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# Study of the Influence of Bakery Agents on the Quality of Finished Products

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## Abstract

The study of new types of raw materials which differ in the properties necessary in technology, have a rich chemical composition, contain structural components which will not only activate the biotechnological processes of bread production, but also save scarce raw materials used in baking, and improve the chemical composition of the finished product is an urgent problem nowadays. In this work, the expediency and usefulness of barley flour using, polysaccharides and cod liver oil in the creation of compositions for new bakery products is considered.

Pectin is a natural polysaccharide which is considered to be enterosorbent. It consists from polygalacturonic acid partially esterified with methanol. Polyfructozan inulin is a natural prebiotic; it is known to give products rich creamy taste and texture. Jerusalem artichoke root powder was a source of inulin consistency. The optimal formulations have been developed experimentally using sensory, physical and chemical methods with the addition of bakery agents (pectin, inulin), as well as a fatty additive -- cod liver oil. The dependence between the force proofing products and a ratio of components flour mixture also the stresses of the compression / cutting of bakery products pulp samples and dosages cod liver oil and inactivated yeast.

The cod liver oil is considered as a bakery agent of oxidative action used to produce bakery products from flour with weak gluten. The formulation was optimized, and the optimal amount of the additive was determined.

The technologies of producing of baking products using bakery agents have been observed, the optimization and quality estimation of them have been carried out.

**Keywords:** bakery agents, pectin, inulin, cod liver oil, barley flour

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## 1. Introduction

It is known that the consumption of food products with low quality characteristics affects the quality of life, including development of series of diseases. In connection with the adoption of the ``Strategy for increasing the quality of food products in the Russian Federation until 2030'', the special attention is paid to the nutrition of the population: improving the quality of food products, introduction of technologies from more advanced processing of raw materials of plant origin, the production of food

products with functional properties, as well as popularization of the basics of healthy food as an essential part of a healthy lifestyle [1].

Thus, there is an actual problem of studying the new kinds of raw materials which are differ by properties needed for the technology, have rich chemical composition and contain structural components which will not only activate the biotechnological processes of bread production, but also save scarce raw materials used in baking, and improve the chemical composition of the finished product.

Polysaccharide additives such as inulin (Jerusalem artichoke root powder, Russia) low-esterized pectin (CP Kelco ApS, Denmark), as well as cod liver oil extracted by microwave cooking of the cod liver have been chosen as the researching objects.

Polysaccharide additives and the cod liver oil fit all the requirements of the Russian standards.

The rationality and usefulness of using barley flour, polysaccharides and cod liver oil and creation the composition of new bakery products is discussed in this work.

Products from cereals are considered to be the main source of useful nutrients decreasing the risk of many diseases [2-4]. Barley groats are made from barley grains (*Hordeum vulgare*) which are the plant of the cereal family. Proteins of this groats are close to wheat proteins by its composition; 70 % of them are glutelins and prolamins. Moreover, barley products by its amino acid composition are more useful than their analogues from wheat, corn and millet. Barley groats contain more than 20 essential and non-essential fatty acids. As barley groats are not acceptable to making bakery products directly, it is reasonable to use the barley flour instead. But consuming the whole grain processing products is more rational because of it helps the human organism to consume phytochemicals [5]. This ingredient has a number of advantages comparing with wheat flour of top and first grade: it contains more minerals (especially calcium, phosphorus, manganese), vitamins and so on. Adding barley flour can decrease glycemic index of the product [6]. Table 1 shows comparison chemical composition of top-grade, first-grade wheat flour and barley flour.

Developing the composition of bakery product with barley flour is oriented for making the customers healthier and creating the product with enhanced content of food fibers and vitamins comparing with products from top-grade wheat flour. As flour mixture with barley flour has weaker gluten [8], including bakery agents into the composition is required.

Including fruits and vegetables or their processing products as the most valuable sources of biologically active substances (especially vitamins, macro- and microelements which are present in the easily digestible form in them and in optimal ratios)

Table 1: Chemical composition of barley, wheat flour of top and first grade [7].

| Characteristic | Barley flour | Wheat flour, top grade | Wheat flour, 1st grade |
|---|---|---|---|
| Water, % | 14,0 | 14,0 | 14,0 |
| Proteins, % | 10.5 | 10.3 | 11.0 |
| Oils, % | 1.6 | 1.1 | 1.5 |
| Carbohydrates, % | 64.9 | 68.9 | 67.0 |
| Mono- and disaccharides, % | 0.8 | 1.6 | 1.2 |
| Food fibers, % | 10.1 | 3.5 | 4.4 |
| Mineral substances, % | 1.2 | 0.5 | 0.70 |
| Starch, % | 68.0 | 68.5 | 66.1 |
| Vitamins | | | |
| Thiamin ($B_1$), mg/100 g | 0.4 | 0.17 | 0.25 |
| Riboflavin ($B_2$), mg/100 g | 0.11 | 0.04 | 0.08 |
| Pantothenic acid($B_5$), mg/100 g | 0.15 | 0.3 | 0.5 |
| Pyridoxine ($B_6$), mg/100 g | 0.39 | 0.17 | 0.22 |
| Folates ($B_9$), µg/100 g | 8 | 27.1 | 35.5 |
| α-tocopherol (E), mg/100 g | 1.1 | 1.5 | 1.8 |
| Nicotinamide (PP), mg/100 g | 6.3 | 3.0 | 2.2 |
| Choline, mg/100 g | 37.8 | 52.0 | 76.0 |
| Minerals | | | |
| Potassium, mg/100 g | 309.0 | 122.0 | 176.0 |
| Calcium, mg/100 g | 32.0 | 18.0 | 24.0 |
| Magnesium, mg/100 g | 96.0 | 16.0 | 44.0 |
| Sodium, mg/100 g | 4.0 | 3.0 | 4.0 |
| Sulfur, mg/100 g | 77.0 | 70.0 | 77.0 |
| Phosphorus, mg/100 g | 296.0 | 86.0 | 115.0 |
| Iron, mg/100 g | 2.68 | 1.2 | 2.0 |
| Cobalt, mg/100 g | - | 1.6 | 2.4 |
| Manganese, mg/100 g | 1.1 | 0.6 | 1.1 |
| Copper, µg/100 g | 348.0 | 100.0 | 180.0 |
| Molybdenum, µg/100 g | 12.0 | 12.5 | 15.9 |
| Titanium, µg/100 g | 16.7 | 11.0 | 18.0 |
| Fluorine, µg/100g | 60.0 | 22.0 | - |
| Chromium, µg/100g | 12.5 | 2.2 | 3.1 |
| Zinc, mg/100 g | 2.0 | 0.7 | 1.0 |

make it possible to develop the functional production. Pectin from apples influences on increasing the specific volume and the porosity of bakery products, resulting in improving structural and mechanical characteristics of crumb. Presence of free carboxyl and hydroxyl groups in pectin molecule results in water holding capacity and more water

content of the product [9]. Pectin is also widely used in confectionery industry improving mechanical properties of gels, jams etc.[10].

Using inulin, having the function of natural prebiotic, in the dosage of 5 % [11, 12] results in giving products rich creamy taste and texture. High water capacity, solubility without caking is main advantages of inulin making it to be an ideal food fiber for bakery. Polysaccharide inulin belongs to the group of non-digestible carbohydrates, so it positively influences on digesting process improving the growth of useful microorganisms -- Bifidobacteria. Inulin also helps human organism to better digest calcium and magnesium. Inulin is also used to preparing starch gels improving their dynamic stability [14].

Using the cod liver oil in the bakery technology can be rational if using flour with poor baking properties. This additive has an oxidative effect and it can improve weak gluten. There is a practice of using bakery agents with both oxidative and reductive actions [15]. Thus, it is reasonable to use the cod liver oil combined with reductive bakery agent -- glutathione [16] which present in yeast cells [17]. At first, inactivated yeast suspension is introduced into the dough, and near the end of the dough mixing the cod liver oil is added.

The use of such a combination of additives results in the decrease of spread of hearth products, increasing porosity and improving sensory characteristics of the finished product. Adding the cod liver oil in the composition also increases the content of polyunsaturated fatty acids in the product. The fatty acids composition of cod liver oil is shown in the Table 2.

According the previously shown data, the aims and tasks of research have been formulated.

The aim of the study is developing the formulations and technologies for bakery products manufacture with the introduction of barley flour, polysaccharide additives (pectin, inulin) as well as fatty additives -- cod liver oil in order to facilitate the process of dough preparation, adjusting the quality characteristics of the finished products, as well as solving the problem of using of low-quality flour.

To achieve this goal formulating the following tasks is needed:

- to prove the choice of ingredients of vegetable and animal origin;

- to find the composition of the products and to optimize it taking into account the influencing factors.

Table 2: Fatty acids composition of the cod liver oil [18].

| Characteristics | Value |
|---|---|
| Total lipids, % | 100.00 |
| Triglycerides, % | 98.40 |
| Phospholipids, % | 0.002 |
| Total fatty acids, % | 95.24 |
| Saturated fatty acids: including | 16.17 |
| C14:0 (myristic) | 5.35 |
| C16:0 (palmitic) | 9.88 |
| C18:0 (stearic) | 0.94 |
| Monounsaturated: including | 51.17 |
| C16:1 (palmitoleic) | 14.10 |
| C18:1 (oleic) | 21.20 |
| C20:1 (gadoleic) | 10.61 |
| C22:1 (erucic) | 5.26 |
| Polyunsaturated including | 27.90 |
| C18:2 (linoleic) | 1.60 |
| C18:3 (linolenic) | 0.38 |
| C18:4 (octadecatetraenoic) | 0.56 |
| C20:4 (arachidonic) | 1.22 |
| C20:5 (eicosapentaenoic) | 5.92 |
| C22:5 (docosapentaenoic) | 8.94 |
| C22:6 (docosahexaenoic) | 9.28 |

# 2. Methods and Equipment

## 2.1. Methods

### 2.1.1. Experimental design

This research includes finding the optimal ingredient ratio in the composition of developed types of bakery products. Thus, the analysis has been carried out using methods of experimental design (exactly -- central composite rotatable plan) to minimize the number of experiments for obtaining the maximum of information about the process [19]. The software ``Oakdale Datafit 9.1'' was used for this purpose.

### 2.1.2. Qualimetric methods

Method of Chizhov and Semenov was used to obtain the generalized quality level according to some quality characteristics with their significance [21].

### 2.1.3. Analytical methods

The methods of measurement scales were used for providing sensory analyses in the current work (ISO 4121:2003). Each characteristic has been estimated with the scale from 1 to 5 taking into account the significance of this characteristic determined by the expert method. As the result, the generalized sensory score has been calculated according to formula:

$$q = \frac{\sum_{i=0}^{i=n}(B_i - B_{min}) \cdot K_{Si}}{\sum_{i=0}^{n} K_{Si} \cdot (B_{max} - B_{min})} \cdot 100 \quad (1)$$

where: $K_{Si}$ – significance coefficient of i-th sensory value; $B_i$ – average mark by all the tasters for i-th sensory value; $B_{min}$ – minimally possible mark from the scale (1); $B_{max}$ – maximally possible mark from the scale (5); n – number of the sensory values in the scale.

In case of more simple way of sensory estimation, 5-point scale was used. In that case generalized sensory score was just divided to 20.

Structural and mechanical parameters were also determined in the work. The stresses of compression and cutting of the bakery products was determined using Food Checker device (Japan). For this purpose, the cylindrical plunger and the knife were used as indentors, which cut the test sample to a depth of 10 mm at a constant speed. [20]

## 3. Results

The addition of inulin to the dough in the dosage from 2 to 8 % by flour weight results in increasing the volume of baking bread. Adding inulin also results in forming fine-grained equal-sized crumbs when sliced which is important for white bread and small buns. During fermentation, enzymes of flour are able to hydrolize part of inulin to fructose which results in formation of the brown crust on the finished product. The developed composition is shown in the Table 3.

Adding cod liver oil and inactivated yeast cells in the composition of bakery products results in decreasing the spreadability of the products, significant improving the of dough and finished product structure, as well as rheological and sensory characteristics of the product. The developed composition of bakery products with cod liver oil addition is shown in the Table 4.

The two-factor experimental design was developed to determine the composition of the buns with pearl barley flour. The sensory estimation of finished product (generalized sensory score/20, Y, points) was chosen as an optimization parameter.

Table 3: Compositions of bakery products with addition of pectin, inulin and barley flour.

| Ingredient | Composition | | |
|---|---|---|---|
| | №1(pectin) | №2(inulin) | №3(barley flour) |
| Wheat flour, top-grade | 32 | 29 | 33 |
| Wheat flour, 1st grade | 40 | 40 | 40 |
| Barley flour | 27 | 27 | 27 |
| Sugar | 6 | 6 | 6 |
| Salt | 2 | 2 | 2 |
| Yeasts | 4 | 4 | 4 |
| Margarine | 3 | 3 | 3 |
| Water | 50 | 50 | 50 |
| Pectin | 0.8 | - | - |
| Inulin | - | 4 | - |

Table 4: Composition of the bakery products with cod liver oil.

| Ingredient | Dosage, g/100 g of flour |
|---|---|
| Wheat flour, 1st grade | 100 |
| Yeasts | 0.6 |
| Salt | 1.8 |
| Sugar | 4.8 |
| Vanilin | 0.01 |
| Inactivate yeast suspension | 1 |
| Cod liver oil | 1 |

Table 5: Experimental planning matrix for buns with inulin.

| $X_1$, % | $X_2$, % | Y, points |
|---|---|---|
| Two-factor experiment | | |
| 20 | 3 | 4.4 |
| 34 | 3 | 4.0 |
| 20 | 5 | 4.2 |
| 34 | 5 | 4.3 |
| ``Star'' points | | |
| 13 | 4 | 4.2 |
| 41 | 4 | 4.0 |
| 27 | 2 | 4.4 |
| 27 | 6 | 4.6 |
| Central points | | |
| 27 | 4 | 4.7 |
| 27 | 4 | 4.7 |
| 27 | 4 | 4.7 |

The dosage of pearl barley flour *($X_1$, %)* and inulin (pectin) dosage *($X_2$, %)* were chosen as variable factors.

The model of regression equation and statistical data processing was carried out using non-linear regression method with the program DataFit 9.1. The experimental planning matrices are shown in the Tables 5 and 6.

After data processing the followed regression equation has been obtained.

$$Y = 1.83 + 0.15X_1 - 2.91{X_1}^2 + 0.38X_2 - 0.04{X_2}^2 \quad (2)$$

The optimum obtained by differentiating the equation is: $X_1$=27%; $X_2$=4%. F-ratio for this equation is 2.683. Plot of the response surface is shown at the Figure 1.

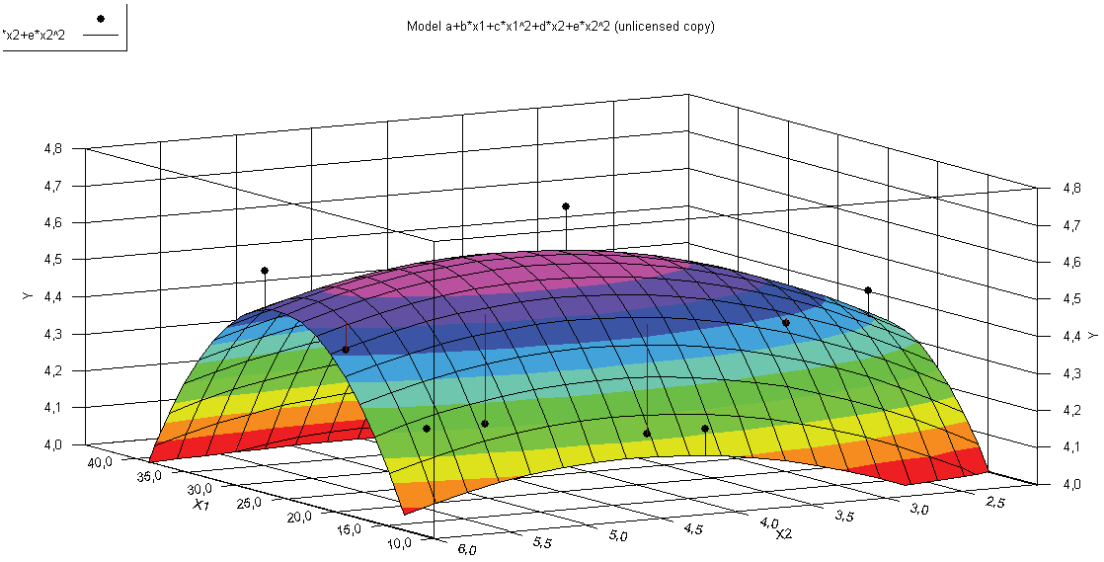


**Figure** 1: Response surface for the experiment with inulin.

Data processing for pectin resulted in the following regression equation:

$$Y = 2.4 + 0.11X_1 - 2.68{X_1}^2 + 2.36X_2 - 1.6{x_2}^2 \quad (3)$$

The optimum obtained by differentiating the equation is: $X_1$ =27%; $X_2$ =0.8%. F-ratio for this equation is 10.96. Plot of the response surface is shown at the Figure 2.

The optimization of the composition of bakery agents such as cod liver oil and inactivated yeast cells has been carried out. The optimal dosage of bakery agents of oxidative (cod liver oil) and reductive (inactivated yeasts suspension) was carried out by mentioned above method.

The cod liver oil ($X_1$) and inactivated yeasts suspension ($X_2$) dosages have been chosen as variable factors. The generalized quality level (by Chizhov and Semenov method) has been chosen. It includes generalized sensory score and compression/cutting stresses of finished product. The response surface is shown at Figure 3.

Table 6: Experimental planning matrix for buns with pectin.

| $X_1$, % | $X_2$, % | Y, points |
|---|---|---|
| Two-factor experiment | | |
| 20 | 0.5 | 4.3 |
| 34 | 0.5 | 3.6 |
| 20 | 1.1 | 4.0 |
| 34 | 1.1 | 3.6 |
| ``Star'' points | | |
| 13 | 0.8 | 4.3 |
| 41 | 0.8 | 3.4 |
| 27 | 0.2 | 3.9 |
| 27 | 1.4 | 3.7 |
| Central points | | |
| 27 | 0.8 | 4.4 |
| 27 | 0.8 | 4.4 |
| 27 | 0.8 | 4.4 |

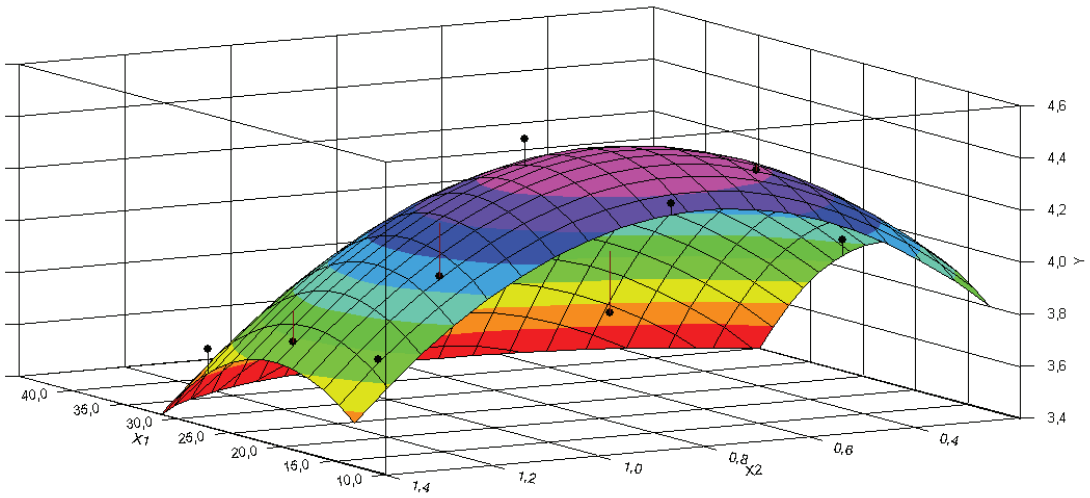


**Figure** 2: Response surface for the experiment with pectin.

The response surface shows values of cod liver oil and inactivated yeasts dosages which are the best for obtaining the maximal value of the generalized quality level. According to this model, the optimal dosages are: $X_1$ = 1.0; $X_2$= 1.0 of the flour weight.

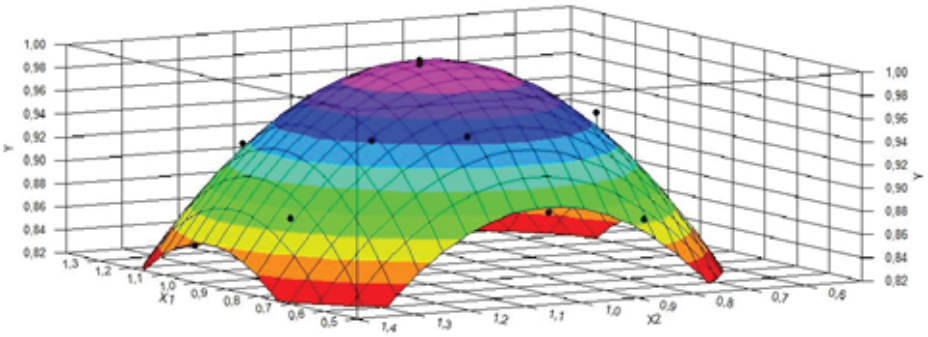


**Figure** 3: Response surface for the experiment with cod liver oil.

## 4. Discussion

Concluding the work, it is reasonable to say than the most successful (by sensory characteristics and lifting force) are the specimens containing 27 % of barley flour and 0.8 % of pectin. The products have a beautiful golden crust, pleasant flavour of fresh bread, elastic crumb, without voids, light grey colour. The second specimen containing 27 % of barley flour and 4 % of inulin has an even soft crust with slightly golden colour, pleasant flavour, with a touch of barley groats, grey crumb, fully baked, elastic, without voids. The dosages of cod liver oil and inactivated yeast suspensions have been determined for products with cod liver oil. These dosages results in the best characteristics of the products.

## 5. Conclusion

The results of the studies prove the ingredient of vegetable and animal origin choice based on analysis of chemical composition, influencing on the process of dough fermentation and sensory characteristics of the finished product. The compositions of the bakery products with addition of pearl barley flour, pectin, inulin, cod liver oil, and inactivated yeasts were developed. The optimisation using central composite design method was also carried out.

These additives provide producing the bakery products with improved characteristics achieved even in case of using the flour of lower baking properties.

Developing and producing the bakery products with functional additives is very actual nowadays, it helps to promote the principles of healthy nutrition and to improve the quality of life of the population.

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## Conflict of Interest

The authors have no conflict of interest to declare.

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