta semi-finished products on the doses of thickeners in the range of 0.25% to 2.00% to the weight of the flour mixture in all samples. The frying time of the control sample prepared from gluten-free raw material without the application of structure-forming agents was 70 seconds.

Guar gum had the least effect on the frying time in the minimum of the studied concentration (0.25% of the flour weight), increasing this value to 98 seconds or 40% compared to the sample solely consisting of the above-described flour mixture, in the maximum concentration (2% of the flour weight) of methyl cellulose, increasing the frying time to 121 seconds or 73%.

The mixture of xanthan and guar gums taken at a ratio of 1:1 had the greatest effect on the frying time of semi-finished products. This mixture showed the maximum frying time in all the studied doses of structure-forming agents increasing the studied value from 66% to 160% in the minimum and the maximum of the studied concentrations, respectively.

The dependence of the proportion of dry matter transferred to cooking water from pasta samples when they are brewed within 15 minutes on the number of introduced structure-forming agents is shown in Figure 2. The study of dry matter transferred to cooking water from instant pasta products during brewing for 15 minutes revealed a nonlinear inverse dependence of this indicator on the number of introduced structure-forming agents.
The duration of the preserved corrugated thread is the main indicator by which the obtained samples were evaluated. For the control sample obtained from wheat flour, this value was 15 minutes. The sample of gluten-free flour without structure-forming agents did not preserve either the corrugated thread or the structure of instant pasta during brewing, immediately forming a flour suspension.

The sample containing the lowest dosage of structure-forming agents, but retaining the shape of the corrugated thread for more than 15 minutes, was prepared according to the formula with the introduction of xanthan and guar gums taken at a ratio of 1:1. In this case the dosage of structure-forming agents was 1% to the weight of the flour, and the retention time of the corrugated thread form was 16 minutes, which was 4 times longer than the sample with the same dosage of methylcellulose and 23% longer than the xanthan gum sample.

On the basis of the obtained data, a formula with a mixture of xanthan and guar gum in a ratio of 1:1 in a dose of 1% to the flour weight was chosen for further studies.

Soy lecithin was chosen as an emulsifier to be added to the formula of instant pasta based on non-conventional raw materials. Modified cold swelling corn starch was also added, which represented a pregelatinized distarch adipate acetylated starch on the basis of waxy maize to increase the strength of finished pasta briquettes. Inulin was added to the formula to enrich instant pasta from non-conventional raw materials with dietary fibers.

Of the studied food additives, only the emulsifier had an effect on the frying time of the semi-finished product. The introduction of modified starch and inulin did not affect the deep-fat frying time of the semi-finished products.

The proportion of a dry matter transferred during brewing of instant pasta during 15 minutes was positively influenced by all additives studied at this stage of work. The addition of modified starch in the concentration chosen for further studies (2.75% to flour weight) resulted in a value of 6.7% dry matter. Further addition of soybean lecithin to the formula reduced the transition of dry matter from
in the lowest concentration to 13% at an emulsifier dosage of 2% on the weight of the flour mixture. The content of lecithin in the formula in the amount of 1.75% of the flour weight corresponds to the value of this indicator by 5.8% of dry matter transferred to cooking water.

The introduction of dietary fibers in the pasta formula also reduced the described value to 8% in the maximum inulin dosage relative to the control sample comprising a mixture of rice, buckwheat and soybean flour, xanthan and guar gum, modified starch and soybean lecithin in the above concentrations. The formula containing a dose of 5% of the flour weight of the dietary fiber chosen based on rheological parameters of the dough sheet corresponds to 5.4% of the dry matter transferred to the cooking water.

It was decided to include the modified starch in the pasta formula at a dosage of 2.75% to the flour weight, which was the smallest dosage that ensured the elasticity of the finished pasta thread similar to that of the instant pasta thread prepared according to the traditional formula. The studied dosages had no appreciable effect on dough sheeting quality, so it was decided to study the effect of the emulsifier. When soy lecithin was added at a dosage equal to or greater than 1.75% of the flour weight, the dough became elastic, and the dough sheet was rolled out without failures and had a smooth surface. The enrichment of pasta with inulin did not affect the form stability of the finished product and the quality of dough sheeting at a dosage of 1% to 5% inulin to the flour weight inclusive. Further increase in the concentration of the studied dietary fibers in pasta resulted in fragility of the corrugated thread and fractures on a dough sheet.

6. Conclusion
The choice of non-conventional raw materials (rice flour, buckwheat flour, soy flour) for the production of instant pasta products is justified. The use of these ingredients in instant pasta technology makes the product available to people with gluten intolerance, and allows creating products with increased nutritional value.

The choice of structure-forming agents is justified, the application of which allows creating the structure of semi-finished and finished product necessary for the production of instant pasta.

The choice of dietary fibers (inulin) to be added to the instant pasta formula as an enriching additive is justified.

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