New aspects of application of microalgae Dunaliella Salina in the formula of enriched bread

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Abstract. The methods of mathematical planning of the experiment determined that the optimal dosages in the formulation of bread powder from microalgae Dunaliella Salina are 5.0-10.0 % by weight of flour in the dough. As a result of applying the recipe of promising new plant additives the organoleptic quality (taste, odor, status crumb) and physical-chemical parameters of the finished products (specific volume and porosity of bread crumb) improves. Due to the increased content of protein substances, including essential amino acids, dietary fibers, vitamins, minerals the bread has increased nutritional and biological value and can be considered as a product of therapeutic and preventive purposes. The range of functional bakery products is also expanding.

1. Introduction
In modern reality, the increasing shortage of vital components in food determines the need to search for additional raw materials.

The effective way to solve the problem of deficiency of high-grade proteins, dietary fibers, vitamins, mineral components is to search for non-traditional high-quality vegetable raw materials with a potentially attractive chemical composition. That is, the use of new non-traditional sources of raw materials of plant origin is of some interest. This is the basis for creating healthy food products. Producing functional products implies an increase in the content of biologically active compounds physiologically significant for humans and / or a decrease in undesirable components (for example, heavy metals and nitrates in plant foods).

Currently, scientists from different countries have developed several full-fledged functional food products with the introduction of puree and powders based on fruit and vegetable raw materials into the recipe [1-16].

The aim of the work is to develop the recipe of bread of increased biological value with the introduction of microalgae powder Dunaliella Salina into the recipe.

The main tasks are:
1) to study the analysis and systematization of domestic and foreign scientific and technical literature and patent information on the topic of research;
2) to justify experimentally the feasibility of using a new additive of plant origin in the production of bread;
3) to optimize the prescription ingredients;
4) to investigate the quality and chemical composition of the finished product.

2. Materials and methods

To determine the quality of bread conventional methods to determine the humidity, porosity, acidity of the crumb, the specific volume of bread were used in the baking industry. Structural and mechanical properties of bread crumb were determined using penetrometer AP-4/2.

The method of simplex-lattice planning of the experiment was used in mathematical data processing. Calculation of optimization parameters was carried out according to the program «STATISTICA». The determination of proteins was provided by the method of Kjeldahl according to GOST 13496.4. To determine the crude fiber the method, based on the removal of product acid, dilaceration substances and the determination of the mass balance conventionally assumed for fiber (GOST 13496.2) was used. Determination of total and monosaccharides in the products was determined by the method of Bertrand and Pochenko. Vitamin composition was determined on the spectrophotometer SF-26. Mineral composition was carried out with the atomic adsorption spectrophotometer AA-30 (Carl-Zeiss Jena). To determine the amino acid composition of bread automatic analyzer of amino acids AAA «AVINO ACID ANALYZER T 339» was applied.

3. Discussion of the results

Powder microalgae Dunaliella Salina was preliminary produced. For this purpose biologically active substance obtained by aerobic cultivation in the fermenter at a temperature of 32-35 °C in the regime of film flow of the culture liquid and its spray drying to the humidity of 4.5 ± 0.5 % [17] was prepared.

Due to the introduction of Dunaliella Salina powder (table 1) the nutritional and biological value of bread increases.

| Table 1. Chemical composition of Dunaliella Salina powder (in terms of DS) |
|---------------------------------------------------------------|
| Name of the component | Content (%)       |
|-----------------------|-------------------|
| Protein substance (%) | 36.4±1.27         |
| Carbohydrates (%)     | 33.0±1.25         |
| Lipid (%)             | 7.8±0.24          |
| Nucleic acid (%)      | 7.7±0.23          |
| Chlorophylls (%)      | 5.0±0.2           |
| Carotenoid (%)        | 4.5±0.15          |
| Ascorbic acid, mg/100 g | 102±4.0         |
| Potassium, mg/100 g   | 432±15.0          |
| Sodium, mg/100 g      | 35.4±1.45         |
| Calcium, mg/100 g     | 210±8.4           |
| Magnesium, mg/100 g   | 137±5.45          |
| Phosphorus, mg/100 g  | 158±6.32          |
| Iron, mg/100 g        | 4.5±0.18          |

The methods of mathematical planning of the experiment established that the optimal dosages in the formula of bread powder from microalgae Dunaliella Salina are 5.0-10.0 % by weight to the flour in the dough.

In a mixing bowl, the dough was mixed in the following prescription components, kg per 100 kg of flour: rye flour bakery peeled – 15.5; wheat flour of first grade – 50.0; liquid starter 76.0 kg; yeast baking pressed – 0.5; powder Dunaliella Salina – 10.0; salt – 1.5; white sugar – 3.0; water – 11.3. Then the fermentation of the dough at a temperature of 30-32 °C for 70-90 minutes follows, then the dough is divided into blanks weighing 675±5 g.
Table 2. Quality indicators of bread

| Name of the indicators | Characteristics of bread quality indicators | bread with the dosage of the powder of the microalgae (%) |
|------------------------|---------------------------------------------|--------------------------------------------------------|
|                        | control (bread stolichniy)                  | 5.0 7.5 10.0                                           |
| Appearance:            |                                             |                                                       |
| form                   | Corresponding to the form in which baking, without side damages was produced | Corresponding to the form in which baking, without side damages was produced |
| surface                | Rough, without major cracks and explosions. | Rough, without major cracks and explosions             |
| The crumb color         | Brown                                       | Brown                                                 |
| Condition of the crumb:|                                              |                                                       |
| porosity               | Uniform without voids and seals             | Uniform without voids and seals                       |
| Degree of baking       | Baked well, not sticky, not wet to the touch, elastic. | Baked well, not sticky, not wet to the touch, elastic |
| Degree of knead        | Without lumps and traces of knead lack      | Without lumps and traces of knead lack                |
| Taste and odor         | Slightly sweet and sour, peculiar to this type of product, without foreign taste and odor | Slightly sweet and sour, peculiar to this type of product, without foreign taste and odor |
| The humidity of the crumb (%) | 46.6±0.2 | 46.4±0.2 | 46.2±0.2 | 46.7±0.2 |
| The porosity of the crumb (%) | 67.0±2.5 | 69.5±2.5 | 69.3±2.5 | 70.0±2.5 |
| The acidity of the crumb (acidity degrees) | 7.5±0.3 | 7.6±0.3 | 7.5±0.3 | 7.7±0.3 |
| Specific volume (cm³/100 g) | 195±7 | 220±7 | 223±7 | 225±7 |
| Structural and mechanical properties of the crumb, unit device: |                                             |                                                       |
| ∆Hgeneral              | 44.4±1.7 | 49.0±2.0 | 49.5±2.0 | 50.0±2.0 |
| ∆Hplastic              | 30.9±1.2 | 34.1±1.4 | 34.6±1.4 | 34.7±1.4 |
| ∆Helastic              | 13.5±0.5 | 14.9±0.6 | 14.9±0.6 | 15.3±0.6 |
| ∆Hplastic relative (%) | 65.6±2.6 | 69.2±2.7 | 70.1±2.7 | 69.4±2.7 |
| ∆Helastic relative (%) | 34.4±1.4 | 30.2±1.2 | 31.1±1.2 | 30.6±1.2 |
| Comprehensive quality assessment (points) | 93.0 | 95.0 | 95.0 | 96.0 |
The blanks were laid out in molds, pre-lubricated with vegetable oil, sent to proofing for 50-60 minutes, baked at a temperature of 220-230 °C for 50±5 minutes. The dough humidity was 48.5 %. The baked bread was cooled and packaged.

Organoleptic and physical-chemical parameters of bread are presented in Table 2.

**Table 3. Chemical composition of bread, %**

| Name of the indicators | Control Bread stolichny | The dosage of the powder of the microalgae Dunaliella Salina, % |
|------------------------|-------------------------|---------------------------------------------------------------|
| Protein content (%)    | 7.1±0.30                | 8.4±0.32 8.6±0.34 9.3±0.34                                    |
| Mass fraction of (%):  |                         | 5.0   7.5   10.0                                         |
| total sugars           | 45.80±0.4               | 47.60±0.4 47.90±0.4 48.60±0.4                              |
| monosaccharides        | 10.0±0.2                | 11.0±0.2 11.4±0.2 11.8±0.2                                  |
| Phosphorus content (%) | 0.5±0.1                 | 1.4±0.1 1.6±0.1 1.8±0.1                                     |
| Calcium content (%)    | 0.04                    | 0.09 0.11 0.13                                           |
| Fiber content (%)      | 0.7±0.1                 | 1.2±0.1 1.5±0.1 1.8±0.1                                    |

**Table 4. Amino acid composition of bread**

| Aminoacid                          | Aminoacid content (%) |
|------------------------------------|-----------------------|
|                                    | Control   | Bread with 10% powder of the microalga Dunaliella Salina |
| Aspartic acid                      | 0.260±0.012 | 0.512±0.024                                    |
| Threonine                          | 0.283±0.013 | 0.299±0.013                                    |
| Serine                             | 0.165±0.008 | 0.352±0.016                                    |
| Glutamic acid                      | 2.065±0.102 | 2.735±0.135                                    |
| Proline                            | 0.857±0.041 | 1.012±0.051                                    |
| Glycine                            | 0.240±0.011 | 0.402±0.021                                    |
| Alanine                            | 0.198±0.011 | 0.345±0.016                                    |
| Valine                             | 0.405±0.021 | 0.457±0.022                                    |
| Methionine                         | 0.092±0.005 | 0.093±0.004                                    |
| Isoleucine                         | 0.315±0.014 | 0.343±0.016                                    |
| Leucine                            | 0.614±0.031 | 0.642±0.032                                    |
| Tyrosine                           | 0.173±0.008 | 0.179±0.009                                    |
| Phenylalanine                      | 0.422±0.020 | 0.462±0.022                                    |
| Cystine                            | 0.258±0.013 | 0.253±0.012                                    |
| Lysine                             | 0.202±0.011 | 0.375±0.017                                    |
| Histidine                          | 0.148±0.007 | 0.270±0.012                                    |
| Arginine                           | 0.390±0.018 | 0.431±0.021                                    |
| Sum of amino acids                 | 7.087±0.432 | 9.162±0.457                                    |

In terms of quality, bread prepared according to the proposed method is not inferior to the control sample, and the physical and chemical parameters are improved, which ensures the production of products of sufficient volume with elastic crumb and well-developed porosity (table 2).

Bread prepared with the use of microalgal powder Dunaliella Salina, has a pleasant odor and taste, without foreign tastes and odors. The crust of the products is evenly colored being brown, the crumb is brown. This is achieved by prescription components characterized by high content of mono-and
disaccharides, amino acids and other intermediate products of protein breakdown. When baking the reaction of melanoidin formation more intensively. As a result, the taste and color of the finished products are improved, their aroma is enhanced.

The analysis of the chemical composition (table 3) showed that the protein content in bread prepared according to the proposed method increased by 1.15-1.26 times, phosphorus content – 2.8-3.6 times, calcium – 2.25-3.25 times, fiber content increased by 1.7-2.5 times.

The biological value of proteins in bread prepared with the use of microalgae powder Dunaliella Salina in the formula is 76.8 % (tables 4-5), which is 10.2 % higher than in the control sample (66.2 %). Score – amino acid score of specific amino acid, %; ∆DAA – difference of amino acid score of amino acid, %.

Table 5. Amino acid score and biological value of bread

| Name of amino acid | Control A (mg/g protein) | Score (%) | Sample 3 A (mg/g protein) | Score (%) |
|--------------------|--------------------------|-----------|---------------------------|-----------|
| Valine             | 32.4±1.61                | 64.8±3.23 | 53.0±2.65                 | 106.0±5.31|
| Isoleucine         | 25.2±1.25                | 63.0±3.14 | 40.0±2.00                 | 99.5±4.97 |
| Leucine            | 49.1±2.44                | 70.2±3.51 | 74.5±3.72                 | 106.4±5.31|
| Lysine             | 16.2±0.80                | 29.5±1.46 | 43.5±2.17                 | 79.1±3.95 |
| Methionine+        | 28.0±2.26                | 80.0±4.00 | 40.1±2.00                 | 114.7±5.72|
| Cystine            |                         |           |                           |           |
| Threonine          | 22.6±1.41                | 56.5±2.81 | 34.7±1.73                 | 86.7±4.32 |
| Phenylalanine+     |                         |           |                           |           |
| Tyrosine           | 47.6±2.37                | 79.3±3.95 | 74.3±3.71                 | 123.9±6.19|
| Coefficient of difference of amino acid spark, (%) | 33.8±1.68 | 23.2±1.15 |
| Biological value (%) | 66.2±3.31               | 76.8±3.84 |

If we take less than 5 % of the powder from the microalgae Dunaliella Salina, the positive effect is not achieved, and if more than 12 %, the physical-chemical and organoleptic characteristics of the quality of bread deteriorate.

4. Conclusion
Thus, the proposed method of bread production using the formula of microalgae powder Dunaliella Salina allows achieving the following advantages:

1) to increase the nutritional and biological value of the finished product by replacing rye flour baking stripped powder from microalgae Dunaliella Salina, additional enrichment with protein, dietary fibers, micronutrients;

2) to improve organoleptic quality indicators (taste, odor, condition of the crumb) and physical-chemical indicators (specific volume and porosity of the crumb of bread);

3) to expand the range of bakery products.

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