Improvement of the concentration and type of malt in flour-based food

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Abstract. This article presents studies of optimization of recipes and nutritional value of bakery products using six types of malt from cereals and legumes. Using the method of mathematical modeling, a reference sample, a blend was determined, and the formulation of multicomponent food products - buns and breads was optimized.

Keywords: *malt, flour-based food, optimization of recipes*

1 Introduction

The priority direction of the state policy of Russia in the provision of national food products may be the formation of domestic production of certain, most demanded types of food materials and an increase in the production of food products of mass consumption (especially common varieties of bakery products), which are enriched with irreplaceable food components that are commonly consumed all segments of the country's population [1-3].

The importance of enrichment of bakery products for the human body is due to the fact that significant modifications have occurred in the structure of their assortment. As a result of modifications, the number of nutrients received by the residents of the Russian Federation with these products has significantly decreased (vitamins: thiamine, riboflavin, nicotinic acid; amino acids, macro- and microelements, extractives, etc.)

In the project «Basic principles of State Policy in the Field of Healthy Living of the Population of the Russian Federation up to 2025»; in «Concept of ensuring sanitary and epidemiological welfare of the population by developing functional and specialized baking in the Russian Federation up to 2020» and «Strategies of improvement of quality of food products in the Russian Federation up to 2030». There are taken various measures to reduce malnutrition-related diseases which are fundamental in the area of rational and preventive nutrition. The success of the Strategy's objectives depended on ensuring the sustainable development of the food and processing industry through knowledge-based approaches and innovative solutions. One of the main directions in this sphere is: «...creation on the basis of the latest achievements ... modern principles of food combinatorics of qualitatively new, import-substituting foodstuffs with directed change of composition and properties». The

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growth of such products could not be achieved without the introduction of new technologies and the use of non-traditional raw materials, including those derived from biotechnology. The forecast for the future is to increase the production of commercial and micronutrient-enriched bread products to 300.000 tons. It is also planned to increase the production of new enriched bakeries and functional foods from 2020.

One of the current directions of bakery production is the use of malt in the processes of dough making. Malt catalyzes enzymatic processes and at the same time is a natural improver of flour: the fermentation process increases, dough becomes more elastic, water is better absorbed, and the crumb is softer and has more structural form [2, 4, 5].

Imported malt extracts are successfully used to solve the problem of expanding the range of malt preparations and bread based on them. Locally-produced malt preparations made on the basis of traditional technology from wheat and rye raw materials are less in demand. Therefore, there is a promising research which study the technological parameter of quality of existing and new malt specimen derived from different types of malt, as well as complex improvers, providing for the production of special purpose flour-based goods.

The aim of our research is a comprehensive evaluation of special purpose flour-based products which contain wheat flour with of different types of fermented malt.

The basic approach to this problem is:

- examination of the range of special purpose bread products with the addition of various types of malt produced by bakeries;
- conduction of the marketing studies to identify the consumer preferences of the population and the extent to which citizens are aware of the products manufactured with malt;
- improvement the production of a line of cereals and legumes in the manufacture of baked goods;
- development of technical and technological documentation for new products and evaluation of research results.

2 Materials and methods

The study subjects of research are dough, bread and buns with wheat, rye, barley, tritic, soy and pea malt. Bread «Stepnoy» and bun «Kuntsevskaya» were used as control samples.

The physical and chemical features of the dough and finished products were determined according to generally accepted methods [6]. Acidity was determined by the acid-base titration arbitration method routinely [7].

The intensity of gassiness was assessed by volumetric method on Yago-Ostrovsky device [6]. Humidity of the crumb was determined according to state standard 21094-75, and rheological indicators – on device «Structurometer ST-1».

Chemical composition of finished products, sampling and preparation of them for an analysis were carried out according to state standard 5667-65, according to acidity indicators (state standard 5670-96), moisture content (state standart 21094-75), protein content (state standard 26889-86), fat (state standard 5668-68) and sugar (state standard 5672-68). The determination of the nutritional value of the baked goods was carried out by the calculation method.

The complex trade analysis of the consumer properties of baked bread and bread made with high-grade wheat flour with malt cereals and legumes was carried out both in freshly prepared samples (within 1 hour) and after storage for 3 days with sensor method according to our 100-point scale descriptors. Consumer demand for a new range of baked goods was conducted by questionnaire-based survey [7].

Mathematical modeling, statistical processing of the results of the research, as well as the solution of the problem of optimization of the process of final discontinuity were carried out

on the PC with the help of application packages Mathematica, MS Excell 2007. The optimal malt concentrations in the dough are determined by mathematical programming.

3 Development stages of design and technological solutions

New bread and buns range was developed by the the method of selection of prescription components and requirements State standard 32691-2014.

The following products have been used in the manufacture of baked goods: high-grade wheat flour, malt specimen produced by industry and laboratory-grade, samples of dough with 6 types of malt and baked bread products with cereals and legumes malt spicemen. The malt was made of grain and legumes raw materials: barley «Elf» grade, wheat, rye, tritikale, soy, peas. For the activation of yeast during the baking of buns malt-free barley was chosen, contributing to the activation of yeast dough [8-9].

However, the type and concentration of malt in bread making is important. In this connection, mathematical programming methods have determined the optimal malt concentrations in the dough.

Mathematical setting to the problem of compounding for most suitable formulation of bread

Basal data: Product Quality standard Vector

$$etalon = \langle etalon(j) \rangle, j=1, M \quad (1)$$

where *etalon* (1) – protein (g) per 100 g of product;

etalon (2) – fats (g) per 100 g of product;

etalon (3) – carbohydrates (g) per 100 g of product;

etalon (4) – energy value (kkal) per 100 g of product;

etalon (5) – vitamin B₁ (mg) per 100 g of product;

etalon (6) – vitamin B₁ (mg) per 100 g of product;

etalon (7) – vitamin (mg) per 100 g of product;

etalon (8) – vitamin A (mcg RAE)/ β per 100 g of product;

etalon (9) – calcium (mg) per 100 g of product;

etalon (10) – vitamin E (mg toc. eq) per 100 g of product;

etalon (11) – phosphorus (mg) per 100 g of product;

etalon (12) – magnesium (mg) per 100 g of product;

etalon (13) – iron (mg) per 100 g of product;

etalon (14) – fibre(g) per 100 g of product;

ingredient set:

$$Ingr(i) \leq ingr(i,j) > i=1, Nj=1, M \quad (2)$$

where *ingr*(*i*, *j*) – *j*-th is the quality index of the *i*-th ingredient.

The set of ingredient quality indicators consists with the quality of the control sample.

Define:

$$vector X \leq x(i) > i=1, N \quad (3)$$

where *x*(*i*) – is the fraction of the *i*-th ingredient in the blend formulation in %, and the value of these fractions can only be taken from a set of 0, 1, 2, 3. This solution is sought with an accuracy of up to 1 per cent.

$$qup(j) = \sum_{i=1}^N ingr(i,j) \times x(i), \quad (4)$$

Acceptable decision:

The acceptable solution is to call a *k*-th variant of a vector for which it is true:

$$\sum_{i=1}^N x(k,i) = 100,$$

(5)

$$\forall k \forall i \text{ minen}(i) \leq x(k,i) \leq \text{maxen}(i)$$

(6)

where minen(i), maxen(i) – is the minimum and maximum allowable value of the ingredient in the blend (specified by the technologist).

The optimum criterium is:

Two options for the test are considered:

1. Criterion 1. Assesses the normalized difference between the reference and the blend:

$$Q1 = \sqrt{\sum_{j=1}^M \frac{(\text{etalon}(j) - \text{qup}(j))^2}{\text{etalon}(j)^2}}$$

(7)

2. Criterion 2. Assess the component with the maximum permissible absolute deviation from the relevant reference:

$$Q2 = \max_j \frac{|\text{etalon}(j) - \text{qup}(j)|}{\text{etalon}(j)}$$

(8)

Optimal solution:

1. Optimum solution 1 calls such a valid vector $X(k)$ that minimizes $Q1$:

$$Q1 = \min_k Q1(k, X(k))$$

(9)

2. The optimal solution 2 is to call such a valid vector $X(k)$ that minimizes $Q2$:

$$Q2 = \min_k Q2(k, X(k))$$

(10)

Solution of the set problem:

The problem in its class belongs to the problems of integer nonlinear mathematical programming. To solve it, an algorithm and a program have been developed that implement a scheme for the directed formation of acceptable options with the elimination of unacceptable ones. The program is implemented on the C++Builder 6.0 platform/ Figure 1 and Figure 2 show the interface of the initial stage of solving the problem for bread and buns (Table 1 and Table 2).

Fig. 1. Program interface at the first stage for bread with malt.

Fig. 2. The result of solving the problem for a bun with malt.

Thus, as a result of the mathematical planning of the problem, the optimal recipe for the ratio of yeast and malt in the production of bread (Table 1), and buns (Table 2) was set. It is obtained that for sourdough when making bread, yeast and malt must be introduced in the ratio of 3 : 4, and for making buns 2 : 3 or 1 : 1. With these ratios, the recipes of bread and buns will be as close as possible in terms of nutritional value to the control samples.

Table 1. Optimal concentrations of yeast and malt for model samples of bread dough.

Name of samples	Concentration yeast: malt	Proteins (g)	Fats (g)	Carbohydrates (g)	Energy Value (kcal)	Vitamin B ₁ (mg)	Vitamin B ₂ (mg)	Vitamin C (mg)
Control-Steppe bread		7.700	1.000	49.900	240.00	0.170	0.080	0.000
Bread with triticale malt	Optimal 1 (3:4)	10.829	1.360	66.743	322.30	0.190	0.060	0.000
	Optimal 2 (3:4)	10.830	1.361	66.740	322.27	0.190	0.062	0.000
Bread with soy malt	Optimal 1 (3:4)	10.829	1.360	66.743	322.30	0.191	0.060	0.000
	Optimal 2 (3:4)	10.830	1.361	66.740	322.27	0.190	0.062	0.000
Bread with pea malt	Optimal 1 (3:4)	11.137	1.360	66.543	322.50	0.207	0.060	0.000
	Optimal 2 (3:4)	11.140	1.357	66.540	322.47	0.210	0.063	0.000
Bread with rye malt	Optimal 1 (3:4)	10.710	1.365	66.795	321.87	0.190	0.060	0.000
	Optimal 2 (3:4)	10.713	1.370	66.800	321.90	0.192	0.065	0.000
Bread with wheat malt	Optimal 1 (3:4)	10.879	1.370	66.943	322.75	0.190	0.063	0.000
	Optimal 2 (3:4)	10.880	1.365	66.940	322.80	0.192	0.060	0.000
Bread with barley malt	Optimal 1 (3:4)	10.729	1.349	67.410	324.99	0.190	0.070	0.024
	Optimal 2 (3:4)	10.730	1.350	67.411	325.00	0.187	0.070	0.020

Table 1. Optimal concentrations of yeast and malt for model samples of bread dough. (continuation)

Name of samples	Concentration yeast: malt	Calcium (mg)	Phosphorus (mg)	Magnesium (mg)	Iron (mg)	Starch, g	Dietary fiber, g	Criterion 1	Criterion 2
Control-Steppe bread		47.00	150.00	47.00	3.900	48.310	4.400		
Bread with triticale malt	Optimal 1 (3:4)	19.60	106.96	21.05	1.400	64.608	3.320	5.26	
	Optimal 2 (3:4)	19.57	109.00	21.10	1.400	64.610	3.324		4.40
Bread with soy malt	Optimal 1 (3:4)	19.60	106.96	21.05	1.400	64.608	3.320	5.26	
	Optimal 2 (3:4)	19.57	109.00	21.10	1.400	64.610	3.324		4.40
Bread with pea malt	Optimal 1 (3:4)	21.97	104.30	20.53	1.470	64.264	3.670	5.13	
	Optimal 2 (3:4)	22.00	104.28	20.50	1.472	64.260	3.668		4.26
Bread with rye malt	Optimal 1 (3:4)	19.70	105.80	21.10	1.420	62.468	3.200	5.24	
	Optimal 2 (3:4)	19.73	105.76	21.05	1.415	62.470	3.220		4.40
Bread with wheat malt	Optimal 1 (3:4)	19.53	105.90	20.57	1.416	64.690	3.652	5.15	
	Optimal 2 (3:4)	19.50	105.92	20.60	1.420	64.688	3.650		4.27
Bread with barley malt	Optimal 1 (3:4)	18.90	103.24	20.10	1.388	62.470	3.504	2.35	
	Optimal 2 (3:4)	18.85	103.20	20.13	1.390	62.468	3.500		1.00

The best types of malt for making buns include tritikale and soy malt, which have the maximum amount of protein, compared to the rest of the malts from the experimental batch.

According to the results of the research, a complex activation of yeast was proposed when obtaining yeast dough in a non-sourdough way: by introducing an additive of malt-free barley and intensive mixing in a kneading machine [3-7, 9, 10]. This makes it possible to improve the technology of bakery products in three areas:

- reduction of the maturation time of the yeast semi-finished product;
- reducing the consumption of yeast in the production of finished products;
- improvement of the technological process by reducing the duration of fermentation of the dough.

Based on the conducted experiments and analysis of the literature data, it can be concluded that the process of dough science based on sourdough depends on the physico-chemical properties of the components of the recipe, the intensification of the technological process: the incoming products, the "strength" of the flour, the moisture content of the dough, the type of malt. Therefore, the proposed new solution to the intensification of dough science process will improve the quality of the dough, as well as the finished product

Table 2. Optimal concentrations of yeast and malts for model samples of sourdough buns.

Sample Name	Concentration yeast: malt	Proteins (g)	Fats (g)	Carbohydrates (g)	Energy Value (kcal)	Vitamin B ₁ (mg)	Vitamin B ₂ (mg)
Kuntsevskaya bun (control)		10.800	1.300	69.900	334.00	0.170	0.040
Bun with triticaevym malt	Optimal 1 (2:3)	9.296	2.077	65.679	354.67	0.161	0.051
	Optimal 2 (1:1)	8.922	3.462	64.624	370.01	0.146	0.042
Soy malt bun	Optimal 1 (2:3)	10.120	2.741	65.342	352.71	0.178	0.054
	Optimal 2 (1:1)	9.161	3.625	64.252	370.72	0.151	0.043
Bun with pea malt	Optimal 1 (2:3)	9.527	2.074	65.619	354.82	0.172	0.051
	Optimal 2 (1:1)	8.999	3.467	64.574	370.06	0.150	0.042
Bun with rye malt	Optimal 1 (2:3)	9.209	2.080	65.808	334.37	0.161	0.053
	Optimal 2 (1:1)	8.893	3.469	64.637	369.91	0.146	0.043
Bun with wheat malt	Optimal 1 (2:3)	9.266	2.080	65.919	337.89	0.161	0.051
	Optimal 2 (1:1)	8.912	3.469	64.674	363.25	0.146	0.042
Bun with barley malt	Optimal 1 (2:3)	9.221	2.068	66.270	356.71	0.157	0.056
	Optimal 2 (1:1)	8.897	3.465	64.791	370.69	0.145	0.044

Table 2. Optimal concentrations of yeast and malts for model samples of sourdough buns (continuation)

Sample Name	Concentration yeast: malt	Vitamin C (mg)	Vitamin A (mg ret. eq)	Vitamin E (mg)	Calcium (mg)	Phosphorus (mg)	Magnesium (mg)
Kuntsevskaya bun (control)		0.001	0.019	1.500	18.00	86.00	16.00
Bun with triticaevym malt	Optimal 1 (2:3)	0.000	0.024	2.623	17.49	89.10	17.48
	Optimal 2 (1:1)	0.000	0.036	3.287	16.45	77.39	14.60
Soy malt bun	Optimal 1 (2:3)	0.000	0.020	2.438	26.35	96.10	22.01
	Optimal 2 (1:1)	0.000	0.036	3.297	19.38	79.46	16.06
Bun with pea malt	Optimal 1 (2:3)	0.000	0.024	2.617	19.29	87.09	17.09
	Optimal 2 (1:1)	0.000	0.036	3.825	17.05	76.71	14.47
Bun with rye malt	Optimal 1 (2:3)	0.000	0.024	2.680	17.61	88.20	17.48
	Optimal 2 (1:1)	0.000	0.036	3.306	16.49	77.09	14.60
Bun with wheat malt	Optimal 1 (2:3)	0.000	0.024	2.686	17.46	88.32	17.12
	Optimal 2 (1:1)	0.000	0.036	3.308	16.44	77.13	14.48
Bun with barley malt	Optimal 1 (2:3)	0.060	0.024	2.613	16.95	86.31	16.79
	Optimal 2 (1:1)	0.060	0.036	3.284	16.27	76.46	14.37

Table 2. Optimal concentrations of yeast and malts for model samples of sourdough buns
 (continuation)

Sample Name	Concentration yeast: malt	Iron (mg)	Starch, g	Dietary fiber, g	Organic acids, g	Criterion 1	Criterion 2
Kuntsevskaya bun (control)		1.200	67.800	3.500	0.200		
Bun with triticalevym malt	Optimal 1 (2:3)	1.198	55.930	2.878	2.800	13.54	
	Optimal 2 (1:1)	1.066	54.860	2.826	2.800		13
Soy malt bun	Optimal 1 (2:3)	1.351	55.350	3.240	2.835	13.65	
	Optimal 2 (1:1)	1.113	54.440	2.935	2.800		13
Bun with pea malt	Optimal 1 (2:3)	1.252	55.670	3.136	2.800	13.54	
	Optimal 2 (1:1)	1.084	54.770	2.912	2.800		13
Bun with rye malt	Optimal 1 (2:3)	1.209	54.320	2.800	2.800	13.54	
	Optimal 2 (1:1)	1.070	54.300	2.800	2.800		13
Bun with wheat malt	Optimal 1(2:3)	1.201	55.990	3.124	2.800	13.54	
	Optimal 2 (1:1)	1.070	54.875	2.908	2.800		13
Bun with barley malt	Optimal 1 (2:3)	1.189	54.320	3.013	2.800	13.54	
	Optimal 2 (1:1)	1.063	54.320	2.871	2.800		13

4 Conclusions

Thus, as a result of the conducted research, it can be noted that the optimized recipes of bread and buns in terms of the ingredient composition will maximally approach the reference sample of bread, which is 4 % malt, and for buns – from 1 to 3 % malt. With these additives, the recipes of bread and buns will be as close as possible in terms of nutritional value to the control samples. And the best types of malt were triticale and soy malt, which have the maximum amount of protein, compared to the other malts from the studied samples.

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