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DEVISING A RECIPE FOR MUFFINS WITH PUMPKIN PASTE

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The object of this research is the production technology of muffins with pumpkin paste. The task was to enrich muffins with pumpkin paste.

The influence of different amounts of pumpkin paste on the physicochemical and sensory parameters of muffins was investigated. It has been established that the addition of pumpkin paste reliably ($p \leq 0.05$) increases the content of vitamin A (RAE), as well as indicators of integrated score, baking, shrinkage, and moisture content of the muffin. The volume of muffins is significantly reduced by adding 10–50 % of pumpkin paste. This trend is due to the high humidity of pumpkin paste.

Owing to a sociological survey, it was determined that most respondents (55 %) liked muffins whose content of pumpkin paste was 15–20 %. It should be noted that 30 % of respondents liked muffins whose content of pumpkin paste was 25–30 %. This trend is due to the fact that the smell and taste of pumpkin in a muffin with the addition of 15–20 % of pumpkin paste is leveled by aromatic compounds. Increasing the amount of pumpkin paste to 25–30 % determines the average level of pumpkin sensory sensation.

In the technology of muffin production, it is optimal to add 15–20 % of pumpkin paste. According to this formulation, the integrated score of vitamin A (RAE) is 21–23 %, humidity – 22.9–25.9 %, baking shrinkage – 8.9–10.0 %, shrinkage due to drying – 2.1–2.2 %, volume – 166–177 cm3/100 g of dough. The porosity is 7–9 points, surface color - light brown, crumb color – yellow, crumb consistency – soft, pumpkin taste level – weak or absent (7.0–8.3 points).

A distinctive feature of the results is the differentiated use of pumpkin paste in the muffin recipe. Based on the survey, it was established that the amount of pumpkin paste could be 15–20 % and 25–30 %.

The devised recommendations can be used by confectionery enterprises of low productivity during the production of muffins

Keywords: confectionery, pumpkin paste, vitamin A (RAE), integrated score, organoleptic characteristics, physical and chemical parameters

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1. Introduction

Confectionery represents one of the most profitable retail products [1]. In addition, confectionary is popular among many people of different age categories. The range of confectionery products enriched with various tastes is large. However, they usually contain a large proportion of easily digestible carbohydrates and fat [2]. Given this, a number of studies are being conducted to increase the biological value of confectionery products by adding fruit and vegetable products or products of their processing [3]. In study [4], adding 10 % of flour from milk thistle seeds to cookie technology was scientifically substantiated. Cookies are enriched with amino acids, fatty acids, mineral elements, and phytochemical compounds that are contained in milk thistle seeds. This changes the quality parameters of cookies. The volume mass of cookies decreases; a dark surface is formed. During consumption, the smell and taste of milk thistle is felt. Promising is the use of flour from hawthorn fruit [5], powder of dried apples, raspberries, calendula leaves, pumpkin oil [6].

The use of non-traditional raw materials in the technology of confectionery production contributes to the expansion of the range and greater use of rare products [7]. An important indicator of additional raw materials is the high biological value and low cost of its production. In addition, they must increase the biological value of the finished product.

Pumpkin is a promising additive in the production of muffins as it has a number of advantages [8]. Pumpkins are characterized by highly stable yield and nutritional value, some varieties have a long shelf life and are easily transported [9]. Pumpkin pulp can contain water 75.8–91.3 %, carbohydrates – 3.1–13.0, protein – 0.2–2.7, fiber – 1.0–1.8, fat – 1.0–1.4, ash – 0.5–2.1 %, carotene – 2.4–5.2 mg/100 g [10]. Pumpkin processing products are also characterized by high biological value [11]. This makes it possible to use them to enrich the beneficial components of food.

In [12], the possibility of using pumpkin flour in biscuit technology is given. It is proved that with this recipe, the content of carotene in the finished product significantly increases. The physicochemical properties of the biscuit were at the level of control. However, studies do not provide consumer attitudes towards such a product.

It should be noted that the finished product is evaluated in accordance with the requirements of the standard. Under modern conditions, it is advisable to determine the demand for products from the point of view of consumers because it determines the demand for the product without significant material and monetary costs. The results of such studies in practice will allow differentiated application of the recipe of muffin with pumpkin paste, taking into account consumer demand. In addition, the production of pumpkin paste has a significantly lower cost compared to pumpkin flour, especially under conditions of reducing energy costs.

2. Literature review and problem statement

It is proved that the addition of an unconventional component to flour products changes their physicochemical and sensory quality indicators [13]. In this case, the optimal amount of additional additive in the formulation is not felt by the sensory organs of a person. This is due to the different attitude of a person to the smell and taste of different products, especially those containing a biologically active component [14].

Studies have confirmed that adding pumpkin to confectionery significantly increases the content of biologically active substances in it. This reduces the energy value of the finished product due to the addition of pumpkin. It is proved that the sensory quality indicators of such products are not inferior to samples obtained according to the classical recipe without pumpkin [15].

It has been established that the addition of fresh pumpkin in the form of slices affects the technological parameters of the muffin in different ways. Thus, adding it in the amount of 5–10 % does not significantly change the rheological and sensory properties of the muffin. The use of 20–25 % of fresh pumpkin slices of various shapes in the technology of muffin production makes it possible to obtain a product with a light-yellow surface and yellow crumb. The nutritional level of the muffin is good, and the smell and taste of pumpkin in it is weak. Increasing the amount of slices over 25 % ensures the formation of a strong smell and taste of pumpkin in a muffin [16]. The use of 5–25 % of slices makes it possible to obtain a muffin with a porosity of 9 points, baking 6.9–8.5 %, humidity 6.9–12.8 %, volume 176–203 cm^3, acidity 1.5–1.7 degrees. In addition, it is possible to use 30–35 % of pumpkin slices. According to this recipe, the muffin has a porosity of 6.5–8.0 points, baking 8.8–9.7 %, humidity 13.4–14.8 %, volume 156–172 cm^3, acidity 1.8–1.9 degrees [17]. However, these studies examined the effect of fresh pumpkin on the quality of the muffin. The technological parameters of the muffin using pumpkin paste are different. Therefore, the recommended amount of fresh pumpkin cannot be used for paste.

In [18], it was proved that the addition of 5, 10, and 15 % of pumpkin paste improved the structure of the muffin and its color. Samples of dough with pumpkin paste were well baked. The energy value was reduced by 60 kcal. However, the authors do not indicate the optimal amount of pumpkin paste in muffin technology. In addition, only three variants with pumpkin paste were used – 5 %, 10 %, and 15 %. There is no information on how consumers treat confectionery products with pumpkin-containing semi-finished products.

The relevant area of research is the use of pumpkin flour in the technology of flour products. It was established [19] that the addition of 1.7 % of pumpkin flour from the weight of the dough improved the technological parameters of the muffin. The porosity score increased from 5.02 to 7.57 points. However, studies [20] have shown that it is optimal to add 15 % of pumpkin flour in muffin technology. It should be noted that pumpkin flour affects the physicochemical properties of the muffin differently compared to paste. This difference is due to the presence of water in pumpkin paste. In addition, the question of the optimal content of pumpkin paste in muffin technology has not been sufficiently studied. The attitude of consumers to such a product has not been established.

In work [21], it was found that the addition of 25–30 % of pumpkin paste in bread technology is optimal. The use of such an amount of pumpkin paste provides a finished product with a volume of 346–348 cm^3/100 g of flour. The smell and taste of bread with so much pumpkin paste is high – 9 points. However, these recommendations apply to bread. Obviously, the optimal amount of pumpkin paste will be different for a muffin.

Another study [22] examined the effect of juice and fresh pumpkin puree on bread quality. It was established that all prototypes of bread had the correct shape, a surface without cracks and explosions, a pleasant color. No inadmissible defects of finished products in terms of appearance and color were detected. However, the study established the possibility of using juice, fresh mashed potatoes, and baked puree in bread technology. The level of individual indicators of bread quality is not given. In addition, the issue of the optimal number of types of pumpkin-containing semi-finished products and the attitude of consumers to such a product were not studied.

In [23], the addition of 5–25 % of pumpkin paste on the content of the macrocomponent, trace elements, and vitamins of bread was studied. However, scientists do not indicate the optimal amount of pumpkin paste in the recipe of bread. In addition, no sensory evaluation of the product is given, and such results cannot be applied to a muffin.

So, the use of pumpkin in the technology of flour products has significant prospects. However, in studies [15, 23], the question of the biological value of the finished product with the addition of pumpkin was studied. In studies [16, 17], the effect of fresh pumpkin slices on the quality of the muffin was studied. In works [21, 22], the authors developed recommendations to the technology of bread. Research results [19, 20] relate to pumpkin flour. All the studies did not investigate the question of consumers' attitude to finished products with different amounts of pumpkin. In this case, as a rule, the experimental scheme has three options – 5 %, 10 %, and 15 % of pumpkin paste in the recipe of confectionery. It has not been studied how the properties of the product will change with an increase in the amount of pumpkin paste. Since an increase in the amount of pumpkin-containing semi-finished product will increase the content of carotene. Given the insufficient study of this problem, our research is relevant. Therefore, it is advisable to develop a muffin recipe with the addition of pumpkin paste, taking into account the nutritional properties.

3. The aim and objectives of the study

The aim of this study is to develop a muffin recipe by adding pumpkin paste according to physicochemical, organoleptic parameters, and sociological research. The use of pumpkin paste in muffin technology will enrich its biological value. In addition, the range of muffins will grow.

To accomplish the aim, the following tasks have been set:

– to determine the physicochemical and organoleptic indicators of the quality of the muffin with the addition of pumpkin paste;

– to conduct a sociological survey on the consumption of muffin with different contents of pumpkin paste;

– to determine the optimal amount of pumpkin paste with a different attitude of consumers to pumpkin.

4. The study materials and methods

4. 1. The object and hypothesis of research

The object of our research was the technology of muffin production. The basic hypothesis assumed that adding the optimal amount of pumpkin paste would vary depending on consumers' attitudes towards the smell and taste of the pumpkin.

Pumpkin paste contains the most water compared to flour. An increase in the amount of pumpkin paste could affect the physicochemical properties of the finished product. In addition, pumpkin paste has a peculiar smell and taste. This could affect the sensory performance of the muffin.

The assumptions made in the study are the differences in the physicochemical and sensory properties of muffin samples enriched with a paste made from different pumpkin varieties.

There were no simplifications in the study.

4. 2. Raw materials

The muffin technology involved wheat flour of the highest grade (gluten content – 28.8 %, gluten deformation index – 93 units GDM (gluten deformation meter)). Flour moisture content is 12.3 %. The pumpkin was added to the muffin in the form of a paste. We used nutmeg pumpkin (*Cucurbita moschata* (Duch.) Duch. ex Poir.) variety Dolya (UA). The production technology of pumpkin paste included peeling the pulp and cooking until a homogeneous mass is formed. After that, the paste was packaged in jars and sterilized in an autoclave at t=100±2 °C for 40 minutes. Before use, the paste was ground in a blender until smooth. The moisture content of the paste is 84.3 %. The content of vitamin A in eggs was 0.26 mg/100 g, β-carotene – 0.06 mg/100 g. The content of β-carotene in pumpkin paste was 4.84 mg/100 g.

4. 3. Program, methodology, equipment

The research was carried out in the laboratory at the Department of Food Technologies of Uman National University of Horticulture (Ukraine).

The muffin dough was prepared according to the following recipe: flour – 70 g, powdered sugar – 50 g, margarine (fat content 72 %) – 50 g, eggs – 50 g, salt – 0.2 g, baking powder (baking soda + sodium phosphate) – 2.5 g, vanilla sugar – 0.3 g. First, the dough was prepared. Salt and vanilla sugar were added to margarine at room temperature. Then it was whipped for 5–7 minutes in a dough mixer (Royalty Line RL-PKM1900.7, Germany) with rotations of 60–65 per 1 min. After that, powdered sugar was added and beaten for another 5–7 minutes. Then we added eggs and whipped for 10 minutes. After that, wheat flour of the highest grade was added and mixed in a mixer for 3–5 minutes. After cooking the dough, pumpkin paste was added. The amount of paste was added to the prepared dough in accordance with the experimental scheme (Fig. 1). After that, the mixture was stirred. The mass of muffin samples without addition and with the addition of pumpkin paste was about 200 g.

Baking a muffin. The baking temperature is 180–185 °C. The baking time, depending on the amount of paste added, was set experimentally. The degree of readiness was determined organoleptically.

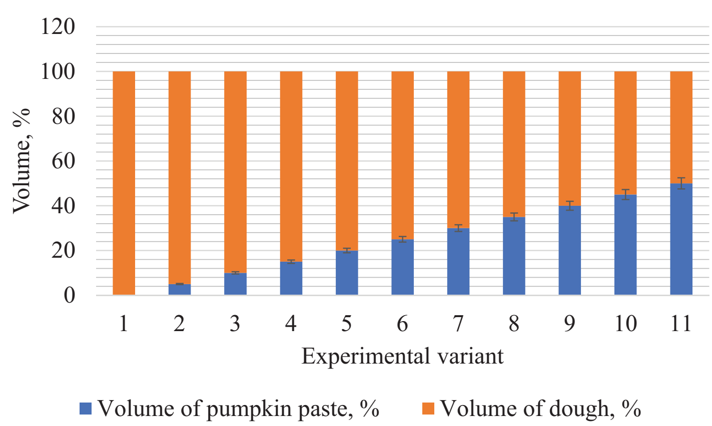

Fig. 1. Scheme of the experiment

The content of β-carotene was determined by liquid chromatography on the Chromos-301 analyzer. The content of β-carotene was converted to the equivalent of retinol activity (RAE). 1 RAE corresponds to 1 μg of pure retinol, 12 μg of "food" β-carotene. Integrated score – according to the following formula:

$$I = \frac{C}{D} \times 100, \quad (1)$$

where I is the integrated score, %; C – actual component content, mg/100 g of grain; D – daily requirement of the component by the body of a healthy person, mg.

Baking shrinkage of the muffin was determined from the following formula:

$$Y = \frac{m_1 - m_2}{100 \cdot m_1}, \quad (2)$$

where Y is the muffin baking shrinkage, %;

m_1 – weight of dough, g;

m_2 – mass of hot muffin, g.

The muffin shrinkage due to drying was determined from the following formula:

$$Y = \frac{m_1 - m_2}{100 \cdot m_1}, \quad (3)$$

where Y is the muffin shrinkage due to drying, %;

m_1 – mass of hot muffin, g;

m_2 – mass of cold muffin, g.

Specific volume – by formula:

$$V_p = \frac{V}{m}, \quad (4)$$

where V_p is the specific volume, cm^3/g of dough (muffin);

V – muffin volume, cm^3;

m – weight of dough (muffin), g.

The volume was determined by the difference between the volume of a container filled with a small-seed crop without a muffin and with it.

Porosity was determined on a scale: 9 – small, thin-walled, or thick-walled, uniform, 7 – non-porous or another part of the crumb occupies up to 25 % of the cross-section, 5 – non-porous or another part of the crumb occupies 26–50 % of the cross-section, 3 – non-porous or another part of the crumb occupies 51–75 % of the cross-section, 1 – non-porous or another part of the crumb occupies 76–100 % of the cross-section.

The surface color and color of the muffin crumb were determined organoleptically. The place of the study is the city of Uman, Ukraine. The number of respondents involved is 25 people. The time of the survey is the 4th quarter of 2021.

Nutritional smell and taste were determined on a scale: 9 – extremely pleasant, 8 – very pleasant, 7 – pleasant enough, 6 – insignificantly pleasant, 5 – unpleasant, 4 – insignificantly unpleasant, 3 – unpleasant enough, 2 – really unpleasant, 1 – extremely unpleasant.

The level of smell and taste of pumpkin in muffin samples was determined on a scale: 9 – absent, 7 – weak, 5 – perceptible, 3 – strong, 1 – very strong.

Baking, shrinkage, bread volume, specific volume, bread mass were checked for consistency of statements by calculating the concordation index. For analysis, the results of sensory examination of experts, which were agreed with each other, were selected. In addition, the quality indicators of the muffin were compared with DSTU 4505:2005. Muffins. Specifications.

4. 4. Statistical data processing

The experimental part had four analytical repetitions that were randomized in time to exclude the influence of other factors. Data processing was carried out using specialized software Microsoft Excel 2016 (Microsoft Corporation, USA) and Statistica 12 (StatSoftStatistica Ultimate Academic, Ukraine) in accordance with methodological recommendations [24, 25].

5. Results of investigating the quality of muffin with the addition of pumpkin paste

5. 1. The physical and chemical indicators of the quality of the muffin depending on the amount of pumpkin paste

The increase in the amount of added paste necessitated an increase in the duration of cooking muffins. According to the results of the trial baking, rational modes of baking muffins enriched with pumpkin paste were established (Fig. 2).

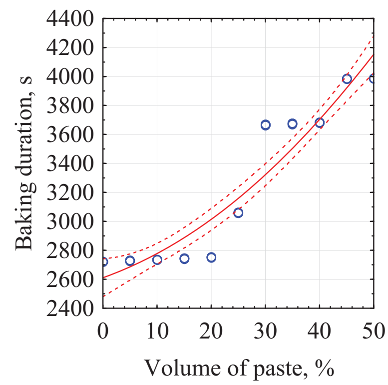

Fig. 2. The duration of baking a muffin depending on the amount of pumpkin paste

With high accuracy (r=0.9371), the cooking time of a muffin (Y) enriched with pumpkin paste can be described by a second-order polynomial:

$$Y = 2610.7115 + 13.0533X + 0.3559X^2, \quad (4)$$

where X – baking time, sec.

The vitamin A content varied depending on the amount of pumpkin paste (Fig. 3, *a*). The addition of 5–50 % of pumpkin paste increased this figure by 1.2–2.7 times compared to control. Carotene content and integrated score increased significantly with the addition of 10–50 % of pumpkin paste compared to control.

The lowest integrated score for vitamin A was in the variant without the addition of pumpkin paste – 14 % (Fig. 3, *b*). The addition of pumpkin paste increased this figure to 17–39 % or 1.2–2.7 times compared to the control sample.

The minimum humidity was recorded in the control sample (13.5 %) (Fig. 3, *b*). When adding the maximum amount of pumpkin paste (50 %), the moisture content of the muffins increased by 2.9 times compared to the control sample (39.7 %). It should be noted that the addition of 35–50 % of pumpkin paste increased the humidity by more than 31.0 %, which did not meet the standard DSTU 4505:2005. Muffins. Specifications.

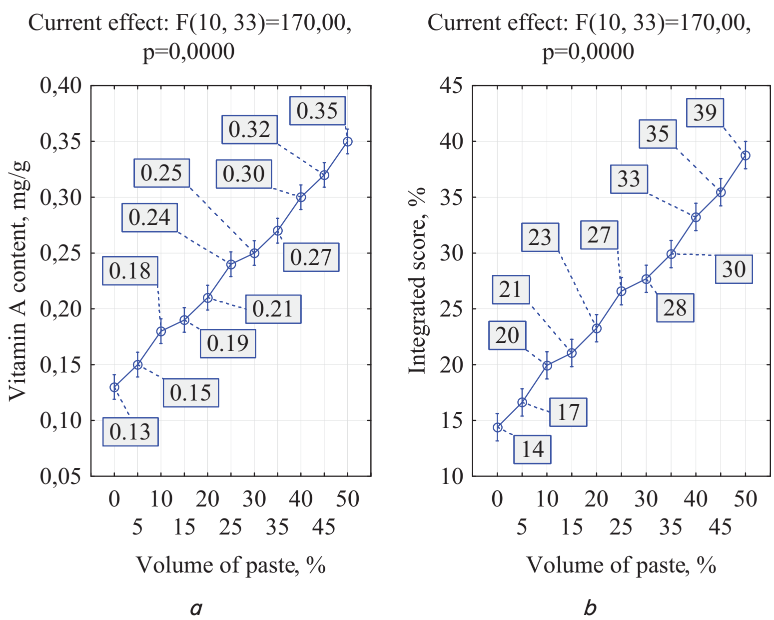

Fig. 3. The content of vitamin A and its integrated score per 100 g of muffin depending on the amount of pumpkin paste: *a* – vitamin A content (RAE), *b* – integrated score, %

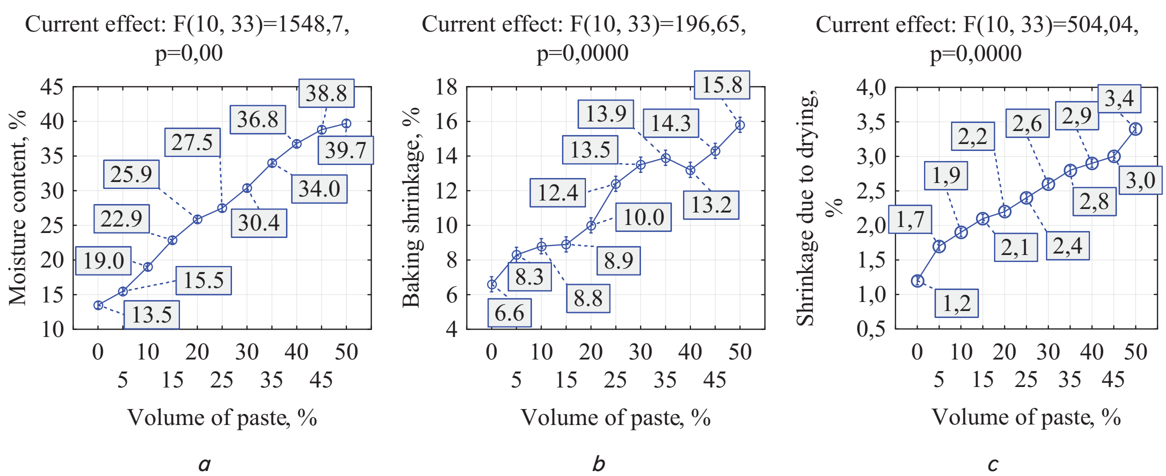

Fig. 4. Physical and chemical indicators of the quality of the muffin depending on the amount of pumpkin paste: *a* – moisture content of the muffin; *b* – baking shrinkage; *c* – shrinkage due to drying. The moisture content of products raises questions about the reliability of research

The dynamics of changes in baking shrinkage and shrinkage due to drying depending on the amount of pumpkin paste added were similar (Fig. 3, *a*, *c*). These indicators significantly increased with an increase in the amount of pumpkin paste. Thus, baking shrinkage with the addition of 5 % of pumpkin paste increased by 1.3 times. The use of 50 % of pumpkin paste contributed to an increase in this indicator by 2.4 times compared to control. The shrinkage of the muffin increased from 1.2 in the control version to 1.7–3.4 % with the addition of 5–50 % of pumpkin paste or by 1.4–2.8 times.

The volume of muffin per 100 g of dough significantly changed depending on the amount of pumpkin paste (Fig. 4). The volume of the muffin (Fig. 4, *a*) significantly decreased with an increase in the amount of pumpkin paste, except for the option with the addition of 5 % of pumpkin paste. The addition of the maximum amount of paste caused the muffin volume to be halved compared to the control sample.

Due to a decrease in the volume of muffin from 100 g of dough, the indicators of the specific volume and the ratio of the volume of muffin to the volume of dough were reduced due to the addition of pumpkin paste. Thus, the specific volume did not significantly change with the minimum amount of pumpkin paste (Fig. 4, *b*). The addition of 25 % of pumpkin paste significantly reduced this figure to 1.8 cm^3/g or 18 % compared to the control option. Increasing the amount of pumpkin paste to 50 % reduced the specific volume to 1.3 cm^3/g or 41 %. A similar trend was obtained for the ratio of the volume of muffin to the volume of dough (Fig. 4, *c*).

The use of 5–15 % of pumpkin paste in the muffin formulation did not affect porosity (Fig. 6). At the same time, this indicator was at the level of control and amounted to 9 points. The addition of 20–25 % of pumpkin paste reduced porosity to 5–7 points or by 1.3–1.8 times compared to control. Increasing the amount of pumpkin paste to 30–50 % reduced porosity to 1 point.

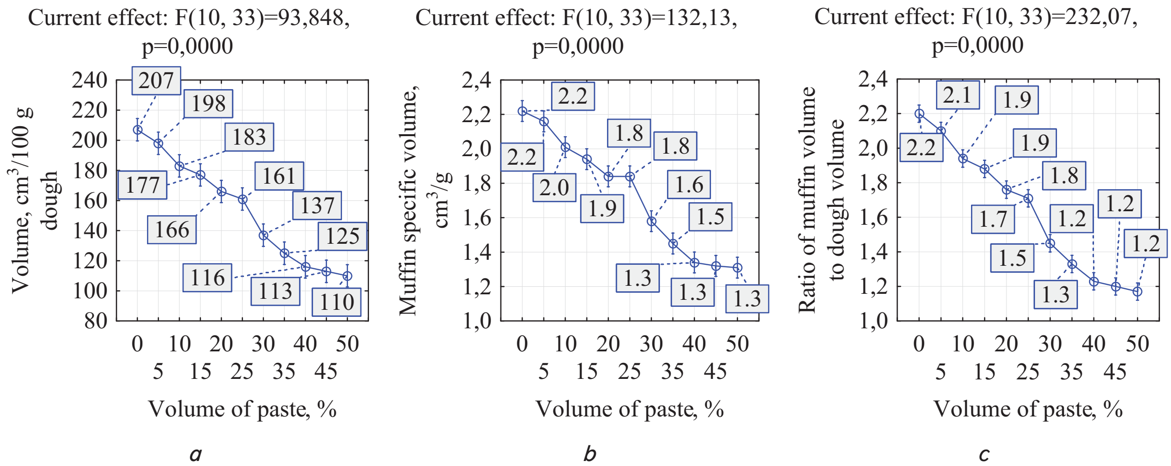

Fig. 5. Muffin volume depending on the amount of pumpkin paste: *a* — volume of muffin; *b* — specific volume of the muffin; *c* — the ratio of the volume of muffin to the volume of dough

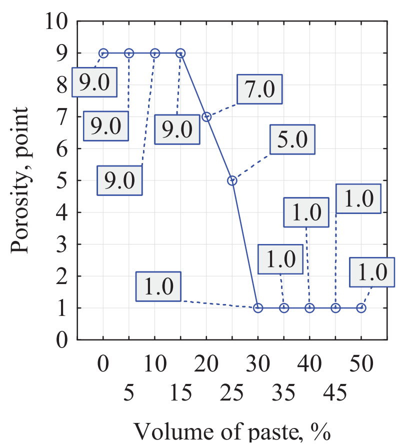

Fig. 6. Porosity of the muffin depending on the amount of pumpkin paste, point

It should be noted that the use of 5–15 % of pumpkin paste had the least effect on the change in the physicochemical parameters of the quality of the muffin.

5. 2. The appearance of the muffin depending on the amount of pumpkin paste

The appearance of muffins varied depending on the amount of pumpkin paste (Table 1, Fig. 6). The surface color of the muffin when added 5 to 20 % of pumpkin paste was similar to a control sample. The increase in the amount of added paste to 25–50 % caused a change in surface color from light brown to brown. A similar trend of color change was recorded during the study of muffin crumb (Fig. 7). Thus, with the addition of 5–10 % of pumpkin paste, the color of the muffin crumb was yellow. Increasing the amount of pumpkin paste to 25–50 % provided muffins with dark yellow crumb.

According to DSTU 4505:2005. Muffins. Specifications, the shape of the muffins was correct, not deformed, except for options with the addition of 40–50 % of paste. The color of all muffin samples also met the requirements of the standard. The surface of the muffins was cracked but they did not spoil the appearance. The taste and smell of the muffin was peculiar, without foreign taste and smell.

Table 1

Surface color, muffin crumb, and its consistency

Experimental variant	Surface color	Crumb color	The consistency of the crumb
Control	light brown	yellow	elastic, soft
5	light brown	yellow	elastic, soft
10	light brown	yellow	elastic, soft
15	light brown	yellow	elastic, soft
20	light brown	dark yellow	elastic, soft
25	brown	dark yellow	rubbery
30	brown	dark yellow	rubbery
35	brown	dark yellow	rubbery, sticky
40	brown	dark yellow	sticky
45	brown	dark yellow	sticky
50	brown	dark yellow	sticky

The view in the cross-section varied depending on the amount of pumpkin paste. Thus, in the control sample and with the addition of 5–25 % of pumpkin paste, the view of cross-section was baked. In the version with the addition of 30 % of paste, the crumb had parts not baked. Increasing the amount of pumpkin paste to 35–50 % ensured the formation of an unbaked crumb. In addition, an unbaked look in cross-section is not allowed by the standard DSTU 4505:2005. Muffins. Specifications. Obviously, the allowable amount of pumpkin paste in the muffin recipe is 25 % to obtain a product with baked crumb.

It should be noted that the use of 5–15 % of pumpkin paste did not affect the surface color and crumb of the muffin compared to the control sample. The characteristic of the crumb was not a level of control. At the same time, the addition of 25 % of pumpkin paste ensured the formation of products with baked crumb. The addition of 30–50 % of pumpkin paste changed the structure of the muffin crumb. The result was a flour confectionery product with properties that are not characteristic of a muffin.

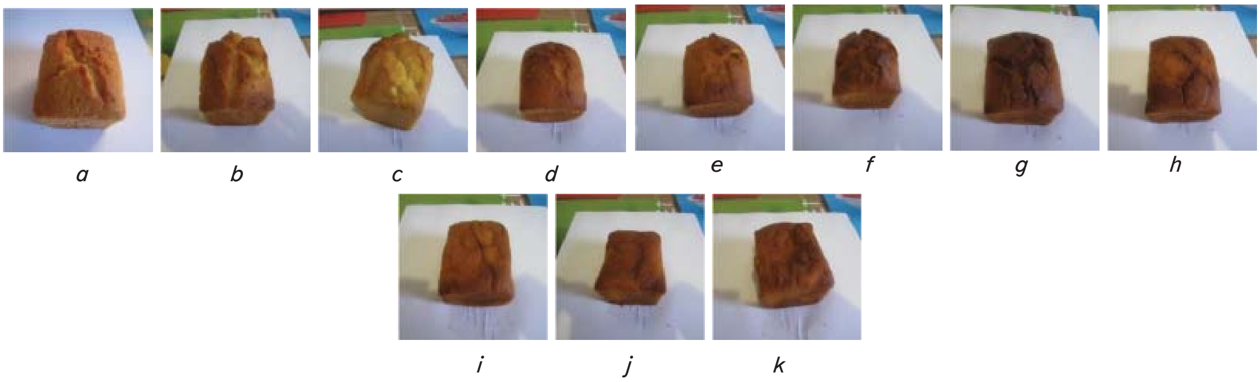

Fig. 7. The appearance of the muffin and its crumb depending on the amount of pumpkin paste: *a* – control sample; *b* – sample with the addition of 5 % of pumpkin paste; *c* – sample with the addition of 10 % of pumpkin paste; *d* – sample with the addition of 15 % of pumpkin paste; *e* – sample with the addition of 20 % of pumpkin paste; *f* – sample with the addition of 25 % of pumpkin paste; *g* – a sample with the addition of 30 % of pumpkin paste; *h* – sample with the addition of 35 % of pumpkin paste; *i* – sample with the addition of 40 % of pumpkin paste; *j* – sample with the addition of 45 % of pumpkin paste; *k* – sample with the addition of 50 % of pumpkin paste

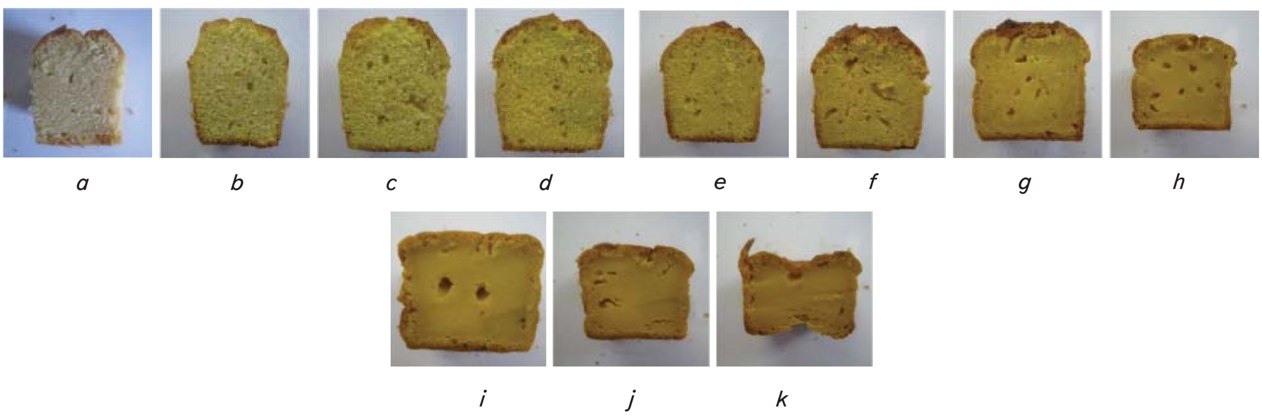

Fig. 8. View in the muffin cross-section depending on the amount of pumpkin paste: *a* – control sample; *b* – sample with the addition of 5 % of pumpkin paste; *c* – sample with the addition of 10 % of pumpkin paste; *d* – sample with the addition of 15 % of pumpkin paste; *e* – sample with the addition of 20 % of pumpkin paste; *f* – sample with the addition of 25 % of pumpkin paste; *g* – a sample with the addition of 30 % of pumpkin paste; *h* – sample with the addition of 35 % of pumpkin paste; *i* – sample with the addition of 40 % of pumpkin paste; *j* – sample with the addition of 45 % of pumpkin paste; *k* – sample with the addition of 50 % of pumpkin paste

5. 3. Determination of the optimal amount of pumpkin paste in the recipe, taking into account the different attitudes of consumers to pumpkin

According to surveys of potential buyers of grain products, organoleptic evaluation is a primary prerequisite for the purchase of such products. A significant share of innovators among buyers is indicated. This significantly expands the potential of food industry production, usually due to the supply of new types of products to the market. A significant proportion of respondents had a positive attitude towards the trend of healthy eating. At the same time, a minimum number of respondents wanted to consume useful products and products with high biological value that have a low sensory assessment [26].

Adding pumpkin paste can significantly reduce the calorie content of the finished product and promotes saturation with biologically active substances. However, the specific taste and smell characteristic of pumpkins can reduce sensory quality [27].

The results of sensory analysis show that with the addition of 5–15 % of pumpkin paste, the level of its smell and taste was absent – 8.3–9.0 points (Fig. 9, *a*, *b*). With the addition of 20 % of pumpkin paste, the smell and taste were at the level of 7.0 points – a weak level. In variants using 25–30 % of pumpkin paste, the level of its manifestation was noticeable – 3.7–5.7 points. Increasing the amount of paste to 35–50 % contributed to a very strong smell and taste of products – 1.0–3.0 points.

From the point of view of the consumer, the taste of the muffin deteriorated significantly as a result of an increase in the amount of pumpkin paste (Fig. 7, *a*). The addition of 5–15 % of pumpkin paste did not significantly change the smell index of the finished product according to consumers, which was estimated at 9 points. The increase in the amount of pumpkin paste to 20–50 % caused a significant deterioration in the smell of the finished product. It should be noted that the addition of 15–20 % of pumpkin paste ensured the formation of average sensory assessment indicators – 7.5–8.1 points. Analyzing the results of organoleptic evaluation of potential consumers, with a probability of 77 % it can be argued that the taste of the product will deteriorate due to an increase in the amount of pumpkin paste (Fig. 7, *b*). Minimal ratings of smell and taste were recorded with the maximum addition of pumpkin paste.

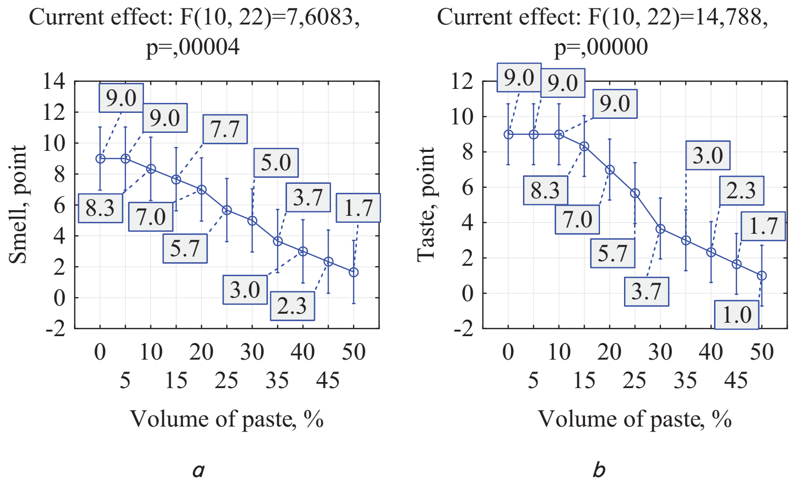

Fig. 9. The level of smell and taste of pumpkin in muffin samples depending on the amount of paste: *a* – the smell of the muffin; *b* – the taste of muffin

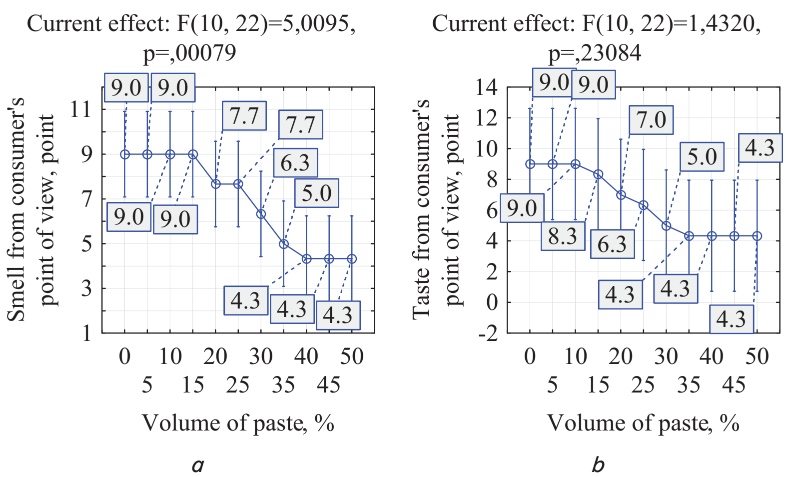

Fig. 10. Sensory quality of a muffin enriched with pumpkin paste from the point of view of consumer: *a* – the smell of the muffin; *b* – the taste of muffin

Among the surveyed potential consumers, everyone is ready to consume a muffin with pumpkin paste (Fig. 11). At the same time, the contents of pumpkin paste influenced the choice of muffins.

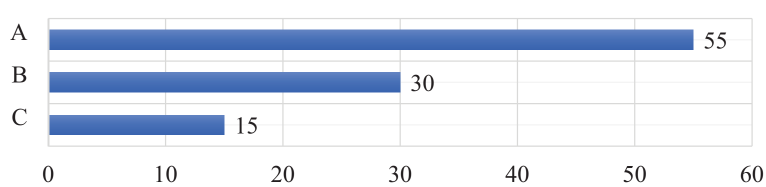

Fig. 11. Number of respondents who will consume muffin with pumpkin paste, in the amount of: A – 5–20 %; B – 25–30 %; C – 35–50 %

The largest number of respondents (55 %) are ready to consume a muffin containing pumpkin paste in the amount of 5–20 %. It should be noted that 30 % of respondents would consume muffins with 25–30 % of pumpkin paste. At the same time, 15 % of the surveyed consumers could consume flour products with the amount of pumpkin paste at the level of 35–50 %.

It is necessary to pay attention to options with the addition of 5–15 % of pumpkin paste. With so much pumpkin paste, organoleptic indicators were at the level of the control option. In addition, the use of 20–25 % of pumpkin paste provided the taste and smell of the muffin at the level of 6.0–7.7 points.

6. Discussion of results of the study on expanding the range of muffins enriched with pumpkin paste

The properties of finished products are important for the development of rational storage modes and justification of the timing of the sale of the finished product. The addition of unconventional raw materials, which differs significantly in technological properties, causes changes in the physicochemical properties of the finished product [28].

The use of pumpkin paste increased the moisture content of the dough. Therefore, the duration of baking muffin increased, especially with the addition of 30–50 % of pumpkin paste (Fig. 2). It should be noted that the duration of baking the muffin is set for dough pieces weighing 200 g.

It is proved [29] that pumpkin and its processed products contain carotene. The addition of pumpkin paste will help increase the content of carotene in the finished product. Obviously, increasing the amount of pumpkin paste in the muffin formulation will increase the carotene content in the muffin (Fig. 3, *a*). Increasing the carotene content in the muffin increases the integrated score (Fig. 3, *b*).

Pumpkin paste most of all contained water (84.3 %). The increase in the amount of pumpkin paste contributed to the increase in the moisture content of the muffin. This affected the increase in the baking and shrinkage rates of the finished product (Fig. 4, *a–c*). The increase in muffin baking indicates its higher humidity.

In studies [30], scientists note that the addition of unconventional raw materials of increased biological value significantly affects the formation of physicochemical parameters of flour products. In this case, the technological properties vary depending on the type of additional raw materials and its quantity [31, 32]. The increase in the amount of pumpkin paste in the muffin recipe contributed to a decrease in its volume. Obviously, an increase in the moisture content of the crumb weakened the formation of a loose consistency of the muffin with gas during baking (Fig. 5, *a–c*). It should be noted that by adding 25 % of pumpkin paste to the recipe, the muffin has properties that meet regulatory requirements.

The appearance of products is important for consumers, which is confirmed by social surveys. In-depth study of issues related to the shape and appearance of new types of products is an important stage of the marketing strategy. In addition, these indicators are used in justifying economic efficiency, calculating the program for the development of food industry enterprises [33].

The color of finished products with the addition of non-traditional raw materials varies depending on their quantity in the product (Table 1, Fig. 7). In addition, subject to the presence of coloring substances in additional raw materials, the color of the surface and crumb of the finished product will change, which is confirmed in other studies [34].

Different amounts of pumpkin paste affected the crumb consistency of the finished products (Fig. 6, 8). Thus, the addition of 5–25 % of pumpkin paste did not affect the consistency of the crumb. With the addition of 30 %, the view in the cross-section was semi-baked. Increasing the amount of pumpkin paste to 35–50 % significantly increased the moisture content of the dough. During the baking of such products, the formation of a porous structure was difficult. Therefore, the view in the cross-section was not baked. To the touch, the crumb was sticky and moist.

It has been experimentally proved that the addition of unconventional raw materials to the formulation of flour products affects their sensory indicators in different ways. The optimal content of additional raw materials varies depending on the level of manifestation of its smell and taste in the finished product [35]. In this case, the level of smell and taste of additional raw materials will depend on the ability to mask them with the aroma of the components of the main product.

Minimal ratings of smell and taste were recorded with the maximum addition of pumpkin paste. This pattern is due to the different attitude to the taste of pumpkin. During the evaluation, there were consumers who liked the taste and smell of pumpkin, did not like it, and did not like it at all.

Given the presence of vanilla in the muffin recipe and its sweet taste, the addition of 5–15 % of pumpkin paste is not felt by human sensory organs. This ensured the formation of the highest level of sensory quality of the muffin. It should be noted that with the addition of 20–25 % the smell and taste of pumpkin is felt at an average level. Therefore, the smell index was at the level of 7.7 points, and taste – 6.2–7.1 points. The addition of 30–50 % of pumpkin paste greatly altered the smell and taste of the muffin, so sensory evaluation was the lowest (Fig. 9, 10). Similar results of such an assessment were obtained in studies by other scientists [36].

Determining the average nutritional smell and flavor of the muffin significantly reduced the score of samples with higher pumpkin paste content. Obviously, a greater number of respondents who liked samples with lower pumpkin paste content will lower the score of muffin samples with higher pumpkin content. This is confirmed by the studies iillustrated in Fig. 11.

Given the different choice of muffins by consumers depending on the amount of pumpkin paste, its content in the recipe will vary. Thus, the greatest demand was for muffins containing pumpkin paste in the amount of 5–20 %. This indicates that it is optimal to add 15–20 % of pumpkin paste to the muffin recipe. According to this formulation, the integrated score of vitamin A is 21–23 %, humidity – 22.9–25.9 %, baking shrinkage – 8.9–10.0 %, shrinkage due to drying – 2.1–2.2 %, volume – 166–177 cm^3/100 g of dough. The porosity is 7–9 points, surface color – light brown, crumb color – yellow, crumb consistency – soft, pumpkin taste level – weak or absent (7.0–8.3 points).

It should be noted that it is possible to increase pumpkin paste to 25–30 % since 30 % of respondents preferred such muffin samples. According to this recipe, a muffin is obtained with an integrated score for vitamin A 27–28 %, humidity 27.5–30.4 %, baking shrinkage – 12.4–13.5 %, shrinkage due to drying – 2.4–2.6 %, volume – 137–161 cm^3/100 g of dough. The porosity is 1–5 points, the surface color of the muffin is brown, the crumb color is dark yellow, the crumb texture is rubberish, the taste level of pumpkin is strong (3.7–5.7 points).

In addition, it is possible to produce confectionery with a pumpkin paste content in the amount of 35–40 %. Confectionery products have an integrated score for vitamin A at the level of 30–33 %, moisture content of the crumb is 34.0–36.8 %, baking shrinkage – 13.2–13.9 %, shrinkage due to drying – 2.8–2.9 %, volume – 116–137 cm^3/100 g of dough. In this case, the view in the cross-section is non-porous (1 point). The surface color of the muffin is brown, the crumb color is dark yellow, the texture is sticky, the taste of pumpkin is strong (2.3–3.0 points).

The use of the developed recipe will allow enterprises to use pumpkin paste in muffin technology without significant changes. The results obtained will allow us to make accurate predictions regarding the physicochemical and sensory parameters of the muffin. This is of practical importance since it minimizes the cash injections associated with the establishment of optimal parameters of the recipe. In addition, the use of pumpkin paste will expand the range of muffins with higher biological value.

The limitation of the research is the use of paste from one type of pumpkin – *Cucurbita moschata* (Duch.) Duch. ex Poir. varieties Destiny. The use of pumpkin paste obtained from other varieties requires additional research. This is especially true of indicators of sensory evaluation of the finished product. In addition, the optimal amount of pumpkin paste is designed for the classic muffin recipe. In muffin technologies of other formulations, it is also necessary to conduct additional research on the optimal enrichment with pumpkin paste.

The disadvantage of the study is the enrichment of the muffin with pumpkin paste of one type and variety. In addition, the research results cannot be applied to other types of pumpkin-containing semi-finished products because they have different technological properties.

The development of this study is to expand information about the physicochemical indicators of the quality of muffins enriched with pumpkin paste. They require further study into the safety of muffins enriched with pumpkin paste and the rationale for the shelf life of such products for consumption. Especially, muffin samples with a higher content of pumpkin paste. One requires additional determination of the biological and nutritional value of the products obtained. These patterns are a prerequisite for further research.

Under martial law, the duration of research and analysis of the results was longer due to power outages. This is due to damage to the infrastructure responsible for the production and transmission of electricity.

7. Conclusions

1. As a result of our research, it was established that the physicochemical indicators of the quality of the muffin vary depending on the amount of pumpkin paste. Research results show that the addition of pumpkin paste reliably ($p \leq 0.05$) increases the content of vitamin A (RAE), integrated score,

baking shrinkage, shrinkage due to drying, and moisture content of the muffin. The volume of muffin is significantly reduced by adding 10–50 % of pumpkin paste.

The surface color of the muffin with the addition of 5–25 % of pumpkin paste is light brown, increasing its proportion to 30–50 % provides a muffin with a brown surface. The light yellow crumb of the muffin is provided by the addition of 5–15 % of pumpkin paste. When adding 20–50 % of pumpkin paste, the color of the muffin crumb is yellow. The use of 5–15 % of pumpkin paste in the muffin recipe provides the highest level of smell and taste (8–9 points). The addition of 20–25 % of pumpkin paste provides an average level of smell and taste – 6.0–7.7 points. Increasing the amount of pumpkin paste to 30–50 % provides the lowest level of consumer evaluation.

2. It was found that the largest number of respondents (55 %) like muffins containing pumpkin paste in the amount of 15–20 %. It should be noted that 30 % of respondents liked muffins with 25–30 % of pumpkin paste. The smallest number of respondents (15 %) liked confectionery products with the amount of pumpkin paste at the level of 35–40 %.

3. In the technology of muffin production, it is optimal to add 15–20 % of pumpkin paste. According to this formulation, the integrated score of vitamin A (RAE) is 21–23 %, humidity – 22.9–25.9 %, baking shrinkage – 8.9–10.0 %, shrinkage due to drying – 2.1–2.2 %, volume – 166–177 cm^3/100 g of dough. The porosity is 7–9 points, surface color – light brown, crumb color – yellow, crumb consistency – soft, pumpkin taste level – weak or absent (7.0–8.3 points).

It should be noted that it is possible to increase the amount of pumpkin paste to 25–30 % since 30 % of respondents prefer such muffin samples. According to this recipe, a muffin is obtained with an integrated score for vitamin A (RAE) of 27–28 %, humidity 27.5–30.4 %, shrinkage – 12.4–13.5 %, shrinkage due to drying – 2.4–2.6 %, volume – 137–161 cm^3/100 g of dough. The porosity is 1–5 points, the surface color of the muffin is brown, the crumb color is dark yellow, the crumb texture is rubberish, the taste level of pumpkin is strong (3.7–5.7 points).

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

All data are available in the main text of the manuscript.

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