

Evaluation of cupcakes bioavailability and nutritional value

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Abstract. Numerous studies aimed at expanding the production of domestic healthy food products meet the objectives of national programs and projects implemented at the state level. Flour confectionery products are known to be an integral part of the food basket of our country's inhabitants. Therefore, the use of non-traditional vegetable raw materials with a high content of fiber, vitamins, and minerals in their manufacture is an important research field. In addition, these technologies are resource-saving and allow expanding the range of products for specialized and therapeutic purposes, including those for people with gluten intolerance. However, it should be mentioned that the introduction of additional raw materials is an interference with the traditional cooking technology and may affect the finished product quality, which requires additional research. Therefore, the effect of biologically active components on the bioavailability and nutritional value of a cupcake enriched with non-traditional types of raw materials was studied in the work. The ciliates *P. caudatum* were used as a test object for assessing the studied samples bioavailability. In addition, indicators of nutritional and energy value were determined in finished products. The studies carried out proved that the use of whole wheat flour, grape seed flour, sesame oil and sesame seeds in the production of cupcakes helps to increase its biotic potential, biological and nutritional value.

1 Introduction

The development of domestic competitive foods that contribute to a healthy lifestyle maintaining is one of the highest priority areas of the Russian Federation state policy. Therefore, the application of non-traditional raw materials for the production and widening of the food products range, including flour confectionery products, the determination of their bioavailability by biotesting with various test systems is an important task. The urgency of this problem is currently growing, since food safety is the main factor determining human health, as well as the gene pool preservation.

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Many food products with non-traditional raw materials have been developed recently [5-10]. The list of functional enrichers is noticeably expanding from year to year. Vegetable raw materials should be noted to have a number of important advantages, as they contain a natural composition of biologically active substances, macro- and microelements in an accessible and digestible form. The technology of its application is resource-saving. Various types of flour, as well as oilseed meal, powders and purees from vegetables and fruits are most often used as non-traditional raw materials in the development of new types of flour confectionery [11-14].

The expediency of the application of vegetable flour from pumpkin seeds, watermelon, rose hips, flax, grapes, milk thistle in the technology of cupcakes as a protein enricher and a source of fiber was determined in the paper [15]. The introduction of pomace and concentrated juice from cherries, black currants, chokeberries and blueberries into the flour confectionery products recipe had a beneficial effect on their physicochemical parameters and antioxidant potential, while the content of vitamins and dietary fiber was increasing [16]. The introduction of vegetable puree instead of wheat flour to the biscuit products recipe increased such indicators as specific volume, porosity and shelf life, enhanced the products mineral and vitamin value [17].

Studies of chemical composition of various non-traditional raw materials prove the adequacy of their use in the production of functional flour confectionery foods.

The cupcake "Kunzhutik" recipe with whole wheat flour, grape seed flour, sesame oil and sesame seeds, which affected the product nutritional value, was developed at the Department of bakery, confectionery, pasta and grain processing technologies of the FSBEU HE "Voronezh state university of engineering technologies".

Studies on biological objects are relevant for determining the possibility of various functional ingredients introduction into food products [5]. Therefore, the determination of the bioavailability and nutritional value of the product is necessary when adding non-traditional raw materials.

The purpose of this work was to determine the effect of biologically active components on the digestibility and nutritional value of the cupcake enriched with non-traditional types of raw material. The objects of research were cupcake samples: № 1 - cupcake "Stolichny" (control, GOST 15052-2014) and № 2 - cupcake "Kunzhutik" (experiment, TC 10.72.12-579-02068108-2023). Whole wheat flour, grape seed flour, sesame oil and sesame seed were added to the prototype recipe.

2 Methods and materials

The ciliates *P. caudatum* were used as a test object for assessing the bioavailability of the studied cupcakes. The use of test organisms in the evaluation of food raw materials and products in the population size control makes it possible to obtain initial data for calculating such important indicators as biotic potential and standardized relative biological value. These indicators allow an indirect assessment of the energy costs for the products digestion in comparison with the reference object (egg protein (albumin)).

The population biotic potential (BP) characterizes the internal potential ability of a given population to grow, this value being understood as the amount of growth of a given population per unit of time per 1 zooid. The value of BP is calculated as the ratio of the number of *P. caudatum* organisms cultivated in a medium based on egg white and an experimental sample at a certain incubation time to the product of the incubation duration (24; 48; 72 or 96 h), taking into account the decrease in generative function in the lag phase [1, 2] according to the formula (1):

$$BP = \frac{N_i}{2000} / t \quad (1)$$

The standardized relative biological value of the product (SRBV, %) is the ratio of the number of protozoa grown on the substrate containing the object under study at a certain incubation time to the number of protozoa in a standard medium with the same amount of proteins at the same incubation time, multiplied by 100 [1, 2]:

$$SRBV = \frac{N_{ot}}{N_o} 100 \quad (2)$$

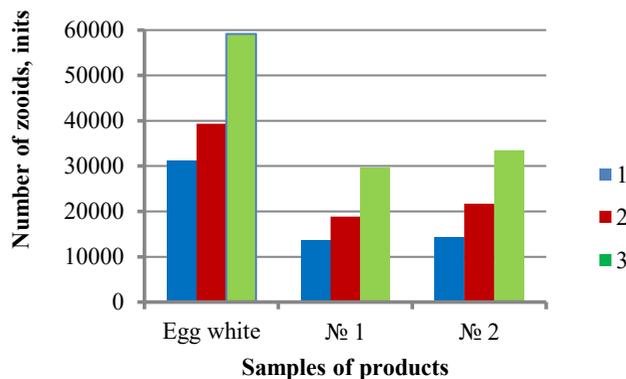
Statistical processing of experimental data was carried out in the Microsoft Excel 2010. Differences were considered statistically significant at $p < 0.05$.

Calculation of the sample weight of the analyzed cupcakes for their introduction into the incubation medium was carried out taking into account the determined level of the minimum daily intake of proteins with foods for men and women over the age of 18 - 0.75-1.0 g/kg of body weight [3]. In the calculations, the value of protein intake was taken equal to 1.0 g/kg of body weight, i.e. 75 g of protein per day for a person weighing 75 kg. Cupcake samples were taken in accordance with the procedure in such a way that, with sequential dilution, the protein content in the cultivation medium *P. caudatum* was 4, 2, and 1 mg/cm³ [2, 4]. The specified content of proteins in aqueous suspensions, taking into account extrapolation, is equivalent to human consumption of 18.75; 37.50 and 75.00 g of protein, respectively [2, 3].

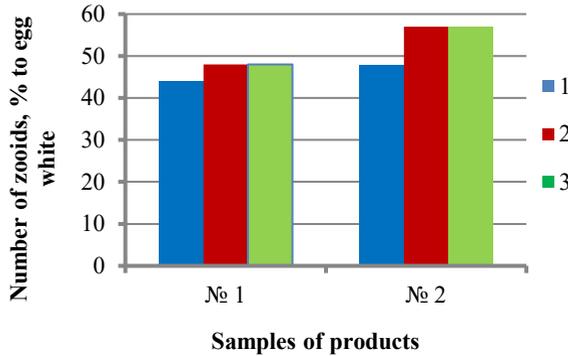
Indicators of nutritional and energy value were determined with the "Complex" program developed at the Department of bakery, confectionery, pasta and grain processing technologies of the FSBE HE "Voronezh state university of engineering technologies". It is based on the methodology approved by the FSBE "Federal research center for nutrition, biotechnology and food safety". The content of vitamins in products was calculated taking into account the safety factors.

3 Results discussion

Monitoring of the *P. caudatum* population state, which developed in experimental substrates with a protein content of 1, 2, and 4 mg/ml, showed the absence of a biocidal effect on ciliates. The calculation of ciliates number cultivated on the substrate containing the studied samples relative to the substrate based on egg white revealed a lower generative function at all control points at the studied concentrations. The number of *P. Caudatum* zooids (Figure 1) increased on average 2.5 times with an increase in protein content in all cultural media.



a



b

Fig. 1. Population size of *P. Caudatum* cultivated in the medium based on egg white and in experimental substrates by samples: a – number of zooids; b - ratio to albumin, expressed in %, with different content of proteins 1 - 1, 2 - 2, 3 - 4 mg/cm³

The biotic potential of ciliates (Fig. 2) cultivated on a substrate containing control and experimental samples was significantly lower in all concentrations studied than on a substrate containing egg white throughout the entire life cycle. The digestibility and biological value of the objects studied were calculated at a protein level in the culture medium of 4 mg/cm³ after 48 h of incubation. After 48 hours, at a protein content of 4 mg/cm³, the biotic potential reached its maximum value (0.34 units), which indicated a rapid growth of the population in this medium.

The standardized relative biological value of the objects studied was calculated in relation to egg white (Figure 3).

The standardized relative biological value of the developed product increased by 9% compared to the control and amounted to 57% in relation to the ideal protein - albumin.

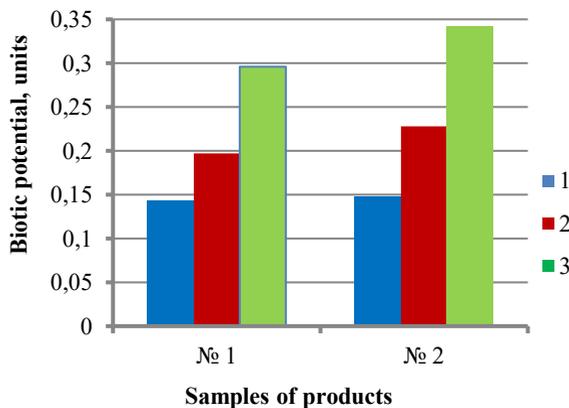


Fig. 2. Biotic potential of *P. Caudatum* zooids cultivated in a medium based on experimental substrates in samples with different protein content of 1, 2, 4 mg/cm³

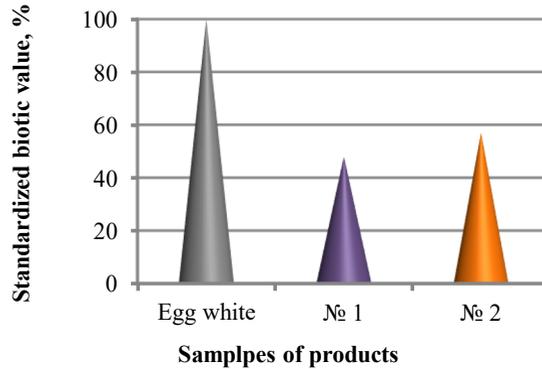


Fig. 3. Standardized relative biological value of cupcakes as evaluated for *P. Caudatum* versus egg white.

During the biotesting it was found out that the cupcakes "Stolichny" and "Kunzhutik" did not have a biocidal effect, demonstrated a lower generative function relative to the substrate, and were inferior to the biological value of egg white in terms of standardized relative biological value.

The prototype cupcake surpassed the control one in terms of biotic potential and biological value, as well as in the population numerical development, which indicated its positive bioavailability.

Comparative assessment of the nutritional value of the cupcakes studied and the degree of daily requirement meeting for substances revealed that the cupcake "Kunzhutik", prepared with non-traditional types of raw material, was superior to the control sample (Table 1).

Table 1. Chemical composition and the degree of meeting of daily requirements of the human body in nutrients through the 100 g of cupcakes consumption.

Nutrients name	Physio-logical daily require-ment, g/mg (TR CU 022/2011)	Content in samples		Degree of requirements meeting due to the use of samples, %	
		№ 1	№ 2	№ 1	№ 2
		Protein, g	75	5,79	6,28
Fat, g	95	17,28	27,20	18	29
Carbohydra-tes, g	430	56,05	45,22	13	10
Dietary fiber, g	30	1,89	2,22	6,3	7
Macroelements, mg:					
potassium	3500	215	86	6	2
calcium	1000	30	41	3	4
magnesium	400	14	35	3,5	9
phosphorus	800	80	95	10	12
Microele-ments:					
iron, mg	14	1,22	4,5	9	32
selenium, mcg	70	-	0,57	-	1
Vitamins, mg:					
thiamine	1,4	0,08	0,09	6	6
riboflavin	1,6	0,13	0,12	8	8
Pantothenic acid	6	0,22	0,27	4	5
tocopherol	10	-	2,27	-	23
niacin	18	0,32	1,69	2	9

It was revealed that 100 g of "Kunzhutik" cupcake contain more proteins by 0.5 g, fats by 10.0 g, dietary fiber by 0.33 g, macronutrients such as calcium, magnesium and phosphorus by 11.0 mg, 21, 0 mg and 15.0 mg, micronutrients, namely iron, by 3.3 mg, thiamine by 0.01 mg than in the "Stolichny" cupcake, while the carbohydrate content was reduced by 10.8 g, potassium by 129 g, riboflavin by 0.01 mg.

It was determined that the consumption of 100 g of cupcakes with the addition of whole wheat flour, grape seed flour, sesame oil and sesame seed provides a degree of requirements meeting of the daily intake of protein by 8%, fat - 29%, carbohydrates - 10%, dietary fiber - 7 %, minerals - 1 - 32%, vitamins - 5 - 23%.

4 Conclusion

Thus, the studies carried out proved that the application of non-traditional raw materials in the cupcake recipe from premium wheat flour helps to increase its biotic potential by 15%, the standardized relative biological value by 9% compared to the control sample and increases its nutritional value. All this makes it possible to draw a reasonable conclusion about the effectiveness of application of whole wheat flour, grape seed flour, sesame oil and sesame seeds in the production of cupcakes to include them in the population diet to prevent various diseases.

References

1. V. D. Bogdanov, O. V. Sakharova, T. G. Sakharova, Scientific works of "Far Eastern state technical fisheries university" **37**, 93-98 (2016)
2. V. A. Dolgov, S. A. Lavina, T. S. Arno, E. A. Semenova, S. S. Kozak, I. G. Seregin, L. P. Mikhaleva, Poultry and poultry products **6**, 50-52 (2014)
3. E. G. Cheremnykh, A. V. Kuleshin, O. N. Kuleshina, Bulletin of RUDN University. Series: Ecology and life safety **3**, 5-12 (2011)
4. O. M. Khrebtova, Bulletin of the Baltic Federal University named after I. Kant. Series: Natural and medical sciences **2**, 73–76 (2016)
5. S. V. Smorodinskaya, N. G. Ivanova, I. A. Nikitin, V. A. Gribkova, V. A. Klimov, Technologies of the food and processing industry AIC - healthy food **2**, 70-79 (2022)
6. I. Yu. Reznichenko, A. M. Chistyakov, T. V. Renzyaeva, A. O. Renzyaev, Khleboprodukty **6**, 40-43 (2019)
7. T. V. Matveeva, *Scientific foundations, technologies, recipes* (FSEE VPO "State University - ESPC", Orel, 2011)
8. V. F. Vinnitskaya, D. V. Akishin, E. I. Popova, A. S. Mantrova, Science and Education **2(2)**, 43 (2019)
9. A. V. Kopylova, A. N. Sapozhnikov, N. I. Davydenko, XXI century: results of the past and problems of the present plus **4(56)**, 138-142 (2021)
10. N. L. Naumova, Innovations and food safety **3(29)**, 47-53 (2020)
11. E. I. Ponomareva, S. I. Lukina, O. B. Skvortsova, Bulletin of VSUET **79(4)**, 114–118 (2017)
12. I. G. Vasilyeva, Alley of Science **3(1)**, 38-44 (2019)
13. E. I. Ponomareva, S. I. Lukina, L. V. Logunova, N. N. Fedorchenko, Innovative technique and technology **9(4)**, 27-31 (2022)

14. I. V. Plotnikova, G. O. Magomedov, T. A. Shevyakova, D. S. Pisarevsky, V. E. Plotnikov, *Khleboprodukty* **6**, 38-41 (2020)
15. I. M. Zharkova, T. N. Malyutina, E. V. Akhtemirov, *Khleboprodukty* **8**, 40-41(2011)
16. A. N. Gulyaeva, M. S. Voronina, N. V. Makarova, *Innovations and food safety* **3(29)**, 7-13 (2020)
17. N. N. Tipsina, G. G. Samitina, *Bulletin of KrasSAU* **2(137)**, 144-149 (2018)