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THE QUALITY AND NUTRITIONAL VALUE OF OATMEAL COOKIES OF DIFFERENT RECIPES

Julia BETZ[1] Natalya NAUMOVA[1]
Aleksandr BUCHEL[2] Vitaly ZHURAVEL[2]
Irina MINASHINA[2]

Abstract: *We established that first-grade baking wheat flour quantitatively prevails in the composition of "Domashnee" cookies, while the oatmeal mixture prevails in the composition of "Premium" cookies. The main carriers of nutritious and functional components are oatmeal and the dry mixture based on it. Taking into account the results of nutritional tests of both types of cookies, we consider flour-based "Domashnee" cookies to be the most adequately balanced sample in terms of protein, fat, carbohydrates, dietary fiber, amino acid scores and the amount of minerals (zinc, copper, calcium, manganese) and vitamin B_1.*

Key words: *Oatmeal cookies, nutritional value.*

1. Introduction

Oatmeal cookies are included in the most widespread group of the baked goods market. They account for about 40% of all baked goods consumed by Russian citizens [16]. Over the past five years there has been an increase in the sales of this product. This is a result of both the promotion of healthy nutrition, and increased consumer interest in oatmeal cookies having an increased nutritional value [6].

Oatmeal is currently considered a source of vegetable protein, lipids, vitamins of group B, PP, E, minerals, and soluble fiber [1], [15]. Oats, as compared to other cereals, are the most effective in reducing the level of "bad" cholesterol in humans and animals [18]. This is due to oat β-glucan, which reduces the absorption of bile acids and cholesterol [2]. Oats also have different pharmacological activity and are notable for their anti-inflammatory, immunomodulatory, and anti-diabetic properties [8].

[1] South Ural State University (national research university), 76, Lenin prospekt, Chelyabinsk, Russia, 454080;
[2] South Ural State Agricultural University, 13, Gagarin street, Chelyabinsk region, Troitsk, Russia, 457100;
Correspondence: Natalya Naumova; e-mail: n.naumova@inbox.ru.

Many proposals for new products in the oatmeal cookie range which are produced with innovative elements have appeared. For example, dry mix-based oatmeal cookies. However, consumers are not always ready to choose new products. They express their distrust of the naturalness and benefits of such products [10, 13]. To this end, it was important to study the quality and nutritional value of oatmeal cookies produced according to different recipes.

2. Materials and Methods

The research objects included:

- High – and first-grade wheat flour, oatmeal produced by Soyuzpischeprom Association LLC (Russia, Chelyabinsk region, Chelyabinsk);
- "Oatmeal bake mix" dry mix produced by TRIER-SPB LLC (Russia, Leningrad region, St. Petersburg). Ingredients: natural textured oatmeal, egg powder, E450i, E500ii baking powder, edible salt, dry milk whey, ground cinnamon, vanilla flavoring;
- Flour-based "Domashnee" (homemade) cookies of a traditional recipe;
- Flour mix- and flour-based "Premium" oatmeal cookies.

The recipes of the cookies are presented in Table 1. The cookies were made taking into account the specifics of the process parameters provided in the relative operating procedures. "Domashnee" cookies were baked in a continuous-flow conveyor oven, the baking duration was 11–13 minutes at the following temperature: in oven zone 1 – 160 ... 180°C; zone 2 – 230 ... 250°C; zone 3 – 120 ... 140°C. "Premium" cookies (based on the dry mix) were baked in a convection oven at 165°C for 18 – 20 minutes. The finished cookies were cooled to a temperature of 18 ± 2°C and tested.

Moisture was determined by drying the sample at 130°C for 40 minutes to a constant mass followed by measurements; protein content – by sample mineralization using the Kjeldahl method; fat content – using the extraction method in a Soxhlet extractor; ash content – by complete combustion of the organic portion of the sample with subsequent gravimetric determination; phosphorus content – by the molybdenum-vanadium method; the content of the remaining mineral elements – by the flame atomic absorption method; fiber content - by hydrolysis and removal of protein and starchy substances with enzymes. β-glucan was extracted from the flour using two-step alkaline and enzymatic methods [20].

The cookies were additionally tested by the following indicators: organoleptic characteristics were determined visually and during testing; the alkalinity was determined by filtrate titration with hydrochloric acid (0.1 mol/dm^3) in the presence of bromthymol blue with subsequent calculation of the studied indicator; the absorptivity of the products was studied by immersing them in water at 20°C for a certain period of time followed by calculation. The number of products in 1 kg was determined by weighing and counting. The content of trans fatty acid isomers was determined by gas chromatography with a capillary column. Vitamin B_1 and B_2 content was determined by the fluorimetric method, vitamin E – by high performance liquid chromatography [20].

The norms of the daily requirements for food and biologically active substances

were taken from Methodological Recommendations "The norms of physiological needs for energy and nutrients for different groups of the population of Russia".

Statistical analysis was performed using Microsoft Excel XP and Statistica 8.0. Statistical error did not exceed 5% (with a 95% confidence level). All statistical analyses were performed using SPSS statistics, version 17.0 (SPSS Inc., Chicago, USA).

Table 1

Summary recipe of oatmeal cookies

Name of raw materials	Mass fraction of dry matter [%]	Consumption of raw materials per 1 ton of finished products [kg]			
		"Domashnee" cookies		"Premium" cookies	
		actually	in dry matter	actually	in dry matter
First-grade wheat flour	85.50	398.33	340.58	–	–
"Oatmeal bake mix" dry mix	91.00	–	–	238.81	217.31
High-grade wheat flour	85.50	–	–	199.01	170.15
Granulated sugar	99.85	295.71	295.26	358.21	357.67
Shortcrust margarine 82%	82.00	199.16	163.31	278.61	228.46
Oatmeal	85.50	170.71	145.95	–	–
Maltose syrup	78.00	34.15	26.64	–	–
Salt	96.50	4.54	4.38	–	–
Baking soda	50.00	3.98	1.99	–	–
Cinnamon	100.00	0.85	0.85	–	–
Vanillin	100.00	0.68	0.68	–	–
Water	–	102.45	–	278.61	–
Total	–	1210.56	979.64	1353.25	973.59
Yield	94.00	1000.00	940.00	1000.00	940.00

3. Results and Discussion

3.1. The Results of Studying the Raw Materials

It is well known that one of the fundamental factors influencing the nutritional value of flour-based baked goods is the chemical composition of the flour used. Therefore, at the first stage of testing, we studied traditional types of flour and oatmeal baking mix from the standpoint of food chemistry. The analysis of the macronutrient composition of various raw materials has shown that the oatmeal and the oatmeal mix significantly (4-5 times) exceed high- and first-grade wheat flour by the lipid content (Table 2). It is known that oatmeal fat is classed as lipids with high biological activity [9], [19], [21, 22].

It was revealed that the oatmeal bake mix differs from the traditional types of flour in its protein and moisture content. The latter circumstance should be considered when calculating the water needed to knead the dough.

The studied wheat and oat raw materials have no extreme differences in the total dietary fiber content. However, the oatmeal baking mix contains a

relatively smaller amount of insoluble fiber, which acts as a kind of "scrub" for the intestines, removing toxins from the body. The test results have revealed a significantly high content of soluble β-glucan in the oat raw materials, which is consistent with the well-known data established by a number of scientists [3], [10], [14]. The European Food Safety Authority has established the influence of beta-glucans on the reduction of the risk of developing cardiovascular diseases and diabetes complications [2]. The content of β-glucan in oats can vary from 3 to 5 g 100 g, depending on their botanical variety and climatic, environmental, and agrotechnical factors [8]. This circumstance, in turn, may explain the smaller amount of the studied functional component in the oatmeal mix.

Table 2

The chemical composition of the analyzed raw materials

Definable indicator	Test results			
	"Domashnee" cookies		"Premium" cookies	
	1-grade wheat flour	oatmeal	high-grade wheat flour	oatmeal mix
Mass fraction of fat in terms of dry matter [5]	1.53 ± 0.02 ^{e}	7.90 ± 0.06 ^{f}	2.21 ± 0.04 ^{e}	7.43 ± 0.05 ^{f}
Mass fraction of protein [%]	10.7 ± 0.3 ^{a}	11.5 ± 0.4 ^{b}	11.9 ± 0.3 ^{a}	13.0 ± 0.2 ^{b}
Moisture content [%]	14.0 ± 0.3	10.5 ± 0.2 ^{f}	13.3 ± 0.3	8.2 ± 0.2 ^{f}
Total content of dietary fiber [g/100 g], including:	4.63 ± 0.04 ^{c}	4.34 ± 0.05 ^{d}	4.41 ± 0.03 ^{c}	4.09 ± 0.04 ^{d}
- soluble,	1.31 ± 0.12	1.21 ± 0.09 ^{d}	1.20 ± 0.07	1.64 ± 0.08 ^{d}
- insoluble	3.32 ± 0.13	3.13 ± 0.11 ^{f}	3.21 ± 0.09	2.45 ± 0.07 ^{f}
Content of β-glucan, %	0.20 ± 0.02	4.44 ± 0.17	0.18 ± 0.02	3.79 ± 0.15
Ash in dry matter [%]	0.72 ± 0.02 ^{e}	1.29 ± 0.04 ^{f}	0.51 ± 0.03 ^{e}	2.92 ± 0.05 ^{f}

The studies were performed in five replicates (n=5). Values with different superscripts in the same row significantly different (a,b - P<0.05; c,d - P<0.01; e,f - P<0.001).

It has been revealed that the mass fraction of ash in the oatmeal mix significantly exceeds the indicator of the traditional flour types, which indicates its rich mineral composition. This may be the result of both the presence of whey and egg powder as well as of baking powder and salt in the composition of the flour mix. In this regard, we studied the content of individual macro- and micronutrients in the raw materials. The obtained results are consistent with the data on the ash content of the corresponding raw material samples (Table 3).

We established the advantage of the oat raw materials over wheat in terms of the content of the studied mineral elements. Compared to first-grade wheat flour, the dry oatmeal mix contains more macronutrients (phosphorus – 6.7 times more, magnesium – 2.7, calcium – 21%) and microelements (iron – 4.3 times more, zinc – 2.8, manganese – 1.8, copper – 1.5). At the same time, the oat baking mix contains 3.4 times more phosphorus, 35% more iron, and 11% more calcium than the traditional oat flour.

3.2. Results of Studying the Finished Products

At the second test stage, we studied the quality and nutritional value of oatmeal cookies.

Table 3

The mineral composition of the analyzed raw materials

Definable element	Test results [mg/kg]			
	"Domashnee" cookies		"Premium" cookies	
	1-grade wheat flour	oatmeal	high-grade wheat flour	oatmeal mix
P	1140.04 ± 184.31	2269.96 ± 327.23 [b]	948.37 ± 172.05	7640.78 ± 1192.42 [b]
Ca	2120.54 ± 168.44	2311.87 ± 201.18	2040.63 ± 154.06	2562.50 ± 224.25
Cu	2.79 ± 0.28 [b]	6.06 ± 0.52	1.81 ± 0.07 [b]	4.21 ± 0.33
Fe	29.54 ± 2.11 [b]	95.35 ± 8.46 [a]	19.70 ± 1.65 [b]	128.29 ± 11.66 [a]
Mg	499.31 ± 47.23	1298.71 ± 116.47	443.33 ± 37.24	1336.40 ± 131.52
Mn	21.20 ± 1.19 [c]	42.80 ± 3.98	11.40 ± 1.32 [c]	38.72 ± 2.37
Zn	7.93 ± 0.55	29.86 ± 2.78	10.10 ± 1.04	22.13 ± 2.09

The studies were performed in five replicates (n=5). Values with different superscripts in the same row significantly different (a - P<0.05; b - P<0.01; c - P<0.001).

Taking into account the characteristics of the production process for each type of cookie, we found the difference in the size of products, and, as a result, the difference in the number of product units in 1 kg. So, "Domashnee" cookies are larger, and, accordingly, there are fewer products per 1 kg (at least 45 pieces). 1 kg of "Premium" cookies contains at least 55 pieces.

The study of the organoleptic properties of oatmeal cookies did not reveal any differences in the external characteristics of the products when the samples were studied visually, by taste, and by aroma. Both of the cookies are round with a characteristic indefinite form, without dents or edge damage. The surface of the cookies is rough, with characteristic winding cracks, without burns or blisters. The product color is brown and uniform throughout the mass. The taste and aroma have sweet, vanilla-cinnamon tones. When broken, the products are well-baked, loose, with a uniform porous structure, without cavities or traces of undermixing. The obtained results of the organoleptic assessment of the cookies' quality fully comply with the requirements of the regulatory documents.

The use of measuring methods allowed us to obtain more objective data. The results of measuring the alkalinity and absorptivity of both types of oatmeal cookies (Table 4) have established that their quality complies with regulations (no more than 2.0 degrees and no less than 150%, respectively).

The moisture content of the studied samples of cookies has a quantitative difference of 1.6%. At the same time, both types of cookies are within the current norms: no more than 10.5% for "Domashnee" cookies, no more than 6.0 ± 1.5% – for "Premium" cookies.

Table 4

Indicators of the quality and chemical composition of oatmeal cookies

Definable indicator	Test results	
	"Domashnee" cookies	"Premium" cookies
Alkalinity [degrees]	1.81 ± 0.03	1.85 ± 0.04
Absorptivity [%]	186.6 ± 2.9	185.4 ± 2.7
Moisture content [%]	7.6 ± 0.3 [a]	6.0 ± 0.4 [a]
Mass fraction of total sugar (by sucrose) [%]	31.2 ± 0.7 [b]	36.1 ± 0.5 [b]
Mass fraction of fat in terms of dry matter [%]	18.1 ± 0.5 [b]	23.8 ± 0.6 [b]
Content of trans fatty acid isomers [%], including:	1.855 ± 0.015	1.856 ± 0.013
C18:1n9t elaidinic-trans	0.215 ± 0.009	0.217 ± 0.006
C18:2t-9,t-12	0.276 ± 0.007	0.278 ± 0.008
C18:2c-9,t-12	0.370 ± 0.009	0.372 ± 0.009
C18:2t-9,c-12	0.360 ± 0.010	0.360 ± 0.012
C18:3t-9,c-12,t-15	0.038 ± 0.005	0.034 ± 0.004
C18:3c-9,c-12,t-15	0.336 ± 0.009	0.333 ± 0.008
C18:3t-9,c-12,c-15	0.260 ± 0.008	0.262 ± 0.009
Mass fraction of protein [%]	6.4 ± 0.3 [a]	5.0 ± 0.3 [a]
Total content of dietary fiber [g/100 g], including:	2.42 ± 0.07 [b]	1.83 ± 0.05 [b]
- soluble,	0.70 ± 0.03 [a]	0.61 ± 0.02 [a]
- insoluble	1.72 ± 0.12	1.22 ± 0.10
Content of β-glucan [%]	0.84 ± 0.05	0.93 ± 0.03
Ash in terms of dry matter [%]	1.08 ± 0.02	1.66 ± 0.04

The studies were performed in five replicates (n=5). Values with different superscripts in the same row significantly different (a - P<0.05; b - P<0.001).

The peculiar features of the recipes (the amount and ratio of sugar, syrup, and margarine) ultimately resulted in a difference in the quantitative content fats and carbohydrates (sugar). The flour mix- and flour-based cookies contain more saturated fats (by 5.7%) and sucrose (by 4.9%).

Experts of the World Health Organization pay much attention to the role of fats and their components in healthy nutrition with an emphasis on the negative impact of trans fatty acid isomers on human health [11]. Studies have established that the content of trans fatty acid isomers in the lipid fraction of both recipes of the cookies from the inclusion of margarine does not exceed the norm – no more than 2.0%. We determined a quantitative 36 – 37% prevalence of the trans isomers of linoleic acid (18:2) over the trans isomers of linoleic acid (18:3), which is characteristic of hydrofats [17]. We also noted the presence of the oleic acid isomer (C18:1n9t) at 0.215 – 0.217%. However, given that the flour mix- and flour-based cookies contain more fats (by 5.7%), there are also more trans isomers in the total mass of these cookies.

It has been established that "Premium" cookies contain less protein (by 1.4%) than "Domashnee" cookies. It is necessary to take into account that the average protein deficiency in the population of the Russian Federation is 25%. Therefore, one of the urgent problems is the rationalization of

nutrition in order to eliminate protein deficiency. The consumption of 100 g of "Domashnee" cookies satisfies 5.5-9.8% of the daily protein requirements for an adult male, and 7.4–11.0% for adult females. "Premium" cookies satisfy 4.3–7.7% for females and 5.7–8.6% for men.

The calorie content of the flour mix- and flour-based cookies is 474 kcal/100 g of product (compared to 446 kcal of the flour-based products). With this in mind, the macronutrient composition of "Premium" cookies corresponds to the concept of modern healthy nutrition to a lesser extent. However, both oatmeal cookies meet the established standards by protein, fat, and carbohydrate content.

The analysis of the oatmeal cookie recipes has shown that first-grade wheat flour quantitatively prevails by the use of raw cereal (by 2.3) in "Domashnee" cookies, and the oatmeal mix (by 20%) – in "Premium" cookies.

The recipe ratio of wheat flour and oatmeal mix recommended by the manufacturer when developing "Premium" cookies allowed us to obtain products with a slightly higher content of β-glucan (by 11%), but a lower total content of dietary fiber (by 25%). The latter does not favor the customer's choice of this product, since dietary fiber is of great importance to the human body. The amount of dietary fiber per 100 g of "Domashnee" cookies satisfies 12% of the daily dietary requirement, whereas in the competing cookies, 9% of the requirement is satisfied.

The ash content of "Domashnee" cookies was 53.7% lower than the analogous indicator of "Premium" cookies. In this regard, we studied the mineral composition of both types of cookies. It has been determined (Table 5) that the flour-based cookies contain less phosphorus (by 2.5 times), and iron (by 18%), magnesium (by 7%), but more zinc (by 25%), copper (by 23%), calcium (by 19%), and manganese (by 4%). The detected amounts of iron and manganese in 100 g of the flour mix- and flour-based cookies can satisfy over 87% of the daily nutritional requirements for adults, phosphorus – 25%, calcium and copper – 20-21%, magnesium – 12%, and zinc – 7%. The consumption of the same amount of flour-based cookies satisfied a larger human need for manganese – 91%, copper – 26%, calcium – 24%, and zinc – 9%. Minerals are very important for maintaining the acid-alkali balance in the body and for building tissue and bone [4].

Scientists note the relatively high content of vitamins B_1, B_2, B_6, B_9, E in oatmeal [15] and moderate content in wheat flour. However, it is also known that in the process of baking flour-based confectionery products, a considerable percentage of vitamins are destroyed. It has been determined that "Domashnee" cookies contain more vitamin B_1 (by 2 times), which contributes to satisfying 11% of the daily nutritional requirement for adults when consuming 100 g of the products. "Premium" cookies are distinguished by a somewhat higher amount of vitamins E (by 39%) and B_2 (by 20%). This contributes to the satisfaction of 113% and 13% of the daily nutritional requirement, respectively, compared to 81% and 11% in "Domashnee" cookies. Vitamin E is not only important for the stimulation of the human immune system [5], [21], but also for the stabilization of the oxidative deterioration of food products rich in fats, which include oatmeal cookies.

Table 5

The mineral and vitamin composition of oatmeal cookies

Definable nutrient	Test results [mg/kg]	
	"Domashnee" cookies	"Premium" cookies
P	823.62 ± 74.13 [a]	2033.41 ± 198.20 [a]
Ca	2428.70 ± 240.44	2041.93 ± 203.84
Cu	2.63 ± 0.22	2.14 ± 0.21
Fe	71.41 ± 6.33	87.20 ± 7.76
Mg	467.47 ± 42.75	500.50 ± 50.13
Mn	18.22 ± 1.72	17.53 ± 1.85
Zn	10.89 ± 1.09	8.70 ± 0.67
E (tocopherol)	12.14 ± 3.90	16.92 ± 5.42
B_1 (thiamine)	0.16 ± 0.05	0.08 ± 0.02
B_2 (riboflavin)	0.20 ± 0.05	0.24 ± 0.05

The studies were performed in five replicates (n=5). Values with different superscripts in the same row significantly different (a - P<0.001).

4. Conclusions

The results of our studies showed that the amount and ratio of ingredients used for the production of two types of oatmeal cookies differ significantly. First-grade bakery wheat flour is quantitatively prevalent in the composition of the flour-based cookies, while oatmeal mixture is prevalent in the dry mix- and flour-based products. The main carriers of nutritional and functional components in the production of the studied cookies are oatmeal and an oatmeal dry mix. The consumer properties and the considered physico-chemical indicators of the flour-based oatmeal cookies and the flour mix- and flour-based products do not have any differences, except for the size of the final product. However, taking into account the cumulative results of testing the nutritional value of both types of cookies, we can consider the flour-based products to be most adequately balanced by the content of macro- and micro-components.

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