Application of textured wheat flour in bakery technology

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Abstract. The paper presents the study results on the effect of textured wheat flour on organoleptic, physical and chemical, and microbiological quality indicators, and storage stability of bakery products. The study objects were samples of bakery products made by the sponge and dough method with and without prior dough fermentation and those made by the quick sponge method. The addition of the studied flour in the amount of 40% by flour weight did not significantly affect the organoleptic quality indicators, as well as the moisture and acidity of bakery products made by different methods. The protein content in the test samples was 7.0–7.5 g per 100 g of the product. The lowest degree of staleness 72 h after baking could be observed in bakery products made by the sponge and dough method with prior dough fermentation. Products made by the sponge and dough method with and without prior dough fermentation showed the first signs of mold on storage day 15. The first signs of rope spoilage were found after 144 h of storage under provoking conditions in bakery products made by the sponge and dough method with prior dough fermentation. The study results yielded bakery products made from wheat flour and supplemented with textured wheat flour in the amount of 40% by flour weight. In accordance with TR TS 022/2011 'Food products in terms of their labeling', bakery products supplemented with 40% textured wheat flour made by the sponge and dough method with and without prior dough fermentation are regarded as a source of dietary fiber. A draft technical documentation has been developed for bakery products made from wheat flour supplemented with textured wheat flour.

1 Introduction

At present, the tendency of the environmental degradation, and changing rhythm of life and diet patterns cause various diseases [1]. In recent years, in Russia, the energy expenditures of humans have decreased significantly; therefore, the need for energy and its food source, reduced. Yet the need for micronutrients and other physiologically relevant substances has not changed. Regular examination of the state of health and nutrition in various groups of

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people in Russia indicates a deficiency of the vital nutrients. Therefore, development of new generation food products with increased nutritional value is of particular relevance.

To replenish the diet with the missing essential nutrients, it should include products enriched with food and biologically active substances that can reliably support all vital functions, help to maintain normal metabolism and protect against diseases and harmful environmental effects [2,3].

Bakery products are daily consumed food; therefore, they are of particular relevance for human nutrition. Bakery products satisfy the daily requirement by 25–30% for protein, by 30–40% for carbohydrates, and by 20–25% for minerals and dietary fiber.

One of the promising areas is the application of textured products for bakery product manufacturing. Such bakery products will impart new structural properties to final products and increase their nutritional value and microbiological safety [4,5].

However, there is no sufficient data on the technologies that use textured grain raw materials as formula components for bakery production to form a new structure of the products and enrich them with essential nutrients.

Thus, the studies addressing the development of bakery technology that employs textured whole grains are of current relevance.

2 Materials and methods

The study employed conventional and special methods for assessing the quality indicators of bakery products [6]. The test bakery samples were made from wheat flour of the first grade, textured wheat flour Protex, baker's pressed yeast, table salt, refined deodorized sunflower oil, white sugar, dry milk whey, and drinking water. Textured flour is made from wheat grains by extrusion and consists of porous beige granules, up to 5 mm in size, with a taste indicative of wheat flour, with flavor of wheat bran.

The quality of bakery products was analyzed 14–16 h after baking. The analysis was performed with respect to physicochemical and organoleptic quality indicators.

Moisture content in the bread crumb was determined in compliance with GOST 21094, acidity was assessed in compliance with GOST 5670, and porosity was estimated in compliance with GOST 5669. Crumbling was determined using the 'Method for determining crumble crumbling of a bakery product STP-1901' developed at the Scientific Research Institute for the Baking Industry. The degree of staleness was determined in compliance with GOST R 70085.

The method for determining aromatic substances in bakery products is based on binding of aldehydes and ketones with sodium bisulfite [6]. The mass fraction of protein in bakery products was determined by the Kjeldahl method, and the dietary fibers were analyzed in compliance with GOST R 54014.

Mold formation in bread is determined by an organoleptic method, which involves visual detection of the growth of visible colonies of mold fungi on the surface of products packed in transparent bags. For the analysis, trial laboratory baking of bread was performed in accordance with the formula and technological parameters used for manufacturing of the studied products. After baking, bread samples were cooled for 1.5–2.0 h to a temperature of 18–22 ºC in the center of the crumb. After that, bread samples were packed in transparent plastic bags for storing in a thermostat at a temperature of 24±1 ºC. Bread samples were examined while being in the bags after 3, 4, 5, 6 and subsequent days until the growth of visible colonies of mold fungi.

Signs of rope spoilage were determined in accordance with the 'Instructions for the prevention of rope spoilage in bread' developed at the Scientific Research Institute for the Baking Industry [7]. Identification of the rope spoilage was also performed by luminescent analysis using the Filin luminoscope. The method employs the phenomenon of fluorescence

(luminescence) of colonies of the rope spoilage microorganisms under ultraviolet rays, which enables detection of the development of microorganisms in the early stages.

3 Results and discussion

For analysis of the effect of textured flour on the quality indicators of wheat flour bakery products, the bread samples were made in laboratory conditions by different methods: liquid sponge and dough method with prior dough fermentation (1) and without prior dough fermentation (2), and quick dough method with the addition of whey (3). Dry textured wheat flour was added in the amount of 40% instead of wheat flour of the first grade during dough making, as was reported by earlier studies. The control was bakery products made by the straight dough method with no textured wheat flour added.

Organoleptic quality indicators of bakery products made with the addition of textured flour are presented in Table 1. Figure 1 shows bakery products made with textured wheat flour added to wheat flour.

Fig. 1. Bakery products made by different methods: C is the control sample made by the straight dough method with no textured wheat flour added; 1 – sample made by the sponge and dough method (40% textured wheat flour); 2 – sample made by the sponge and dough method without prior dough fermentation (40% textured wheat flour); 3 – sample made by the quick dough method (40% textured wheat flour)

Table 1. Organoleptic indicators of the quality of bakery products made with the addition of textured wheat flour

Indicators	**Quality indicators of bakery products**			
	C	**1**	**2**	**3**
	straight dough method without textured wheat flour	**sponge and dough method (*40%* textured wheat flour)**	**sponge and dough method (*40%* textured wheat flour)**	**quick dough method (*40%* textured wheat flour)**
Appearance of bread; shape	Regular, with a slightly convex upper crust, without blowing out			
surface	Smooth, no cracks or breaks	Rough, without large cracks and undermining, with inclusions of textured wheat flour		
color	Light yellow	Light brown		
Crumb state: color	Gray	Gray with beige inclusions		
elasticity	Good			
doneness	Baked well, not sticky, not wet to the touch			
porosity	Developed, nonuniform, without voids and seals			
Taste	Peculiar to wheat bread			
Smell	Peculiar to wheat bread			
Clumping when chewed	Absent			
Crumbling	Insignificant			

Organoleptic analysis showed that all bakery products made with the addition of textured wheat flour exhibited a regular shape with a slightly convex upper crust without blowing out, a rough surface with developed uniform porosity without voids and seals, and with taste and smell peculiar to wheat bread. After cooling (4 h after baking), all bakery products made supplemented with textured flour had an original crispy crust. Further, 14–16 h after baking, the bakery products did not crunch due to moisture redistribution.

Physical and chemical indicators of the quality of bakery products are summarized in Table 2.

Table 2. Physical and chemical indicators of the quality of bakery products made from wheat flour with the addition of textured wheat flour

Indicator	Bakery products made from wheat flour			
	C	**1**	**2**	**3**
	straight dough method without textured wheat flour	**sponge and dough method** (40% textured wheat flour)	**sponge and dough method** (40% textured wheat flour)	**quick sponge method** (40% textured wheat flour)
Volume yield, cm^3	368	327	297	336
Crumb moisture content, %	42.5	42.5	42.5	42.5
Crumb acidity, deg	2.0	2.0	2.0	2.0
Crumb porosity, %	71.0	64.0	61.0	63.0
Crumble crumbling, %	0.20	0.27	0.22	0.22
Aromatic substances, ml	10.0	16.5	15.8	16.4
Mass fraction of dietary fiber, g/100 g of product	2.6	3.7	3.9	2.9
Proteins, g/100 g of product	7.5	7.5	7.5	7.0

The data in Table 2 show that bakery products made by the straight sponge method with prior dough fermentation (option 1) and by the quick sponge method with the addition of whey (option 3) and 40% textured wheat flour exhibited the best physical and chemical indicators.

Bakery products made by different methods showed the content of aromatic substances increased by 44.0–65.0% compared to that in the control. The formation of aromatic substances in bakery products depends on the baking formula, the dough making method, and the fermentation time. The protein content in bakery products made by different methods varied from 7.0 to 7.5 g per 100 g of product.

Bakery products made by different methods with the addition of textured wheat flour exhibited the content of dietary fiber increased by 3.8–50.0% compared to that in the control. The increased content of soluble and insoluble dietary fiber in the test samples is likely due to both the method of dough making and different duration of fermentation of semi-finished products.

Consumer properties of bakery products, primarily taste qualities, deteriorate during storage, which is related to staling and drying processes. During these processes, the crumb becomes firmer and less elastic; it loses its taste and flavor. These transformations are caused by complex physicochemical, colloidal and biochemical processes that occur during bread storage and are related to changes in the structure and properties of the main biopolymers, such as gluten proteins and starch (staling), and to the decreased weight due to loss of moisture and volatile substances (drying out).

We studied the effect of textured wheat flour on the rate and degree of staleness in bakery products (Table 3).

Table 3. Indicators of the degree and rate of staleness in bakery products supplemented with textured wheat flour during their storage

Sample*	Indicators of the degree of staleness (F, g)			Rate of staleness (ΔF/Δτ, g/day)
	after 24 h	after 48 h	after 72 h	
C	623	743	831	103,75
1	1284	1369	1840	277,75
2	1500	2077	2302	401,00
3	1281	1500	1951	335,25
*C – control sample made by the straight dough method (without textured wheat flour); 1 – samples made by the sponge and dough method (40% textured wheat flour); 2 – samples made by the sponge and dough method without prior dough fermentation (40% textured wheat flour); 3 – samples made by the quick sponge method (40% textured wheat flour)				

It was found that 72 h after baking, bakery products made according to option 2 showed the highest degree of staleness; it attained 2302 g, which is 18–25% higher compared to that in the test samples. The highest rate of staleness was revealed for bakery products made according to option 2; it amounted to 401 g/day. The lowest rate of staleness was observed in bakery products made according to option 1.

A significant amount of wheat flour supplied to plant bakeries is infected with spores of mold fungi and potato bacillus, which cause mold and rope spoilage in bread. This problem is one of the main challenging issues in the baking industry.

After baking, bakery products are sterile, yet they become secondary contaminated during cooling, stacking, cutting, and packaging. The optimal conditions that induce development of microorganisms is a temperature of 20–40 ºC, pH of 5–6, and moisture content exceeding 20%.

To reveal the first signs of mold, bakery products made with the addition of textured wheat flour were placed in transparent plastic bags and stored in the thermostat at 24 ± 1 ºC. The samples were examined in the bags. The data obtained are presented in Figure 2.

Analysis of the data in Figure 2 showed that the first signs of mold were revealed in bakery products made by the quick sponge method (option 3) on storage day 13. In other bakery products, the first signs of mold were found on day 15.

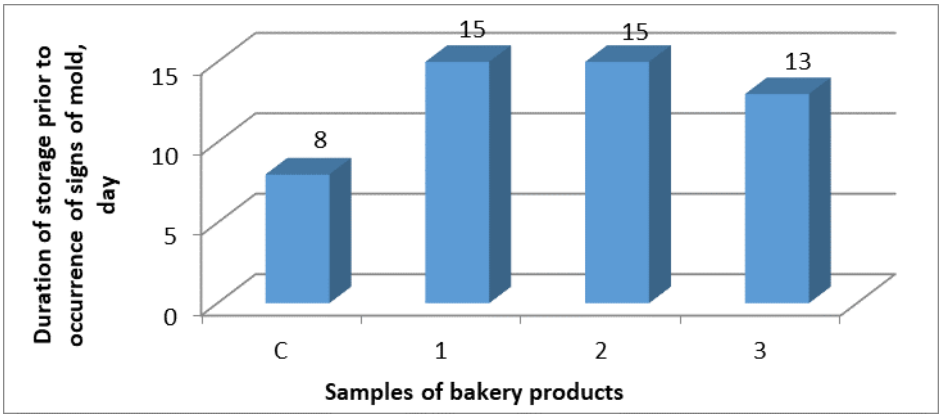

Fig. 2. Mold resistance of bakery products made by different methods: C – the control sample made by the straight dough method (without textured wheat flour); 1 – samples made by the sponge and dough method (40% textured wheat flour); 2 – samples made by the sponge and dough method without prior dough fermentation (40% textured wheat flour); 3 – samples made by the quick sponge method (40% textured wheat flour)

Figure 3 presents the study results on the effect of the bakery method that involves textured wheat flour on the development of rope spoilage.

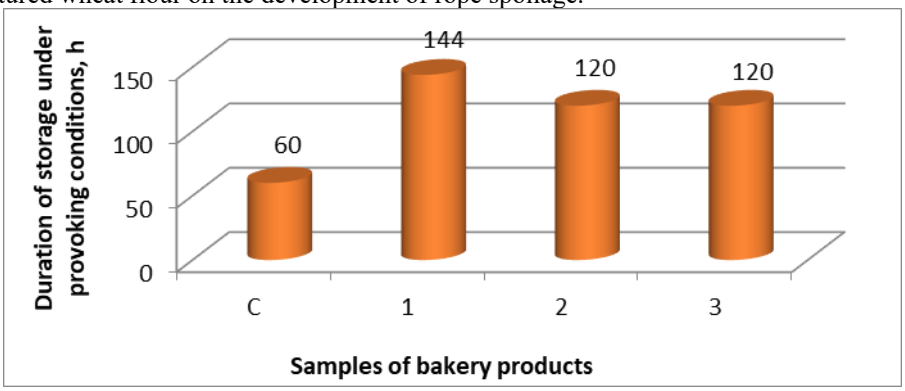

Fig. 3. Rope spoilage resistance of bakery products made by different methods: C – control sample made by the straight dough method (without textured wheat flour); 1 – sample made by the sponge and dough method (40% textured wheat flour); 2 – samples made by the sponge and dough method without prior dough fermentation (40% textured wheat flour); 3 – samples made by the quick sponge method (40% textured wheat flour)

The analysis of the data presented in Figure 3 showed that bakery products made by the quick sponge method (option 3) and by the sponge and dough method without prior dough fermentation (option 2) exhibited the first signs of rope spoilage after 120 h of storage. Bakery products made by the sponge and dough method with prior dough fermentation exhibited the first signs of the disease after 144 h under provoking conditions.

In accordance with Annex 5 to the technical regulation of the Customs Union 022/2011 'Food products in terms of their labeling', bakery products made according to option 1 with a dietary fiber content of 3.7 g/100 g and those made according to option 2 with a dietary fiber content of 3.9 g/100 g are regarded as a source of dietary fiber (not less than 3 g per 100 g for solid food products) [8].

In the study, bakery products were made from wheat flour and supplemented with textured wheat flour in the amount of 40% by flour weight. The draft technical documentation was developed for bakery products supplemented with textured wheat flour.

4 Conclusions

The results of the study into the effect of textured wheat flour on organoleptic, physical and chemical, microbiological quality indicators, and storage stability of bakery products showed that the addition of this flour in the amount of 40% by flour weight did not significantly affect the moisture content and acidity of bakery products made by different methods.

Bakery products made by different methods and supplemented with textured wheat flour in the amount of 40% showed a regular shape with a convex upper crust, a rough surface with inclusions of textured wheat flour, developed nonuniform porosity, and taste and flavor peculiar to wheat bread.

It was found that the protein content in the test samples varied from 7.0 to 7.5 g per 100 g of product. In accordance with TR TS 022/2011 'Food products in terms of their labeling', bakery products supplemented with 40% textured wheat flour and made by the sponge and dough method with and without prior dough fermentation are regarded a source of dietary fiber (not less than 3 g per 100 g for solid food products).

The lowest degree of staleness 72 h after baking was found for bakery products made by the sponge and dough method with prior dough fermentation and addition of 40% textured wheat flour; it attained 1840 g, that is 5–20% lower compared to that in other bakery products.

The first signs of mold were observed in bakery products made by the quick sponge method on storage day 13. In bakery products made by the sponge and dough method with and without prior dough fermentation, the first signs of mold were found on day 15. The first signs of rope spoilage were found in bakery products made by the quick sponge method and by the sponge and dough method without prior dough fermentation after 120 h of storage under provoking conditions; bakery products made by the sponge and dough method with prior dough fermentation exhibited the first signs of the disease after 144 h. The study results were used to make bakery products from wheat flour with the addition of textured wheat flour in the amount of 40% by flour weight and to develop a draft technical documentation for bakery products supplemented with textured wheat flour.

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