Research of consumer properties of butter cookies composed of non-traditional raw materials

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Abstract. This paper examines the influence of non-traditional raw materials of plant origin on the formation of consumer properties of functional butter cookies. It considers the biological value and balance of wheat and spelt flour. It scientifically proves that the lysine content (the most deficient essential amino acid) is significantly higher in spelt flour than in wheat flour. The analysis of organoleptic and physicochemical properties provided a basis for determination and scientific substantiation of the composition of butter cookies. It is found that it is technologically possible to use 40% of spelt flour of the total flour weight and 4% of barley malt extract. This dosage ensures high consumer properties of the products. It was proved that cookies with spelt flour and barley malt extract have higher quality characteristics during the entire shelf-life, as compared to the control samples. It was found that new potentially healthy ingredients of plant origin can enrich butter cookies with minerals, protein and some essential amino acids, enhancing the nutritional and biological value of the finished products. The results obtained in this paper have practical significance for improving the biscuit baking technology, namely, for enhancing its nutritional and biological value.

1. Introduction

One of the most popular types of pastry products is cookies. They are visually appealing, delicious, and easily digestible. One of the promising areas in the confectionery industry is the production of enriched pastry products with the use of new potentially healthy ingredients of plant origin, which have functional components and give health-promoting properties to the finished products [1-3].

Currently, a large number of both domestic and international scientific researches is devoted to the development of pastry products with enhanced nutritional and biological value, including butter cookies. Most scientists believe that partial replacement of wheat flour with non-traditional types of flour (amaranth, triticale, millet, etc.) is a popular trend of technological development in the pastry industry [4-5].

In view of the above, the studies aimed at the practicability substantiation of spelt flour for butter cookies, are increasingly becoming more relevant.

2. The purpose of the study

This paper is aimed at the substantiation of formulations for functional butter cookies made with spelt flour.

To achieve this goal, the following problems were solved:
• to explore the amino acid composition of wheat and spelt flour samples, the amino acid score, the rationality coefficient of amino acid composition, biological value and the difference coefficient of amino acid scores;
• to explore the processing characteristics of spelt flour and the dynamics of change when mixing with wheat flour;
• to explore the influence of spelt flour on the course of technological processes and properties of semi-finished products when baking butter cookies;
• to explore the quality and safety characteristics of butter cookies made with spelt flour and the dynamics of their change during the shelf-life.

3. The object of the study
Objects of research: samples of wheat and spelt flour; barley malt extract; semi-finished products for butter cookies with additives; control and test samples of butter cookies.

4. Materials and methods
Conventional and special organoleptic, physicochemical and mathematical research methods were used in this paper. The method developed by N. N. Lipatov was used to evaluate the balance of amino acid composition of the protein. This method was used to calculate the following indicators: amino-acid score, biological value, rationality coefficient of amino acid composition, difference coefficient of amino acid scores, essential amino acid index [6].

The experimental data were statistically processed using software packages Microsoft Excel.

5. Discussion of the results
Spelt flour has a special place among other types of grain-based flours. This type of raw material is characterized by rich content of protein, unsaturated fatty acids, vitamins A, E, B1, B2, B3, the increased amount of total sugar and reducing sugar, necessary for normal activity of baker’s yeast when producing pastry products [7-9]. It contains special soluble mucopolysaccharides capable of fortifying the human immune system [10].

The quality parameters of spelt flour are presented in Table 1.

| Parameter                                           | Test values     |
|-----------------------------------------------------|-----------------|
| Moisture content, %                                 | 9.75±0.9        |
| Flour whiteness, standard units of RZ-BPL device    | -               |
| Weight fraction of gluten, %                        | 25.74±3.5       |
| Gluten quality, gluten deformation index            | 85.00±4.6       |
| Gluten extensibility, mm                            | 125.00±9.8      |
| Moisture content of wet gluten, %                   | 57.20±8.7       |
| Hydration capacity of gluten, %                     | 133.64±11.3     |
| Falling-number value, seconds                        | 421.00±23.1     |

The biological value of food proteins is characterized by amino acid scores. The amino acid score is calculated as a percentage ratio of the amino acid composition in the test protein to the amino acid composition in the reference protein that meets the needs of the human body [11-13]. The biological value and balance of the amino acid composition of spelt flour were evaluated using the following protein quality parameters: amino acid score, biological value, rationality coefficient of amino acid composition, difference coefficient of amino acid scores, essential amino acid index (table 2).
Table 2. Parameters of biological value and balance of wheat and spelt flour

| Amino acid                     | Spelt flour | Wheat flour |
|--------------------------------|-------------|-------------|
| Amino acid score, %            |             |             |
| Valine                         | 106.4       | 92.0        |
| Lysine                         | 58.4        | 48.2        |
| Methionine (+cystine)          | 119.4       | 84.6        |
| Tryptophan                     | 85.0        | 112.0       |
| Isoleucine                     | 102.0       | 95.5        |
| Leucine                        | 106.8       | 99.7        |
| Threonine                      | 72.5        | 65.0        |
| Phenylalanine (+tyrosine)      | 158.0       | 138.2       |
| Amino acid score, min, %       | 58.4        | 48.2        |
| Difference coefficient of amino acid score, % |
| Biological value, %            | 57.3        | 56.3        |
| Essential amino acid index, units | 0.97       | 0.89        |
| Rationality coefficient of amino acid composition, fraction unit | 0.56 | 0.52 |

An important aspect in the development of food products with increased nutritional value involves the need to increase the amount of limiting amino acids with score <100%. It should be noted that spelt flour is limited in lysine and threonine, however, the lysine content is higher in spelt than in wheat by 21.2%, and the threonine content - by 11.5%.

As compared with wheat flour, spelt flour is characterized by slightly higher biological value and lesser values of the difference coefficient of amino acid score, which shows the surplus of essential amino acids used for constructive metabolism.

It should be noted that spelt flour has a higher rationality coefficient of amino acid composition and essential amino acid index, which determines its practicability for the production of pastry products with increased biological value.

The comprehensive analysis of spelt flour showed that products produced with this type of raw material will have higher nutritional and biological value. Moreover, its chemical composition may influence the processing characteristics of flour and thereby change the dough properties and the quality of finished products.

The bread-making properties of wheat flour are considerably determined by the protein content and gluten quality. The research results concerning the gluten properties in spelt-wheat-mixture are presented in Table 3.

Table 3. Influence of the percentage composition of spelt flour on the gluten properties

| Percentage composition of spelt flour of the total flour weight | Parameter                  |
|-----------------------------------------------------------------|----------------------------|
|                                                                 | Gluten extensibility, mm   | Moisture content of wet gluten, % | Weight fraction of gluten, % | Hydration capacity of gluten, % |
| 0.0                                                             | 95.0                      | 49.6                         | 27.24                       | 98.41                         |
| 10.0                                                            | 105.0                     | 49.8                         | 27.20                       | 99.20                         |
| 20.0                                                            | 113.0                     | 50.4                         | 26.94                       | 101.61                        |
| 30.0                                                            | 115.0                     | 50.9                         | 26.88                       | 103.67                        |
| 40.0                                                            | 117.0                     | 51.3                         | 26.82                       | 105.34                        |
| 50.0                                                            | 120.0                     | 52.1                         | 25.84                       | 108.77                        |
The hydration capacity of gluten in the test samples increased by 0.8-10.5% with the addition of spelt flour, which can be explained by the fact that the spelt flour increased the protein content. The increase of this parameter will improve the softening and plasticity of dough during technological processes [14].

The moisture content of wet gluten also increased, which apparently can be explained by a large amount of cellulose, pentosans, mechanically damaged starch kernels in spelt flour, which accelerated the rate of moisture absorption and increased the volume of absorbed moisture.

The gluten extensibility increased from 95 to 120 mm, however, the gluten in all samples was estimated as “average”.

It should be noted that gluten of the wheat-spelt mixture is characterized by a darker colour, which becomes more intense with the increase of spelt flour percentage.

It was found that the weight fraction of gluten changed when a portion of wheat flour was replaced with spelt flour. The weight fraction of gluten decreased by 0.15-5.14%, as compared with the control sample. The weight fraction of gluten proteins in wheat flour decreases due to the reduced content of alcohol-soluble fraction of wheat gluten in the protein complex of spelt flour.

It was found that spelt flour does not have a great impact on the gluten quality (II quality group), but it should be noted that it is characterized by extensibility, which can be explained by low content of gluten fraction.

Considering that the rheological properties of dough are determined by the elasticity of gluten [15], it may be assumed that the addition of spelt flour will have an impact on this parameter. In view of this, the researches concerning the influence of spelt flour on rheological properties of dough were carried out. The rheological properties of dough were estimated using an instrumental method, Chopin Alveograph, Table 4.

| Percentage composition of spelt flour of the total flour weight | Parameter | Dough elasticity-to-extensibility ratio, (P/L) |
|---------------------------------------------------------------|-----------|-----------------------------------------------|
| 0.0                                                           | 244       | 147                                           | 3.59 |
| 10.0                                                          | 227       | 152                                           | 4.22 |
| 20.0                                                          | 213       | 140                                           | 3.68 |
| 30.0                                                          | 199       | 138                                           | 3.94 |
| 40.0                                                          | 155       | 89                                            | 1.82 |
| 50.0                                                          | 144       | 79                                            | 1.52 |

It was found that partial replacement of wheat flour with spelt flour leads to the decrease of dough elasticity by 53%, however, the dough extensibility increases when spelt flour is added.

The flour strength decreases by 41%, which suggests that plasticity of semi-finished products increased. This correlation may be explained by lower content of gluten-forming proteins in spelt flour and their hydration capacity.

Based on these findings, it is advisable to add 40-50% of spelt flour instead of wheat flour, which will not have adverse effects on the processing characteristics of dough.

The process of developing the formulation for butter cookies involved the use of technological instructions on the production of pastry products and the formulation of butter cookies “Kochetovy slasti”, in which a portion of wheat flour was replaced with spelt flour. See Table 5.

It should be noted that replacement of wheat flour with spelt flour in butter cookies does not have a great impact on the alkalinity values of finished products, which meet the specified requirements.

In addition, it was found that with the increase of percentage of spelt flour in the mixture, the moisture content of the finished products decreases. As compared with the control samples, the
moisture content of the cookies made with 50% spelt flour decreased by 5.3%, which may be explained by the fact that moisture fixation during dough kneading is more slowly, and there is more free moisture in dough at the baking stage, which results in a more intensive moisture transfer into the baking chamber.

It was also found that the absorptivity increased with the increased percentage of spelt flour in dough, which is explained by hydrocolloid properties of spelt flour.

Table 5. Correlation between quality physicochemical parameters of butter cookies and dosage of spelt flour

| Percentage composition of spelt flour of the total flour weight | Moisture content, % | Alkalinity | Absorptivity, % |
|---------------------------------------------------------------|---------------------|------------|----------------|
| 0                                                             | 5.52±0.2            | 1.55±0.03  | 125±4          |
| 10.0                                                          | 5.48±0.5            | 1.55±0.02  | 129±5          |
| 20.0                                                          | 5.43±0.4            | 1.56±0.05  | 136±4          |
| 30.0                                                          | 5.35±0.6            | 1.54±0.01  | 142±6          |
| 40.0                                                          | 5.28±0.2            | 1.55±0.02  | 149±7          |
| 50.0                                                          | 5.23±0.1            | 1.56±0.01  | 156±5          |

Having regard to the complex quality parameters, the butter cookies made with 40% spelt flour were chosen as an optimal sample.

As the pastry products are characterized by the imbalance between nutritional values and caloric content [16], the next stage of this research was devoted to finding raw materials that can enrich butter cookies with nutrients. Thus, the next stage of the experiment involved the analysis of the influence of barley malt extract on the quality of butter cookies made with wheat-spelt mixture.

Barley malt extracts were used in a dose of 2-6% at 2% intervals. The addition of barley malt extracts changed the dough moisture content (it increased by 2-5%).

The degustation of butter cookies showed that the addition of barley malt extracts (up to 4%) improved the taste properties of cookies, enhancing their aroma and flavour. The addition of 6% extract leads to the deterioration of these characteristics.

The increase of sugar content in barley malt extract makes it possible to limit the excessive swelling of flour particles, which increases the dough plasticity and decreases the density of finished products, while the absorptivity increases. See figure 1.

Based on the received results and complex quality parameters, the samples of butter cookies made with wheat-spelt mixture and 4% of barley malt extract were chosen for further analysis.

The analysis of literature data allowed to assume that the use of baking powder can be reduced by 40-50% and the use of ammonium carbon salt can be completely abandoned, if 3.0-6.0% of barley malt extract is used in the production of butter cookies made with wheat-spelt mixture. To prove this hypothesis, we explored the possibility of reducing the amount of baking powder in butter cookies. We baked butter cookies using wheat-spelt mixture with barley malt extract and sodium bicarbonate in a dose of 20-100% at 20% intervals.

The organoleptic evaluation showed that all samples of cookies were delicious and regular-shaped, but it should be noted that the content of baking powder ≤ 40% resulted in the excessive firmness of the finished products. The optimal dose of sodium bicarbonate was considered to be 60% of the total amount. The results of the conducted research were used for the development of new formulations and production technology for butter cookies “Labirint”.
To substantiate the shelf-life of the developed sorts of butter cookies, a sanitary-epidemiological assessment was carried out. The samples of butter cookies were put in plastic bags (100 g) and stored for 30, 60, 90, 105 days, at a temperature (18 ± 5) °C and relative humidity ≤75 % [17]. After that, the quality of the products was evaluated.

It was found that the addition of barley malt extract to the formulation of butter cookies made with wheat-spelt flour has a positive impact on the organoleptic parameters of quality during the entire shelf-life. The experiments proved that the product preserved its shape, surface condition and colour during the entire shelf-life.

Figure 2 shows the dynamics of change of physicochemical parameters of quality of the developed varieties of butter cookies during the shelf-life.

Based on the analysis of the dynamics of change of the physicochemical parameters of cookies, it should be noted that the extension of shelf-life leads to the increase of the product fragility and the decrease of moisture content and absorptivity.

The microbiological examination of butter cookies at the end of the shelf-life showed that the use of spelt flour and barley malt extract (“Labirint” cookies) does not increase microbiological contamination of products during the shelf-life. The microbiological safety parameters in all samples of cookies were within the normal range and met the requirements of TR CU 021/2011 (Technical Regulations of the Customs Union). See Table 6.
Table 6. Microbiological quality parameters of butter cookies at the end of the shelf-life (105 days of storage)

| Microbiological parameters, CFU/g | Requirements of TR CU 027/2012 [18] | Values |
|-----------------------------------|--------------------------------------|--------|
| **Control samples**               |                                      |        |
| Maximum allowed quantity of mesophilic aerobic and optionally anaerobic microorganisms | 1.0·10^4 | 2.2·10^2 |
| Product weight (g) Coliform bacteria (coliforms) | 0.1 | not detected |
| in which bacteria are not allowed | Pathogenic bacteria (including Salmonella) | 25.0 | not detected |
| S. aureus | Inadmissible | not detected |
| Yeast | 50.0 | 36.0 |
| Mold fungi | 100.0 | 31.0 |
| **Cookies “Labirint”**            |                                      |        |
| Maximum allowed quantity of mesophilic aerobic and optionally anaerobic microorganisms | 1.0·10^4 | 2.6·10^2 |
| Product weight (g) Coliform bacteria (coliforms) | 0.1 | not detected |
| in which bacteria are not allowed | Pathogenic bacteria (including Salmonella) | 25.0 | not detected |
| S. aureus | Inadmissible | not detected |
| Yeast | 50.0 | 40.0 |
| Mold fungi | 100.0 | 39.0 |

The chemical analysis of the developed variety of butter cookies showed that the protein content increased by 25.38%, as compared with the control sample, and the dietary fibre content increased by 95.96% [19].

The intake of 100g of cookies helps us meet our body’s needs for protein by 17.29%; for dietary fibres by 20.75%; for magnesium by 37.58%; for phosphorus by 37.33%, respectively [20].

Thus, the butter cookies made with spelt flour and barley malt extract can be attributed to functional food products.

6. Conclusion

The amino acid composition of wheat and spelt flour samples was examined. The analysis of the amino acid composition of the samples revealed that spelt flour contains 37.5% of essential amino acids of the total amount, which is by 13.6% higher than that in wheat flour. It should be emphasized that, compared with wheat flour, spelt flour has a higher content of lysine (the most deficient essential amino acid).

The bread-making characteristics of spelt flour and the wheat-spelt mixture were determined. It was found that the mass fraction of gluten decreases by 0.15-5.14% with the increase in the percentage content of spelt flour and the replacement of a portion of wheat flour with spelt flour.

The formulations for butter cookies “Labirint” were developed, which included the replacement of a portion of wheat flour with spelt flour in quantity of 40% and addition of 4% barley malt extract.

The shelf-life of the developed sort of butter cookies was determined. The samples of cookies made with spelt flour and barley malt extract were characterized by higher quality parameters during the entire shelf-life, as compared with the control samples.
It was found that new potentially healthy ingredients of plant origin can enrich butter cookies with minerals, protein and some essential amino acids, enhancing the nutritional and biological value of the finished products.

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