The use of plant raw materials in the production of healthy food

Toshev Abduvali Dzhabarovich
South Ural State University (National Research University)
Chelyabinsk, Russian Federation
toshevad@susu.ru
0000-0001-8620-2065

Shcherbakova Elena Ivanovna
South Ural State University (National Research University)
Chelyabinsk, Russian Federation
shcherbakovaei@susu.ru

Rushchitc Anastasia Andreevna
South Ural State University (National Research University)
Chelyabinsk, Russian Federation
rushchitcaa@susu.ru

Abstract. The purpose of this article is to analyze the use of barley malt flour in flour products from yeast dough on the example of homemade buns. To provide the reliability of the data obtained, all analyzes were performed at least three to five times, with two parallel assessments being performed in each experiment. It was established that barley malt flour increases the nutritional and biological value of products (amino acid and fatty acid), the content of B vitamins, minerals (iron, calcium, magnesium, potassium, phosphorus) and improves organoleptic properties. Such flour products made of yeast dough with barley malt flour can be recommended for athletes.

Keywords - flour confectionery, barley malt flour, nutritional and biological value, nutrition for athletes

I. INTRODUCTION

Currently, food products must meet not only the requirements of quality and safety but solve the problem of a balanced diet resulted from increased nutritional value.

One of the problems in the nutrition of the population and athletes in recent years is the growing deficit of mineral substances (both macro- and microelements) and vitamins.

The solution to this problem goes simultaneously in two directions: by using dietary supplements containing vitamins and minerals and by developing new food technologies that provide for the maximum preservation of natural, irreplaceable nutritive elements in raw materials.

The most effective, physiologically justified, and economically affordable way to provide athletes with essential nutrients is the products enriched with them in doses corresponding to daily physiological needs. These products include flour products.

Analysis of scientific works by Polandova R.D., Ivannikova E.I., Ratushniy A.S., Dubtsova G.G., Dubtsova G.N., Tsyganova TB, Koryachkina S.Ya., Vasilenko Z.V. , and others showed that the most intensive studies on improving the technology of flour products were carried out in the last three decades [1, 2, 3, 4].

One of the promising sources of enzymes, minerals and vitamins is germinated grain called malt. The use of barley malt flour in flour confectionery products not only increases their nutritional value but also improves their quality: appearance, taste, aroma, porosity, friability.

Based on the research, the formulae of flour products with barley malt flour were developed for athletes.

II. LITERATURE REVIEW

In the Russian Federation, there are more than 450 items of flour products, incluing the products made of yeast dough (50%), cookie dough (25%), biscuit dough (15%), etc. (10%) [5, 6].

Certain types of flour products contain expensive raw materials: lipids, eggs, sugar, which increase the cost of products and calorie content (Table 1).

TABLE 1. CHEMICAL COMPOSITION AND ENERGY VALUE OF SOME FLOUR AND BAKERY PRODUCTS FROM HIGH QUALITY WHEAT FLOUR

Product	**III. CHEMICAL COMPOSITION, %**							**Energy value kcal/ 100 g**
	Water	***Proteins***	***Lipids***	***Sugar***	***Starch***	***Dietary fibers***	***Ash***	
Cream cake:								
Biscuit dough	27.2	6.8	11.6	42.5	6.8	–	0.6	356
Cookie dough	12.5	7.0	17.1	36.1	16.4	–	0.5	446
Choux pastry	20.2	5.5	25.4	31.6	6.0	–	0.5	457
Puff pastry	14.1	5.6	39.1	15.7	17.8	–	0.5	553
Yaroslavskaya bun	31.0	7.4	4.8	10.0	43.8	0.2	1.0	297

Due to the increase in the number of overweight people, it should be borne in mind that the reduction in caloric intake must be carried out, first of all, by reducing sugar, the consumption of which exceeds physiological norms.

The consumption of flour products plays a significant role in meeting the need for protein and the most important amino acids. So, the daily need for protein is covered by 38.0%, including vegetable protein by 85.5%, and in individual amino acids within 60%. The need for lysine, the amino acid most deficient in the nutritional balance, is not adequately covered. The total demand for methionine and cysteine is not satisfied.

Flour products are an important source of carbohydrates. They contain both digestible (sugar, starch, dextrins) and non-digestible carbohydrates (inulin, cellulose, hemicellulose, gum substances and mucus).

In a rationally balanced carbohydrate part of the diet, the proportion of starch in the total mass of carbohydrates should be 75%, sugars 20%, pectin 3% and fiber 2%. Flour products, depending on their formulae, satisfy the need for carbohydrates: in starch and dextrins by 41.0, in ballast substances by 57.2, and in mono- and disaccharides - by 17.4–40.0% [1 , 7].

Flour products satisfy the need for lipids in adults by 8.9-15.0%, for polyunsaturated fatty acids by 62.0%, and for phosphatides - 23.4% [1, 5, 8, 9, 10].

According to scientists, with the help of flour products, the population in the Russian Federation satisfies about 47% of the need for such important elements as copper, manganese, zinc, cobalt, the need for calcium is covered by 11.5%, and phosphorus - by 45.6%, in magnesium - by 43.1%, in iron - by 84.7% [11, 12].

Flour products are an important source of vitamins E, B1, B6, PP. The need for vitamin B3 is satisfied by 25%. The need for vitamin B2 is the least satisfied (by 18.7%).

During the baking of flour products, in the process of melanoidin formation, aldehydes, melanoidins, furfural, hydroxymethyl furfural and other compounds are formed that give the product an appropriate taste and aroma [3, 4, 13].

Thus, to use flour products for athletes, it is necessary to improve their nutritional and biological value by increasing the content of protein, amino acids (lysine, methionine, tryptophan), minerals, vitamins, polyunsaturated fatty acids due to the application of flour improvers [9 , 14, 15].

All improvers can be conditionally divided into 3 groups according to the mechanism of action: affecting the protein-proteinase complex of flour; affecting the carbohydrate-amylase complex; additives of combined action [2,6, 10, 16, 17, 18].

Complex enzymes are widely used. The source of enzymes is sprouted grain (malt), as well as various types of microorganisms (yeast, bacteria, various types of fungi). When they are added, the volume of bakery products increases, porosity, taste, aroma improve, the crumb becomes more tender, the crust acquires an intense color and gloss [16, 19, 20].

When choosing an improver for targeted modification of the protein and starch components of wheat dough, a number of requirements must be taken into account, the main of which are as follows:

- harmlessness to humans;

- effect on protein and carbohydrate components;

- specific nutritional value;

- availability and low cost.

Grain malt meets the best the abovementioned requirements.

Since ancient times, malt from various grain crops has been used in food production: barley, wheat, rye, millet, buckwheat and others. However, barley malt is the most versatile.

III. Materials and methods

Research was carried out at the Department of Technology and Catering Organization of the South Ural State University. Premium-quality wheat flour, barley malt, flour products from yeast dough (prepared according to the traditional recipe and with barley malt) were studied. For research, barley malt was preliminarily crushed in a laboratory mill LZM-3 and sieved through a mesh diameter of not more than 2 mm. The amount of flour obtained was 94-97%.

Sampling and preparation of raw materials was carried out in compliance with GOST 26929-94, finished products were treated according to GOST 5904-82. Experimental and control samples were prepared from the same batches of raw materials. Organoleptic indicators were determined by conventional methods using a five-point scale.

Physico-chemical indicators: the mass fraction of moisture in raw materials, dough and baked semi-finished products was determined according to GOST 5899-85; the content of soluble substances was determined refractometrically; total nitrogen content and mass fraction of protein were established using the Kjeldahl method; amino acid composition of samples was studied by ion exchange chromatography on an Hitachi KLA-3B amino acid analyzer; the content of total carbohydrates was determined by the permanganate method according to Bertrand; mass fraction of fat was studied by extraction in a Soxhlet apparatus; the content of thiamine and riboflavin was defined by the fluorimetric method on an OF / 3MA fluorimeter; niacin content - by high performance liquid chromatography on a Shimadzu Prominence LC-20 system; ash content - according to generally accepted methods; macro- and microelements - by the method of atomic emission and atomic absorption spectral analysis; mass fraction of phosphorus - by the molybdenum-vanadium method; fiber content - according to the method of Kürschner and Hanek.

The technological process was carried out in accordance with technological instructions and sanitary norms for catering enterprises, in compliance with the basic parameters of preparing raw materials, yeast dough, and baking products.

To obtain reliable values of the experimental data, all analyzes were carried out at least three to five times with two parallel assessments being performed in each experiment.

IV. Results and discussion

The chemical composition of wheat flour and barley malt was studied (Table 2).

The chemical composition of barley malt flour exceeds wheat flour in terms of protein content by 1.13 times, mono- and disaccharides - by 2.2 times, fiber - by 3.5 times, ash - by 1.6 times. The fat content in barley malt flour is 1.8 times less than in wheat flour.

The results of the study of the vitamin-mineral composition of wheat flour and barley malt are presented in table. 3.

Table 3 shows that barley malt flour is significantly superior to wheat flour in terms of vitamins and minerals. The content of vitamin B1 in barley malt flour is 3.3 times higher than in wheat flour, vitamin B2 - 15 times, and vitamin PP - 1.2 times.

The mineral content in barley malt flour is also higher than in premium-quality wheat flour: copper - 2.2 times; iron – 3 times; calcium - 4.3 times; magnesium – 6 times; potassium and phosphorus - 4.2 times.

The fatty acid composition of premium-quality wheat flour lipids and barley malt was studied (Table 4).

The content of saturated fatty acids in lipids of barley malt flour is lower than in lipids of wheat flour. The content of unsaturated fatty acids in barley malt flour is higher: linolenic acid - 2.8 times; arachidonic acid - 1.5 times.

Thus, barley malt flour is superior to premium wheat flour in terms of lipids, mono- and disaccharides, fiber, B vitamins, minerals and polyunsaturated fatty acids. These features of the chemical composition of barley malt flour make it possible to consider it as a natural improver in the production of flour products.

The introduction of barley malt flour into flour products will increase the nutritional and biological value of products and make it appropriate for inclusion in the diet of athletes.

TABLE 2. CHEMICAL COMPOSITION OF PREMIUM-QUALITY WHEAT FLOUR AND BARLEY MALT FLOUR

Substance	**Content, % dry matter**	
	Premium-quality wheat flour	***Barley malt flour***
Protein	12.90	14.54
Fat	1.5	0.84
Mono- and disaccharides	1.65	3.64
Starch	79.93	69.31
Cellulose	0.12	0.42
Ash	0.58	0.91

TABLE 3. VITAMIN-MINERAL COMPOSITION OF PREMIUM-QUALITY WHEAT FLOUR AND BARLEY MALT FLOUR

Substance	**Content, % dry matter**	
	Premium-quality wheat flour	***Barley malt flour***
Vitamins, mg %:		
thiamine (B1)	0.20	0.66
riboflavin (B2)	0.04	0.60
Niacin (PP)	1.34	1.63
Mineral substances, mg %:		
sodium	2.98	2.99
potassium	108.60	455.80
calcium	18.10	77.50
magnesium	17.80	107.20
phosphorus	84.00	352.00
iron	1.48	4.48
copper	0.21	0.46

TABLE 4. CONTENT OF FATTY ACIDS IN LIPIDS OF PREMIUM-QUALITY WHEAT FLOUR AND BARLEY MALT FLOUR

Fatty acids	**Content, % dry matter**	
	Premium-quality wheat flour	***Barley malt flour***
Myristine (C14: 0)	0.88	0.66
Palmitic (C16: 0)	14.62	13.22
Stearin (C18: 0)	1.54	1.02
Oleic (C18: 1)	14.66	14.86
Linoleic (C18: 2)	64.81	60.70
Linolenic (C18: 3)	3.45	9.49
Arachidonic (C20: 4)	0.04	0.06

Experiments were carried out on the preparation of flour products with barley malt flour. The studies were conducted on samples of bakery products (for example, homemade buns), replacing a part of wheat flour with barley malt flour. The amount of barley malt flour was equal 5.0-10.0% by weight of wheat flour.

It was found that the amount of more than 7.5% of barley malt flour significantly reduces the quality of products. The specific volume of products decreases, shape stability worsens, the crumb is wet, sticky with large pores. The color of the products is dark, uneven, there is a sour smell and a pronounced taste of malt.

Products with barley malt flour in the amount of 5-7.5% were not inferior in quality indicators to the control sample. A sample with 7.5% had improved organoleptic and physicochemical properties (Fig. 1).

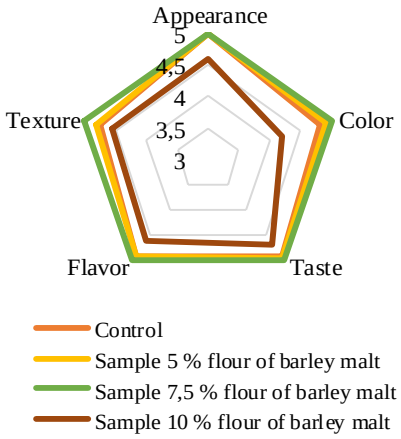

Fig. 1. Organoleptic assessment of the studied products

Further studies of the nutritional value of the developed products were carried out for the sample with barley malt four in the amount of 7.5%.

The nutritional value of the developed products was considered appropriate by the content of basic food substances, amino acids, vitamins and minerals.

The content of basic food substances in the studied samples is presented in Table 5.

Table 5 shows that the nutritional value of samples with barley malt flour is higher than that of the control sample. The protein content increased 1.1 times, mono- and disaccharides - 1.18 times, dietary fiber - 2.14 times, ash - 1.26 times. In a sample with barley malt flour, a ratio of nutrients is more balanced. The energy value of the studied samples was the following: control - 325.54, with barley malt flour - 306.56 Kcal.

Thus, the use of barley malt flour can significantly increase the nutritional value of bakery products, improve the ratio of nutrients and reduce calorie content.

To assess the effect of barley malt flour on the biological value of bakery products, the vitamin-mineral and amino acid composition was studied. The results are presented in Fig. 2. and Tables 6 - 8.

TABLE 5. CONTENT OF BASIC FOOD SUBSTANCES IN BAKERY PRODUCTS SAMPLES

Food substances	**Samples**	
	Control	***With barley malt flour 7.5 %***
Proteins, %	7.47	8.22
Lipids, %	7.70	6.72
Mono- and disaccharides, %	12.74	15.08
Starch, %	43.85	38.22
Dietary fibers, %	0.07	0.15
Ash, %	0.96	1.21
Proteins-lipids-carbs ratio	1:1.03:7.58	1:0.8:6.48

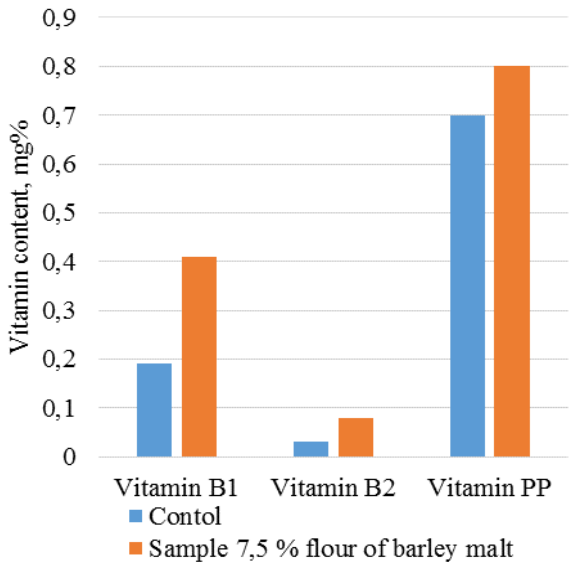

Fig. 2 Vitamin content in the samples of bakery products

Fig. 2 shows that the sample with barley malt flour contains significantly more vitamins than the control sample. In a sample prepared with barley malt flour, the thiamine content increased by 2.16 times; riboflavin by 1.33 times; niacin by 1.14 times.

TABLE 6. CONTENT OF BASIC FOOD SUBSTANCES IN SAMPLES

Food substances	**Samples**	
	Control	***With barley malt flour 7.5 %***
Copper	0.10	0.20
Iron	0.08	0.25
Sodium	0.16	0.16
Calcium	1.04	4.15
Magnesium	1.07	5.35
Potassium	54.35	217.40
Phosphorus	4.00	15.50

TABLE 7. AMINO ACID COMPOSITION OF BAKERY PRODUCTS (mg per 100 g)

Amino acids	**Samples**	
	Control	***With barley malt flour 7.5 %***
Essential amino acids:		
valine	378	403
isoleucine	283	305
leucine	527	569
lysine	230	243
methionine	261	269
tryptophan	162	167
phenylalanine	473	498
Amount of essential amino acids	*2314*	*2454*
Non-essential amino acids:		
alanine	310	327
arganin	297	318
aspartic acid	507	525
histidine	159	169
glycine	230	248
glutamic acid	2229	2390
proline	376	427
serine	306	332
tyrosine	320	333
cystine	268	278
Amount of non-essential amino acids	*5002*	*5347*
Total sum of amino acids	*7316*	*7801*

TABLE 8. AMINO ACID SCORE IN SAMPLES

Amino acids	**FAO/WHO ideal protein**	**Control**		**With barley malt flour 7.5 %**	
		A*	***B****	***A****	***B****
Valine	5.0	5.02	100.40	5.02	100.40
Isoleucine	4.0	3.75	93.75	3.79	94.75
Leucine	7.0	6.99	99.90	7.08	101.14
Lysine	5.5	3.02	54.90	3.05	55.45
Methionine-cysteine	3.5	7.00	200.00	6.81	194.60
Threonine	4.0	2.87	71.75	2.87	71.75
Tryptophan	1.0	2.15	215. 0	2.08	208.00
Phenylalanine-tyrosine	6.0	10.53	175.50	10.34	172.33

*A – amount of amino acids, %; B – chemical score, %.

The mineral content in the samples with barley malt flour also increases (Table 6): copper by 2 times; iron by 3.13 times; calcium by 3.99 times; magnesium by 5 times; potassium by 4 times; phosphorus by 3.88 times.

Amino acid composition and amino acid rate for developed flour products are given in Tables 7 - 8. Table 7 shows that when adding barley malt flour to the product, the total amino acid content increases by 6.6%, including all essential amino acids. The ratio of fractions of non-essential and essential amino acids in the studied samples is the same. In wheat flour, the fraction of essential amino acids of the total amount of amino acids is 31.6%, and in barley malt flour is 31.5%.

Table 8 shows that the content of isoleucine, leucine and lysine increased in the sample with barley malt flour. The limiting amino acids are lysine and threonine.

Thus, the use of barley malt flour in the production of flour products made it possible to increase their nutritional and biological value and reduce calorie content.

The results obtained make it possible to consider flour products with barley malt flour as a promising food for athletes. Due to the high content of protein and

carbohydrates, the developed products can serve as a source of energy during intense physical exertion. A number of amino acids (valine, isoleucine, leucine, glutamic and aspartic acids and asparagine) contained in the developed products are involved in maintaining the normal energy supply of muscle fibers during training and improving performance. Vitamins of group B (B1, B2, PP), being cofactors of oxidation reactions, also contribute to the regulation of energy metabolism in muscles during physical exertion. Minerals participating in various biochemical reactions ensure the maintenance of normal functioning of various systems and organs. Particular attention in the diet of athletes is given to the intake of iron.

Increased physical activity contributes to the removal of iron from the body and an increased risk of iron deficiency anemia [13, 14, 19]. The developed bakery products will allow athletes to adjust the intake of necessary macro- and micronutrients.

The new technology was introduced at public catering enterprises in the city of Chelyabinsk and the Chelyabinsk region, protected by copyright certificate No. 1734624 “Method for the production of flour confectionery”.

V. CONCLUSIONS

1. Theoretically substantiated and experimentally proved the effect of barley malt flour on improving the quality characteristics of yeast dough and products from it.

2. Based on the studies, the optimal dosage of barley malt flour was established, which amounted to 7.5% of the mass of wheat flour according to the recipe. Reducing or increasing the dosage leads to a deterioration in the quality of the test and finished products.

3. Products made from yeast dough prepared with barley malt flour have a higher nutritional and biological value compared to traditional recipes.

4. Developed flour confectionery products are recommended for athletes, as they have a higher content of amino acids, unsaturated fatty acids, B vitamins, iron, calcium, magnesium, potassium, phosphorus, compared to control samples.

5. The range of flour confectionery products has been expanded.

ACKNOWLEDGMENT

This work was supported by the Government of the Russian Federation (Act No. 211 dd. March 16, 2013).

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