Use of non-conventional raw materials from spring wheat grain in functional food products

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Abstract. The research represents an overview of the use of non-conventional raw materials in the food industry, as a means used for cost-cutting the final product and ensuring food's functional properties. The use of dietary fibers in functional food products has been considered. Relevance of using wheat fibers in functional food products has been substantiated. The article contains data on the chemical composition of bran, on the study of adsorption properties of wheat bran, namely the absorption of water and vegetable oil. Conclusions have been made about the wheat bran's ability to absorb water-soluble toxins and fat-containing substances from traditional raw materials and about the efficiency of using wheat bran for ensuring functional properties of cupcakes. The article presents the research on non-conventional use of spring wheat bran. Consumer quality of traditional cupcakes made with the use of bran have been investigated.

1. Introduction

Russian sphere of nutrition is characterized by a specific conception which determines a number of tasks for the food industry workers. These include: improving the structure of functional products' supply for Russia's population; solution of this problem is based on the use of non-conventional raw materials, through which the products will have an improved and more perfect chemical composition allowing for providing people with healthy food; increasing economic efficiency by saving and replacing the main raw materials with analogous ones; ensuring the competitiveness of finished products.

Therefore, the use of raw materials obtained from the processing of crop products, namely wheat grain, will improve food quality and economic performance, as well as ensure food's functional properties. All this makes relevant the research topic, which is aimed at expanding the range of food products and improving the already known formulas and technologies of food production which involves the use of products of grain processing industry.

Today we can observe the reassessment of values in developed countries. People are increasingly striving for a healthy lifestyle, both in general and in the field of nutrition. But in the majority of developed countries, the market relations, including the sphere of healthy diet, are often based on the demand-supply principle. Unfortunately, the flow of information is huge, and it is not always correct, and ordinary people may experience difficulties in finding reliable data since most of it is of
promotional and subjective character. That is why in the age of products abundance it is so important to pay attention to scientific research [1].

Today there are numerous studies that confirm the relevance of research into the field of food products, namely the use of various types of non-conventional raw materials to create functional products. Significant contribution in the development of such flour confectionery products was made by V. Rumyantsev, S. Yu. Karachkina, Kummar Kh. N., Mazza, G. Lebesi, D. M. [2.3.4.5.6.7]

Food products enriched with vitamins and minerals are part of a broad group of functional products, that is, food enriched with physiologically beneficial food ingredients that improve human health. These ingredients, along with vitamins and minerals, also include dietary fibers, lipids containing polyunsaturated fatty acids. Thus, enrichment of food with vitamins is only a part of the overall problem of food enrichment with the abovementioned essential nutrients. It is necessary to take into account the fundamental data of modern science about the role of nutrition and individual nutrients in maintaining human health and life, including the body's needs for certain nutrients and energy, the real structure of nutrition, as well as the actual provision of vitamins, macro- and microelements for Russian population [8].

Basic principles of increasing the nutritional value of food products were formulated by Russian and foreign scientists on the basis of years-long experience in the development, production, use and evaluation of effectiveness of food enrichment.

Enrichment of food products with vitamins and minerals must not impair the consumer properties of these products: reduce the content and digestibility of other nutrients contained in them, significantly change taste, aroma, freshness of products, reduce their storage terms.

When enriching food with vitamins and minerals, it is necessary to take into account the possibility of chemical interaction of enriching additives with each other and with food, and to choose such combinations, forms, methods and stages of use that ensure maximum safety of food during its production and storage.

However, in some cases, the combination of some enriching additives in one product is undesirable or impossible due to taste incompatibility, instability or undesirable interactions with each other. For example, in food enriched with iron salts or other micro-elements, it is not always advisable to add dietary fibers since they can firmly bind these elements, disrupting their absorption in gastrointestinal tract.

Flour and bread should be enriched with B vitamins, which are resistant to high temperature in the baking process, and vitamin C, on the contrary, is much less heat-resistant. In this connection, vitamin C is almost never used for enriching flour and bread. Adding small amounts of ascorbic acid in vitamin and vitamin-mineral mixtures for flour enrichment has other, purely technological purposes: it is known that ascorbic acid accelerates the process of flour maturation and improves its baking properties.

The key role in the enrichment of food is given to dietary fibers since they are contained in most sources of vitamins and minerals [3, 4].

Dietary fibers (vegetable dietary fibers and ballast substances) is a group of food components that are not broken down by enzymes of gastrointestinal tract. Our traditional diet includes cellulose, hemicellulose, pectins, and lignin – biopolymers with linear and branched structure with a molecular weight of considerable magnitude.

For a long time, dietary fibers had been considered as unnecessary ballast which should have been removed from food to increase its nutritional value. Today, a wide range of refined products, completely free from dietary fibers, has been developed: sugar, confectionery, bakery products made from fine flour, clarified fruit and vegetable juices, etc.

Reduced consumption of natural vegetable products, such as cereals, vegetables, bread made from coarse flour, and increased consumption of refined products have led to significant reduction (in 2-3 times) in the amount of dietary fibers in human diet. Lack of dietary fibers in the diet of modern man has led to decrease in the body's resistance to negative effects of the environment and to the growth of
the so-called diseases of civilization: diabetes, atherosclerosis, coronary disease of heart and bowel, obesity, malignant neoplasms, etc.

2. Materials and methods
Anatomical parts of wheat grains perform various biological functions, so they have an original chemical composition. Approximate content of main chemicals in wheat grain: protein – 10-20%, starch – 60-75%, fiber – 2-3%, fat – 2-2.5%, ash content – 1.5-2.2%. These data show that grain hulls contain more than 70% of all fiber, about 70% of minerals and about 30% of lipids. Protein content in grain hulls makes 5-8%, in seeds – 15-20%, in the aleurone layer – 16-20%. Crude fiber contents: 20-22% – in grain hulls, 1-1.5% – in seeds, and 5-7% – in the aleurone layer. Fat: 1-2% – in grain hulls, up to 0-0.2% – in seeds, 10-15% – in the aleurone layer. Ash content: 3.5-24.5% – in grain hulls, 7-20% – in seeds, 14.5-17% – in the aleurone layer. Pentosans' content makes 25-30% in grain hulls, 14-36% – in seeds, and 6-8% – in the aleurone layer. Endosperm (without the aleurone layer) contains more than 75% of all protein.

Prolamins (gliadin) and glutenin are the main wheat proteins, which build up gluten and have the greatest technological (baking) value. They account for about 74% of the total weight of protein substances. Albumins account for 20-22%, and globulin – 5-6%.

The quality of gluten, which is washed from wheat grain under normal conditions, depends on the qualitative characteristics of protein. The amino acid composition of gluten is well studied. It is defined that the properties of gluten are rather determined by structural features of proteins forming gluten than by the difference in chemical composition. The amino acid composition of strong and weak gluten is the same. Gluten is not a pure protein, it consists of 1% of lipids and 5% of starch. Different protein content and amino acid composition in grains are of different colors. It is noted that dark and yellow grains of red winter wheat differ in both characteristics. In dark grains, the protein content ranges from 13.5% to 16.63%, in yellow – from 10.811% to + 14.717%.

Anatomical parts differ markedly in ash content, which is used in practice to control the quality of graded flour. Ash content: 0.35-0.50% – in the starchy part of endosperm, 5.5-6.5% – in the embryo with a shield, 14.5-17% – in the aleurone layer, 3.5-24.5% – in grain hulls, 7-20% – in seed hulls.

Hulls of wheat grains mainly contain substances that are not assimilated by human body, such as fiber and pentosans. Distribution of chemicals in the endosperm is also uneven. The content of biologically important compounds (proteins, vitamins, minerals) increases from its center to the periphery. The aleurone layers of endosperm are characterized by the highest relative content of these substances. In the endosperm's core the protein content decreases sharply, and it's practically absent in hulls. But the cells of aleurone layer have thick walls that defy the enzymes of the human digestive tract. Therefore, consuming the aleurone layer is almost useless. Besides, it has high lipid content, which adversely affects the quality of finished food product during their storage.

The present study has revealed the adsorption properties of wheat bran obtained from different varieties of spring wheat grown with the use of growth stimulants in the Voronezh region and their further use in the manufacture of functional-purpose cupcakes.

Spring wheat bran of the following varieties was used as raw material: Prokhorovka, Krestyanka, Voronezhskaya 12, Darya. Organoleptic and adsorption properties of wheat bran have been studied.

3. Study of wheat bran's properties
Bran is a by-product of milling, which represents the hard hull of grain. The chemical composition of wheat bran is presented in Table 1.

As can be seen from the data presented, grains and oilseeds contain significant amount of dietary fibers (fiber, hemicellulose, pectin) and proteins characterized by fat-binding, fat-emulsifying properties and have a high ability to absorb moisture and to swell.

Proteins have a diphilic structure. Due to this, they are surfactants and are able to form and stabilize oil-water emulsions.
Table 1. Chemical composition of 100 g of wheat bran

| Composition: | Fatty acids: | Minerals: | Vitamins: |
|-------------|-------------|-----------|-----------|
| Water 9.89 g | Myristic acid 0.01 g | Potassium 1181 mg | E 1.49 mg |
| Carbohydrates 21.71 g | Palmitic acid 0.59 g | Calcium 73 mg | K 1.9 mg |
| Dietary fibers 42.8 g | Stearic acid 0.04 g | Magnesium 611 mg | B1 0.52 mg |
| Fats 4.25 g | Palmitoleic acid 0.02 g | Sodium 2 mg | B2 0.58 mg |
| Proteins 15.55 g | Oleic acid 0.62 g | Phosphorus 1013 mg | B5 2.18 mg |
| Ash 5.79 g | Linoleic acid 2.04 g | Iron 10.57 mg | B6 1.3 mg |
| Linolenic acid 0.17 g | Selenium 77.6 mcg | Copper 1 mg | PP 31.9 mg |
| Archidonic acid 0.01 g | Zinc 7.27 mg | Manganese 11.5 mg | B9 79 mg |

Amino acids:

- Arginine 1.09 g
- Isoleucine 0.49 g
- Methionine 0.23 g
- Phenylalanine 0.6 g
- Valine 0.73 g
- Leucine 0.93 g
- Threonine 0.5 g
- Asparagine 1.13 g
- Histidine 0.43 g
- Lysine 0.6 g
- Tryptophan 0.28 g
- Alanine 0.77 g
- Cysteine 0.37 g
- Tyrosine 0.44 g
- Serine 0.68 g
- Proline 0.88 g

Content of hemicellulose and fiber in bakery products is important because of its ability to bind water. Special attention paid to production of baked products is conditioned by the fact that hemicellulose and fibre prevent sticking.

In addition, all polysaccharides tend to thicken (to increase viscosity) due to low flexibility and the ability to form zones of compounds between the areas of macromolecules' ordered conformation. Hydrocolloids increase the viscosity of continuous dispersion medium, thereby ensuring the stability of emulsion.

Thus, on the basis of the chemical composition, we can assume that wheat bran are able to bind and emulsify fats, and absorb moisture. In this regard, they are promising raw materials being used as stabilizing additives when preparing stable emulsion in the production of flour confectionery products, as well as additional sources of dietary fibers, vitamins and minerals, which will significantly increase the nutritional value of finished products and, possibly, give them functional properties.

Adsorption properties of bran have been determined by analyzing the ability to bind moisture during swelling, absorption rate, volume increase, the ability to bind oil depending on the temperature of environment. Table 2 presents the parameters of bran processing.

Table 2. Adsorption properties of wheat bran

| No. | Environment | Temperature, °C | Amount of absorbed substance, ml/g |
|-----|-------------|----------------|-----------------------------------|
| 1   | Distilled water | 7              | 2.3                               |
| 2   | Distilled water | 20             | 2.7                               |
| 3   | Distilled water | 40             | 3.4                               |
| 4   | Vegetable oil  | 7              | 0.1                               |
| 5   | Vegetable oil  | 20             | 0.4                               |
| 6   | Vegetable oil  | 40             | 0.5                               |

As it follows from the abovesaid, the swelling of bran depends on temperature and environment. Wheat bran has the ability to absorb water and oil. Oil is absorbed much more slowly. Absorption proceeds better when the temperature rises to 40°C. And we can conclude that bran have adsorption properties and can absorb water-soluble toxins getting into the body. Besides, the ability to absorb oil
or fat in liquid form can help reduce the caloric content of the diet. Bran fibers, however, are not soluble in intestine and are excreted from body along with harmful substances and partially with fat.

The problem of increasing the amount of dietary fibers in modern man's diet is particularly acute in developed countries. Today, Russia and other countries are actively seeking for sources of dietary fibers and technology for their production and use in food products. Adult's daily requirement for dietary fibers is 25-30 g.

4. The use of wheat bran in traditional cupcakes

We have studied the effect of replacing flour with wheat bran on the quality of finished cupcakes. First of all, we've carried out the organoleptic assessment of cupcakes' quality, as the results of organoleptic analysis are decisive in determining the consumer properties of new products and developing new technologies for obtaining basic food products.

We’ve held the tasting and presented samples of confectionery products enriched with dietary wheat bran and oilseeds, cupcakes made in compliance with GOST 15052-2014. The organoleptic assessment has been carried out on a 5-point system, according to the following criteria: appearance (on 1 to 5 scale), color (on 1 to 5 scale), taste (on 1 to 5 scale), smell (on 1 to 5 scale) [48].

Two varieties of cupcakes were presented at the tasting:
Variety 1. Control – "Traditsionnyy" (Traditional) cupcake made according to the recipe;
Variety 2. Experience – "S otrubyami" (With bran) cupcake made according to the recipe of "Traditsionnyy" with partial replacement of flour with wheat bran;

Results of the tasting are presented in Table 3.

| Quality indicators on a 5-point system | "Traditsionnyy" (control) | "S otrubyami" (experience) |
|----------------------------------------|--------------------------|----------------------------|
| Appearance                             | 5                        | 5                          |
| Color                                  | 4                        | 5                          |
| Taste                                  | 3                        | 4                          |
| Smell                                  | 5                        | 5                          |
| Total assessment                       | 4.25                     | 4.75                       |

The Commission notes that the experimental samples of confectionery cupcakes "S otrubyami" are equivalent to "Traditsionnyy" ones in appearance and smell, and are superior over the latter in taste and color. They meet the requirements for finished food product according to GOST 15052-2014 "Cupcakes". General specifications

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