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TECHNOLOGICAL AND ECONOMIC JUSTIFICATION OF MUFFIN TECHNOLOGY FOR HEALTHY NUTRITION

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Abstract

Aim. Scientific substantiation and development of the optimal recipe and technology for the production of muffins using functional ingredients to better meet the needs of the consumers. Methods. Standard methods of analysis were used for the research. The quality of finished food products was controlled by organoleptic, physicochemical parameters. The results of experimental studies were subjected to statistical processing using standard Microsoft Office software packages. Results. In the research, the technology of muffins has been improved due to the use of functional ingredients. The relevance of creating low-calorie muffins has been substantiated in order to embrace a bigger market segment of consumers. The effect of these additives on the properties of muffins has been determined. A study of organoleptic and physicochemical quality indicators, calculation of nutritional and energy value has been carried out. The socio-economic effect of the introduction of the proposed muffin recipes into production is presented. Conclusions. The expediency of using locust tree beans powder – carob and using stevia with erythritol to improve the taste and nutritional value of muffins has been confirmed. A recipe has been developed and the technological scheme for the production of muffins has been improved. The introduction of the proposed technology will allow expanding the range of flour confectionery products with increased biological value to enable the manufacturer to exert sufficient influence on the end consumer.

Keywords: muffins; flour confectionery; low-calory products; carob; stevia; erythritol; consumer; market segment; production.

ТЕХОЛОГІЧНО-ЕКОНОМІЧНЕ ОБҐРУНТУВАННЯ ТЕХНОЛОГІЇ МАФІНІВ ДЛЯ ЗДОРОВОГО ХАРЧУВАННЯ

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Анотація.

Мета. Наукове обґрунтування і розробка оптимальної рецептури і технології виробництва мафінів з використанням функціональних інгредієнтів для більшого задоволення потреб споживачів. Методи. Для дослідження використовували стандартні методи аналізу. Якість готової харчової продукції контролювали за органолептичними, фізико-хімічними показниками. Результати експериментальних досліджень піддавали статистичній обробці за допомогою стандартних програмних пакетів Microsoft Office. Результати. У роботі удосконалено технологію виготовлення мафінів за рахунок використання функціональних інгредієнтів. Обґрунтовано актуальність створення мафінів зниженої калорійності з метою охоплення більшого ринкового сегменту споживачів. Визначено вплив даних добавок на властивості мафінів. Проведено дослідження органолептичних та фізико-хімічних показників якості, розрахунок харчової та енергетичної цінності. Наведено соціально-економічний ефект від впровадження у виробництво запропонованих рецептур мафінів. Висновки. Підтверджено доцільність використання порошку плодів ріжкового дерева – керобу та застосування стевії з еритритолом з метою покращення смакових якостей та харчової цінності мафінів. Розроблена рецептура та удосконалена технологічна схема виробництва мафінів. Впровадження запропонованої технології дозволить розширити асортимент борошняних кондитерських виробів підвищеної біологічної цінності, що дозволить виробнику мати суттєвий вплив на кінцевого споживача.

Ключові слова: мафіни; борошняні кондитерські вироби; низькокалорійна продукція; кероб; стевія; еритритол; споживач; сегмент ринку; виробництво.

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Introduction

Global trends in the field of functional food products are dynamically changing, they are aimed at the development of technologies and economic relations, ensuring the formation of segments for new types of products to be positioned as healthy food products.

The current state of the market requires new and innovative approaches to the development of flour confectionery to meet the requirements of a balanced and healthy diet, because sweets occupy a significant part of the human diet. They, like other food products, affect the health of the population. Therefore, confectionery goods must have not only high organoleptic indicators, but also health-improving properties, while guaranteeing economic benefits [1–6].

It is common knowledge that flour confectionery goods are high-calorie products characterized by an unbalanced chemical composition. As a result of their excessive and frequent consumption, diabetes, cardiovascular diseases, obesity, etc. can develop. Taking into account the limited possibilities of consumption of traditional confectionery products by people with special nutritional needs, one of the main directions for intensifying the production of flour confectionery products is to improve the technology of flour confectionery products using functional ingredients [1; 2; 7; 8].

Problem

To date, domestic and foreign researchers are conducting research and improving technological processes, creating new food products, expanding the range and enriching products by adding functional ingredients to the composition of traditional recipes. Ukrainian scholars have made a significant contribution to the creation of scientific and practical foundations for the production of special and health-improving products. [9–12].

The rhythm of life of a modern person increasingly forces one to refuse a full meal, giving preference to snacks or fast food. Muffins belong to snack products, which is a segment of fast food products that has shown high growth rates in recent years, which has formed a constant demand for muffins among the population. However, their significant drawback is high energy and low nutritional value, lack of dietary fiber, which contributes to the violation of the balanced diet for the population.

Therefore this group of products is a promising and accessible object in solving the problem of health improving for the population of Ukraine and for enriching basic products with missing functional ingredients – proteins, polyunsaturated fatty acids, dietary fibers, vitamins and minerals.

The production of functional flour confectionery goods that will meet the requirements of nutritive science at the current stage of development can be carried out by using sweeteners, special, physiologically functional ingredients that will enrich the products with the necessary nutrients.

Studies

Scientific research and publications of recent years [8; 10; 13–16] testify to the persistent interest of specialists in muffin technology improvement.

Scientists investigated [17] the possibility of developing a mixture for muffins enriched with apple pomace powder (33 %), which serves as a source of a large amount of dietary fiber and improves the nutritional quality of the product.

A muffin mix was developed [18], made with chia seeds (20 %), which has a significantly higher mineral content (calcium, phosphorus, zinc and iron) compared to the control.

M. Niharika, G. Sireesha, D. Madhavi, A. M. Bulah, P. Preethi Vineela [14] conducted studies on the development of an enriched mixture for quick-cooking muffins with calcium (chicken eggshell). Compared to other calcium supplements, eggshell calcium is quickly absorbed by the body and can reduce bone-related problems such as osteoporosis.

H. Ramya, A. Shivanna [10] developed muffins with 25 % coconut flour and using honey as a sweetener. Coconut flour is a source of dietary nutrition, fiber and protein. The introduction of this raw material contributed to the improvement of the consumption quality of muffins, their aroma, color and texture.

Scientists of Poltava University of Economics and Trade [11] proposed the technology of muffins with pumpkin filling to increase their nutritional value.

A. M. Dorohovich and N. P. Lazorenko [12] developed muffin technologies with different types of sugars (sucrose, fructose, lactulose) and determined their influence on the formation of organoleptic and physicochemical indicators of products.

Scientists of Oles Honchar Dnipro National University [16] developed recipes and technologies for quick-cooking muffins from dry semi-finished products adding of dry blueberry powder. This technology ensures the preservation of beneficial effect for biologically active substance after heat treatment. The developed dry mixes for muffins do not contain fat and sugar.

Stevia leaf extract adds sweetness to the product, cocoa powder was completely replaced by a domestic analogue – flour made from seeds of dark grapes.

Australian specialists [19] developed recipes for muffins enriched with dried crushed flax seeds and flax flour (5…10 %), and eggs were excluded from the recipe composition of these muffins without deteriorating the quality of the finished product and excluding allergic reactions.

Researchers of South Kazakhstan State University [20] developed a recipe for high-quality muffins with the addition of rice flour, which contributes to the elimination of protein deficiency in human nutrition.

Scholars of National University of Food Technologies developed recipes and technologies for gluten-free muffins using gluten-free types of flour (corn, rice, buckwheat) [21–23], with the use of lactulose and other sugar substitutes [24].

According to the above-mentioned, the formation and development of functional muffins, in order to obtain a product with a wide range of functional properties directed at various aspects of the body's activity, is a promising and urgent task. The solution is to replace traditional types of raw materials in these confectionery products (granulated sugar, cocoa powder [25–28]) with natural substitutes (stevia, erythritol, carob fruit powder) to increase nutritional value of muffins, reduce calorie content and expand the range of functional products. Taking into account rapid increase of people with impaired carbohydrate and fat metabolism, patients with diabetes and atherosclerosis, this study is highly topical.

Goal

The purpose of the research covered in the article is the scientific substantiation and development of the recipe and technology for the production of muffins using functional ingredients.

To achieve the set goal, the following tasks must be solved: to investigate modern approaches to improving the technology of muffins production with functional ingredients; to substantiate functional properties of muffins ingredient composition; to justify the choice of recipe economically, as well as its raw material base for using in flour confectionery products; to substantiate theoretically and develop the technology for using carob and stevia with erythritol; to study the consumer properties of new products in terms of organoleptic, physico-chemical indicators and nutritional value.

Findings

Muffin technology using functional ingredients was chosen as the object of research. In the recipe of the muffins cocoa powder was completely replaced with carob fruit powder and sugar with natural sweeteners – stevia and erythritol in the specified ratios.

At the first stage of experimental and economic study to manufacture a product with a functional purpose, we replaced 100 % of the sugar in the classic muffin recipe with a sweetener.

Today, products using sugar substitutes, mostly natural, are widespread in the world. It should be noted that synthetic sugar substitutes and sweeteners carry a potential health risk. With systematic use, they reduce a person's intellectual abilities and can provoke allergies, decreased visual acuity, headache, fatigue, dizziness, nausea, tachycardia, memory impairment, brain tumors and other diseases. Natural sugar substitutes are almost completely absorbed by the body, participate in metabolic processes, and, like ordinary sugar, provide the body with additional energy, they are harmless and have certain medicinal properties. Among the plants with a sweet taste, the best known is stevia (Stevia rebaudiana Bertoni), a natural sweetener recommended by the Ministry of Health of Ukraine for wide use. There are many works that testify to the healing properties of stevia due to its sweet glycosides. Therefore, stevia-based products were chosen as sweeteners in this work [29].

To justify the choice and study the impact of the sweetener on the quality of muffins when using them in the recipe instead of sugar, two sweeteners were added: Stevia sweet with natural sweetener Grean Leaf (Ukrainian Specifications 10.8-43160955-002:2020) [30] and «Bactosyla» Steviasun (Ukrainian Specifications 15.8-30729147-003:2004) [31]. Given that sweeteners have different sweetness, they were added in amounts corresponding to the sugar content in the control recipe. Thus, the Grean Leaf sweetener was added in a ratio of 1:1 to sugar, and the Steviasun sweetener was added in a ratio of 1:15 to sugar.

Materials and methods

Experimental research and development of the recipes were conducted in the laboratories of the Department of Food Technologies of Oles Honchar Dnipro National University.

Generally accepted research methods were used to determine the functional, technological, physicochemical, and organoleptic characteristics of semi-finished and finished products.

The experimental and control samples were prepared from the same batch of raw materials. The semi-finished products were brought to culinary readiness by baking in a Convotherm combi steamer (OES 10.10) at a temperature of 180...185 °C. To assess the quality of the samples, sampling was first carried out according to DSTU 5904:2006. The experiments were repeated three times. The experimental data obtained are presented in units of the international SI system. Relative error of experimental measurements within the confidence interval of 0.05.

The mass fraction of moisture in the tested samples was determined by drying to a constant weight according to DSTU 4910:2008. A drying oven of the SNOL 7/350 type was used for the analysis. The alkalinity of the finished products was determined in accordance with DSTU 5024:2008. The wettability of muffins was determined according to DSTU 5023:2008. The porosity of muffins was determined according to DSTU 7045:2009. Organoleptic evaluation of the quality of finished products was carried out according to DSTU 4683:2006. The weight of the products was determined by weighing on a electronic laboratory balances MHZ 0.01–500, with an accuracy of 0.01 g.

Results and discussion

The influence of the selected sweeteners on the properties of dough and organoleptic quality indicators of the finished products were determined. The obtained data served as the basis for the development of recipes and technological schemes for muffins production using carob instead of cocoa powder and with a complete replacement of sugar with a sweetener.

The classic technology of making muffins includes the following stages: preparation of raw materials; preparation of egg-sugar-butter emulsion; combination with dry ingredients (wheat flour, cocoa powder, baking powder); kneading the dough; dosage; baking.

It should be noted that the sweetener can be added at the stage of making the egg-butter emulsion directly to eggs and at the same stage, but to milk. It was found out that adding a sweetener to eggs did not allow it to fully dissolve, it was more effective to introduce it in the form of a pre-prepared mixture with milk for better dissolution, added to the beaten egg-butter emulsion, which made it possible to ensure an even distribution of recipe components.

In the dough for muffins, the density and humidity were determined, as well as the baking of the finished products. The results are shown in Table 1.

Table 1

The results of studies for muffins with various sweeteners (n=3, p≤0.05)

Type of product	Moisture content of the dough, %	Dough density immediately after mixing, g/cm ^{3}	Baking the finished product, %
Muffin – control	33.4±0.5	1.108±0.05	8.05±0.3
Muffin with Green Leaf sweetener	34.5±0.5	1.148±0.05	8.70±0.3
Muffin with Steviasun sweetener	44.2±0.5	1.162±0.05	8.80±0.3

The research results (Table 1) show that the dough moisture of the muffin-control and muffin with Green Leaf sweetener are at the same level, unlike the muffin with Steviasun sweetener, which has a dough moisture content 10 % higher than the control. The use of sweeteners in the muffin recipe has a significant effect on the density of the dough. Compared to the density of the control, in both types of dough, the density of the experimental samples tends to increase.

The dependence of the baking rate of muffins on the type of sweetener added to the recipe was determined. When mixing the control sample and a muffin with Green Leaf sweetener, the dough had high plastic properties. This is explained by the fact that wheat flour proteins swell and form gluten, which gives the dough qualities that have a positive effect on the forming process – the dough is evenly distributed over the form. The conducted studies showed that the use of Steviasun sweetener provides a more liquid dough consistency.

In the course of the organoleptic evaluation of muffins with Grean Leaf sweetener, the tasters noted the pleasant dark brown color of the crust, pleasant and moderately sweet taste, correct, not vague shape of the finished products. During the tasting of the muffin with Steviasun sweetener, the tasters pointed to the poor chewiness, insufficient sweetness of the product and an unpleasant bitter aftertaste. Therefore, Green Leaf sweetener was used for further research and development of the recipe for functional muffins.

At the next stage of the research, cocoa powder was replaced by carob powder in muffin recipes (in the amount of 5, 10, 15 %). Carob is a low-

calorie sweet powder obtained from the pulp of carob fruits (pods). It somewhat resembles the taste and smell of cocoa, but has its own characteristics and advantages. According to the conclusion of the US Food and Drug Administration (FDA), the consumption of carob powder is safe for humans, it belongs to the class GRAS (Generally recognized as safe) [32].

Carob is used as a substitute for cocoa, sugar and chocolate, as well as as a thickener and stabilizer. It has a number of valuable functional properties, is a valuable source of dietary fibers, sugars, potassium, calcium, magnesium, water- and fat-soluble vitamins, in particular: A, E, D, B2, B6, B12, C, as well as substances of antioxidant action. According to the composition of proteins, fats and carbohydrates, it can be classified as a dietary product recommended for a balanced diet and in the treatment of some diseases. First of all, it can be used in the nutrition of patients with diabetes, in diseases associated with a violation of fat-carbohydrate metabolism, as well as for people with excess weight. Despite the fact that there are few proteins in carob (3...8 % of dry weight), they contain almost all free amino acids, including essential ones.

Carob does not contain psychotropic substances (caffeine, theobromine), which can lead to habituation and allergic reactions of the human body. In addition, it does not contain phenylethylamine and fromamine, which cause migraines and allergies, instead it contains tannins that have the ability to bind and remove toxins from the body. In addition, there is no gluten in carob, which makes it possible to use the sweet powder for people with a diagnosis of celiac disease. Therefore, the use of carob fruit powder allows you to make muffins affordable and useful [26].

Unlike cocoa powder, carob is lighter and sweeter, as the amount of sugars in its composition is 48...56 %. The sweetness coefficient of carob is 0.5...0.6 of the sweetness of sucrose, due to which it is possible not to add sugar to the recipe of confectionery products or to add it in a smaller amount. And the low fat content (0.2...0.6 %), compared to cocoa, has a positive effect on the shelf life of finished products. Eating 100 g of carob powder per day satisfies an adult's daily need for dietary fiber [33].

The developed recipes of muffins using functional ingredients are shown in Table 2.

Table 2

Rational recipes of muffins using functional ingredients

The name of the raw material	Mass fraction of dry substances, %	Costs of raw materials and materials for 6 pieces of finished products (480 g)							
		Control		Muffin with carob 5 %		Muffin with carob 10 %		Muffin with carob 15 %	
		in kind	in dry matter	in kind	in dry matter	in kind	in dry matter	in kind	in dry matter
Wheat flour of the highest grade	86	180	154.8	199	171.14	189	162.54	179	153.94
Sugar-sand	99.85	90	89.87	–	–	–	–	–	–
Stevia + erythritol	100	–	–	80	80.0	80	80.0	80	80.0
Milk 1,0 %	12	108	12.96	115	13.8	115	13.8	115	13.8
Chicken egg	27	72	19.44	90	24.3	90	24.3	90	24.3
Vegetable oil	100	36	36	39.8	39.8	39.8	39.8	39.8	39.8
Baking powder	92	3.6	3.312	3.6	3.312	3.6	3.312	3.6	3.312
Cocoa powder	84.17	28.8	24.24	–	–	–	–	–	–
Kerob	92.75	–	–	9	8.35	18	16.70	27	25.04
Cooked food salt	96.5	0.6	0.58	0.6	0.58	0.6	0.58	0.6	0.58
Vanilla essence	0	2.4	0	2.4	0	2.4	0	2.4	0
Dried cranberries	80	46.8	37.44	46.8	37.44	46.8	37.44	46.8	37.44
Total	–	568.2	378.64	586.2	378.72	585.2	378.47	584.2	378.21
Losses, %		15.5		15.5		15.5		15.5	
Yield		480		480		480		480	

It is widely known that the quality of muffins is formed at all stages of their production, including at the stage of kneading the dough and during baking. At the same time, the structure of the dough is fixed due to the denaturation of its protein components and pasteurization of starch, and air bubbles that expand with increasing temperature form voids.

During the development of muffin technology with the addition of functional raw materials, it is important to ensure the necessary structural and mechanical properties of the dough, which will contribute to good formation and preservation of the shape of the products The effect of carob and sweetener on the compression properties of the dough for muffins was studied, and as to the quality indicators density and moisture were determined (Table 3).The classic muffin recipe served as a control.

Table 3

The value of the density and moisture indicators of muffin dough based on natural raw materials (n=3, p≤0.05)

Indicator	Control	Samples of muffins on natural raw materials with carob		
		5 %	10 %	15 %
Dough density, g/cm ^{3}	1.108±0.05	1.113±0.05	1.138±0.05	1.144±0.05
Dough moisture, %	33.4±0.45	36.5±0.45	36.1±0.45	35.7±0.45

Analyzing the obtained data, it can be concluded that the use of carob and sweetener in the recipe of muffins affects the density and moisture of the dough. It was found that the density of the dough for muffins in the presence of carob and sweetener under the conditions of increasing the dosage of carob fruit powder has a tendency to increase, compared to the control. It was noted that for muffins with 5, 10 and 15 % additives, the increase in density is 0.005, 0.03 та 0.036 g/cm^3 respectively. The increase in the value of the studied indicator is due to the fact that carob powder is characterized by a finely dispersed state, as a result, its particles fill the pores of the muffins, reducing their volume, but it does not have a noticeable negative effect on the formation process.

Conversely, the moisture content of the dough tended to increase relative to the control, it increased by 9.2 % in muffins with 5 % carob, by 8.08 % with 10 % carob and by 6.8 % with 15 % carob dosage. Note that in the developed muffins, an increase in the dosage of cherub from 5 % to 15 % leads to a decrease in the mass fraction of moisture in the dough by 2.19 %. This is explained by the fact that the moisture-retaining capacity of carob is 1.7 times higher than that of high-grade wheat flour. The high moisture-retaining capacity of carob is due to the presence of cellulose and hemicellulose in the composition. Thus, carob affects the quality of the dough, but does not have a noticeable negative effect on the forming process.

With a purpose of researching the impact of recipe components on the rise of the dough (as it depends on the volumetric output of finished products) for muffins with natural raw materials, during baking, the kinetics of the rise of the dough was studied with the help of a graduated ruler, the obtained results are indicated in the table. 4.

Table 4

The flow-up index of muffins on natural raw materials with the introduction of carob and sweetener (n=3, p≤0.05)

Height indicator, mm	Control	Samples of muffins on natural raw materials with carob		
		5 %	10 %	15 %
before baking	27±1	25±1	25±1	25±1
after 20 minutes of baking	48±1	45±1	46±1	47±1
$K_п$, per unit.	1.78±0.05	1.8±0.05	1.84±0.05	1.88±0.05

The data obtained indicate that muffins with the use of carob and sweetener are characterized by an almost similar flow-up index depending on the dosage of carob. Thus, the flow-up index of the control sample was 1.78, and the samples with the addition of carob in the amount of 5, 10, and 15 % were 1.8, 1.84, and 1.88, respectively.

It is worth noting that the degree of baking is an important technological characteristic, since the yield of finished products depends on it. This indicator depends on the temperature and duration of baking, the relative humidity of the air environment of the baking chamber, as well as on the features of the recipe. Based on this, the impact of carob on the weight loss of muffins was studied. After baking the muffins, the technology involves keeping them at room temperature (15...25 °C) for 10 minutes to fix the structure. During this time, moisture is redistributed between the crust and the inner layers of the pulp and a certain part of it is lost from the upper layer. Thanks to this, a stable porous structure is formed. In the process of

research, the effect of adding carob on the loss of moisture immediately after baking and after proofing was determined. The results of the research are shown in Fig. 1

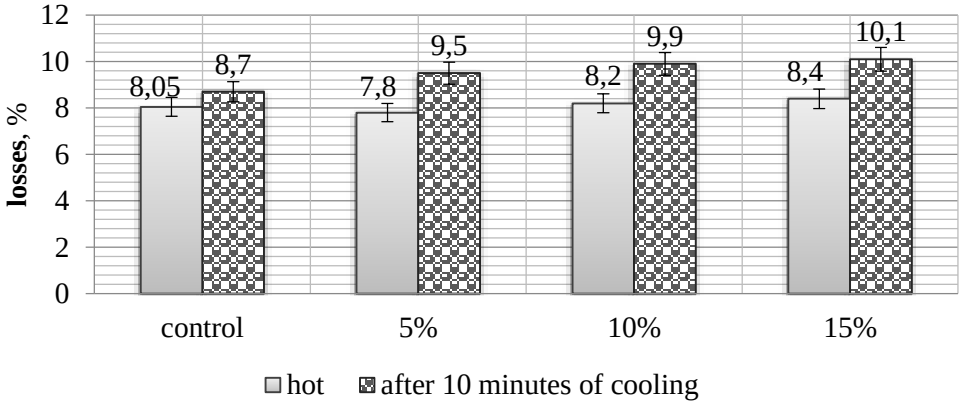

Fig. 1. The effect of carob on the baking of muffins using natural raw materials

It was found out that in hot and after 10 min of cooling muffins using natural raw materials (Fig. 1) with an increase in the content of the additive, the value of the baking index increases in the sample by 10 and 15 % compared to the control by 1.86 and 4.3 %, respectively, and 13.7 and 16.09 %. A significant increase in losses during baking is undesirable – at the same time, the costs of raw materials increase, which will lead to an increase in the cost price of muffins.

At all stages of the production of flour products, humidity is controlled because it has a significant impact on the quality of the products. It was determined that under the conditions of carob dosing in the amount of 5, 10 and 15 %, the moisture content of products based on natural raw materials is equal to 30.2; 27.9 and 24.6 %, which is more than in the control sample by 24.3 %; 18.1 and 7.1 relative percentages, respectively. Examining the samples with carob, we can note a tendency to reduce the humidity of the muffins. The decrease in the moisture content of muffins with the additive is explained by the fact that carob has certain features of the polysaccharide composition, the food fibers of the additive are represented mainly by cellulose, which has a developed system of thin submicroscopic capillaries. Therefore, it can be assumed that dietary fibers contained in carob are able to bind free and physically-mechanically bound moisture, and partially reduce its evaporation during drying. The results of the study of the moisture content of the finished muffins are presented in Figure 2.

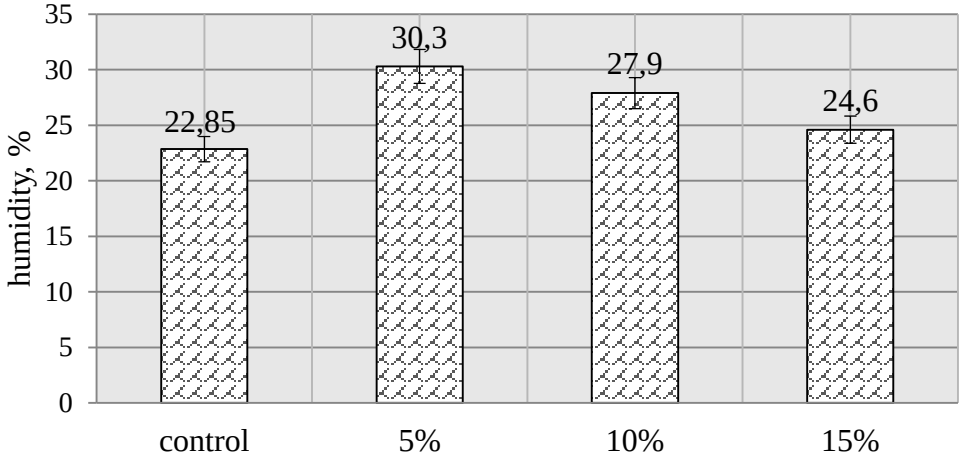

Fig. 2. The effect of carob on the moisture content of muffins

There alkalinity studies of finished products have been conducted, as this indicator is regulated by regulatory documentation (DSTU 4505:2005 "Cupcakes. General technical conditions") and should not exceed 2 degrees. The results of the research are presented in Fig. 3.

The data obtained during the research (Fig. 3) are within the limits regulated by the requirements of the current regulatory documentation. Studies have shown that adding carob and sweetener to the composition of muffins made of natural raw material reduces the alkalinity index from 1.5 degrees to 1.2 degrees.

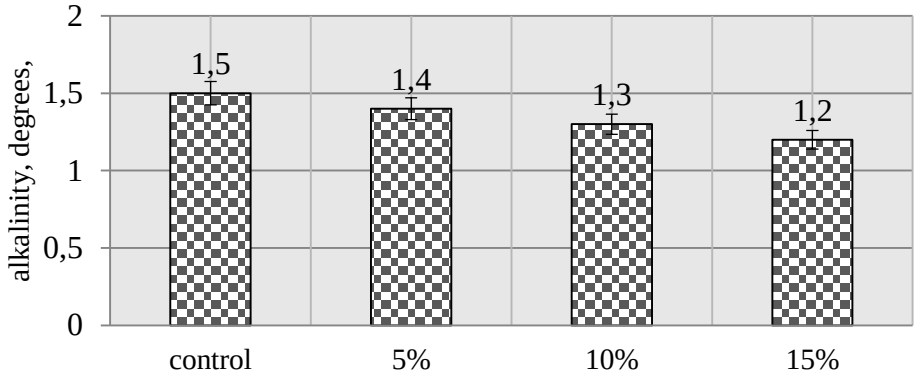

Fig. 3. Effect of carob on the alkalinity of muffins

The decrease in alkalinity is probably due to the fact that carob contains organic acids in its composition that interacts with the baking powder of an alkaline nature, which leads to its neutralization, in addition, the decrease in alkalinity has a positive effect on the quality of the finished product and on its organoleptic indicators.

One of the important indicators that characterizes the structural and mechanical properties of muffins is wettability, the research results are presented in fig. 4. The obtained data show that with an increase in the percentage of the additive, this indicator increases, this is explained by the content of dietary fibers, which have a higher water absorption capacity, in the composition of carob. It was established that all the tested samples meet the requirements of regulatory documentation by the value of the wettability index – according to the DSTU, this indicator must be at least 100 %.

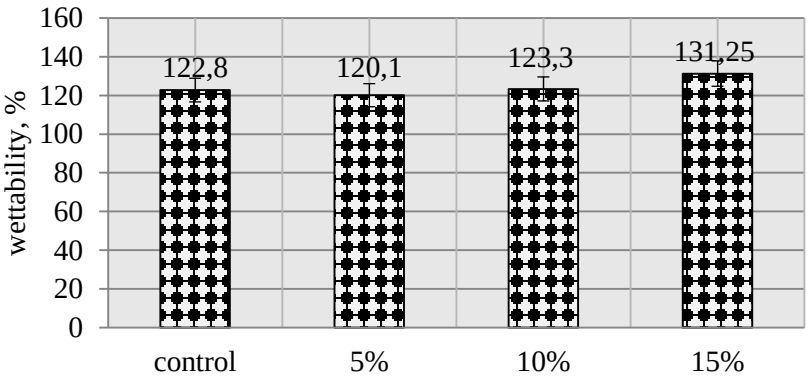

Fig. 4. The effect of carob on the wettability of muffins

Another important characteristic of the quality of baked muffins is the porosity of the products, which significantly affects their ability to be quickly and evenly impregnated with syrup and filling and determines the texture of the finished products. It has been established that the developed muffins with the addition of carob in the amount of 5, 10 and 15% have porosity of 58.4, 56.6, and 54.05% respectively, with a control of 45.8%.

Organoleptic evaluation of the quality of finished products was carried out according to DSTU 4683:2006 «Confectionery. Methods of determination organoleptic quality indices, sizes, net-mass and components» [34]. According to DSTU 4683:2006, organoleptic indicators of muffins include taste, smell, shape and appearance when broken.

For organoleptic evaluation of the quality of finished products after heat treatment, a scoring system was used. It makes it possible to quantify the quality of the finished product. The organoleptic analysis of muffins with the addition of carob powder and stevia with erythritol was carried out on a five-point scale. The number of tasters is 10 people. For each member of the commission, one product of each type according to the developed technology and control was presented for tasting. For a more correct comparative organoleptic evaluation, a system of indicators was developed, which includes the appearance, crumb condition, aroma, taste, and chewiness of the crumb. Importance coefficients

were established depending on the significance of the organoleptic indicator.

The results of the tasting evaluation of the tasters were recorded in the tasting cards. The average score for each product was determined as the arithmetic mean of the scores for all indicators. After processing the results, extended profiles of organoleptic indicators were built using the MS Excel computer program.

As a result of the organoleptic evaluation (Fig. 5, 6), it was found out that the developed muffins with the addition of carob in the amount of 10 and 15 % to the mass of flour have indicators at the control level. The products had an attractive appearance, a characteristic taste and a pleasant aroma, the surface kept the correct convex shape without tears and cracks. With the addition of 5% carob, the tasters noted the uneven porosity and dense structure of the crumb, the faintly expressed color of the crust.

Thus, based on the results of the research, it can be stated that the use of carob in the amount of 10 and 15 % to the mass of flour and the sweetener Stevia sweet Grean Leaf contributes to the improvement of the technological indicators of muffins and makes it possible to obtain finished products with quality indicators not lower than control.

Fig. 5. Appearance of finished muffins: 1 – control; 2 – 5 % carob (sample №2); 3 – 10 % carob (sample №2); 4 – 15 % carob (sample №2)

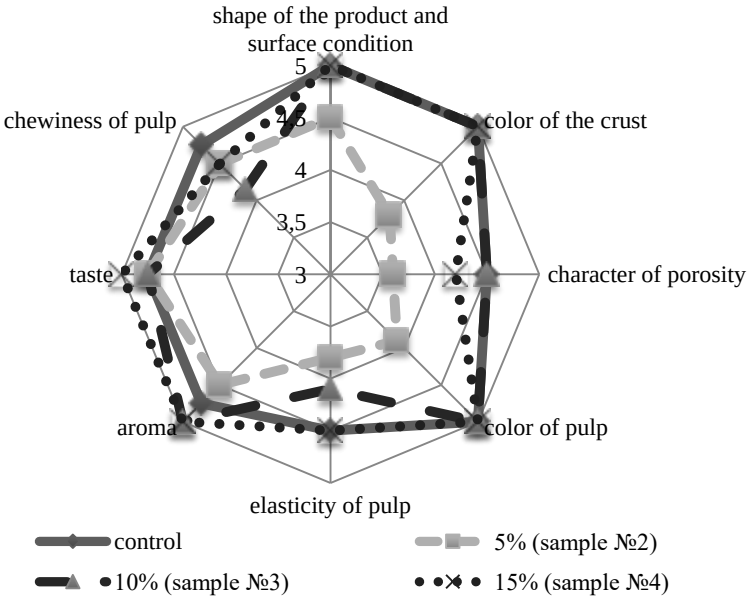

Fig. 6. Organoleptic profile of developed muffins and control

Based on the proposed recipes and conducted research, the technological scheme for the production of functional muffins has been improved (Fig. 7).

The results of the conducted study showed that the optimal content of carob in muffin technologies is 15 % of the amount of flour with a complete replacement of granulated sugar with a sweetener. These samples received high organoleptic and physicochemical quality indicators within the limits set in the regulatory documentation.

The application of a system approach during the development of muffin technology on natural raw materials with the use of functional ingredients makes it possible to distinguish subsystems in the technological system: C_1, C_2, C_3, C_4, B, A. The functioning of the system is ensured by the functioning of individual subsystems in accordance with the assigned tasks. It should be noted that the sequential transition from one subsystem to another provides the final product with specified properties. The purpose of individual subsystems functioning is shown in Table 5.

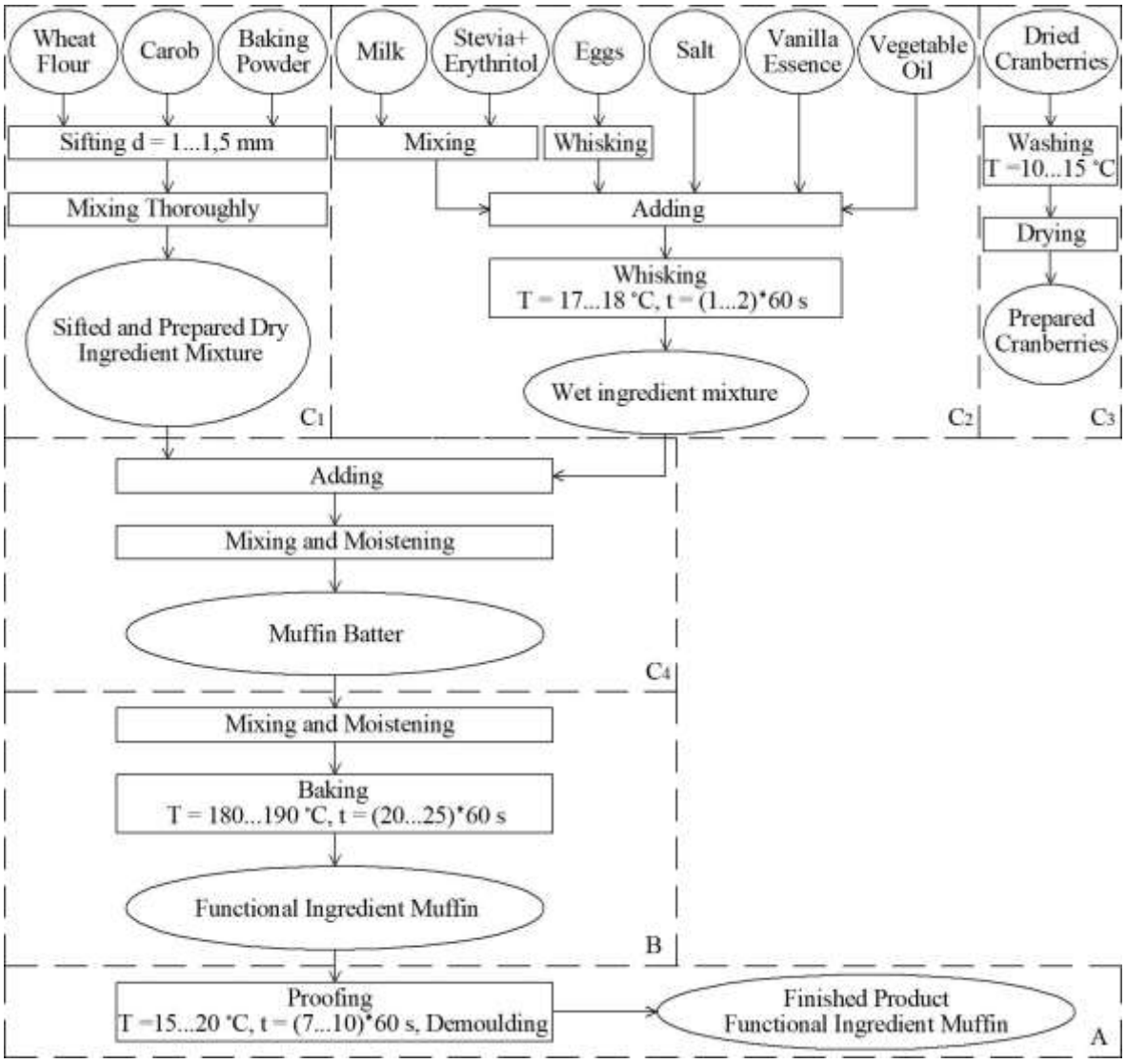

Fig. 7. Technological scheme for making muffins using functional ingredients

Due to developed technological maps, the nutritional and energy value of muffins based on natural raw materials was calculated, as well as the comparative characteristics of the control sample and improved muffins.

During the development of muffin recipes, the main attention was paid to reducing their energy value and increasing the content of functional ingredients (proteins, dietary fibers, vitamins, etc.). Thanks to the addition of additives (carob, stevia, erythritol), we managed to reduce energy value of the developed products.

Table 5

The structure of the technological system and the purpose of its constituent parts functioning

Subsystems	The name of the subsystem	The purpose of the subsystem functioning
A	Creation of the finished product	Obtaining the finished product "Muffin with the use of functional ingredients"
B	Formation of a semi-finished product	Obtaining semi-finished product "Muffin with the use of functional ingredients"
C_1	Formation of a semi-finished product is a sifted and prepared mixture of dry ingredients	Obtaining semi-finished product "Mixture of dry ingredients". Sequential implementation of operations with obtaining a semi-finished product for further use
C_2	The formation of a semi-finished product is a mixture of wet ingredients	Obtaining a semi-finished product "Mixture of wet ingredients". Preparation of raw materials for further processing
C_3	Formation of a semi-finished product - the cranberry is prepared	Obtaining a semi-finished product "Cranberry is prepared". Preparation of raw materials for further use
C_4	Formation of a semi-finished product - dough for muffins	Obtaining a semi-finished product "Dough for muffins". Preparation of raw materials for further technological processing

The nutritional and energy values of the developed muffins and the control are shown in the table (Table 6).

The calculation showed that the energy value of muffins made on natural raw materials with stevia and erythritol with the addition of 5 % carob is 18.5 % less than the caloric value of the sugar sample, and the muffin with 15 % carob, respectively, is 20.2.

The calorie content of muffins made from natural raw materials with 15 % carob decreased by 64.2 kcal compared to the control.

Table 6

Nutritional and energy value of developed muffins and control, 100 g

Food substances	Найменування виробів			
	Control	Muffin with carob (5%)	Muffin with carob (10 %)	Muffin with carob (15 %)
Proteins, g	7.8	7.4	7.3	7.1
fats, g	10.2	10.6	10.5	10.4
Carbohydrates, g	48.4	33.5	33.0	32.5
Food fibers, g	2.0	2.6	3.3	3.9
Energy value, kcal	317.4	258.6	255.9	253.2
Vitamins:				
A, mcg	37.8	47.0	47.0	47.0
B_1 (thiamine), mg	0.08	0.09	0.08	0.085
B_2 (riboflavin), mg	0.122	0.138	0.145	0.153
B_4 (choline), mg	60.75	72.31	71.49	70.66
B_5, mg	0.464	0.442	0.437	0.431
B_{12}, mcg	0.161	0.18	0.186	0.186
PP (niacin),mg	2.18	2.08	2.05	2.03
E,mg	4.008	4.41	4.39	4.37
D, mcg	0.31	0.39	0.39	0.39
H, mcg	4.32	5.168	5.128	5.088
Mineral substances, %:				
Potassium, K, mg	188.9	128.2	140.65	153.09
Calcium, Ca,mg	50.81	53.59	59.5	65.4
Iron, Fe, mg	2.1	1.044	1.073	1.102
Sodium, Na, mg	79.46	84.82	85.39	85.96
Phosphorus, P,mg	117.8	93.1	92.8	92.5
Manganese, Mn, mg	0.49	0.26	0.25	0.25
Cobalt, Co, mcg	2.2	2.63	2.6	2.57
Selenium, Se, mcg	7.06	8.5	8.501	8.47

Thus, on the basis of the conducted study, a social effect has been achieved, which consists in expanding the traditional range of flour confectionery products with functional products with improved consumption properties. The proposed muffin recipes are characterized by improved nutritional value and have a reduced calorie content compared to the control.

To confirm the expediency of muffins production using kerob, we determined social and economic efficiency of their implementation into production (Table 7). First of all, it is expressed in the profit for the enterprise, higher quality parameters of the developed products compared to the analogue product for the consumer and high competitiveness in the food market of flour confectionery products.

Table 7

Passport of a new product – muffins with the use of functional ingredients

Name	Characteristic	
Destination indicators		
Classification	According to commodity classification	Flour confectionery products
Functional	Projected composition of products	Muffins with carob and sweetener
	Energy value (100g)	253.2 …255.9 kcal
	Nutritional value	Proteins – 7.1…7.3 g, Fats – 10.4..10.5 g, Carbohydrates – 32.5…33.0 g
Social	Business process	B2B, B2C, Food service
	Consumer segment	Retail and wholesale trade enterprises, ZRG, ordinary people

Continued Table 7

Informational	Marking	According to the "Technical Regulation on the Rules of Labeling of Food Products", the Law "On Information for Consumers on Food Products"
Reliability indicators		
Longevity	7...12 days (depending on the packaging method)	
Storage conditions	The products are stored in dry, clean, well-ventilated rooms that do not have extraneous odors, are not infected by pests of grain stocks, at a temperature of (18±3) oC and a relative humidity of air not higher than 75%.	
Indicators are ergonomic		
Organoleptic indicators	Appearance:	Round, not deformed, without overflows, inherent in the form in which the products are baked, without contamination.
	Color:	Attractive, characteristic for raw materials, light brown
	Taste and smell:	Pleasant, harmonious, characteristic for this type of products with a pronounced taste and smell of applied additives. Extraneous taste and smell are not allowed
Anthropometric indicators	The mass of the product in the consumer container	500 g
Aesthetic indicators		
Form of packaging	Individual muffins can be packed in cardboard boxes with an artistically designed label in accordance with DSTU4260-2003, packaging made of polymer materials with subsequent covering with an artistically designed film, as well as bags made of cellophane or other polymer films approved by the Central Executive Authority in the field of health care. Boxes with prepackaged muffins are tied with silk, viscose, kapron, cellophane, adhesive tape, silk or alum cord, or the lid and bottom of the box are pasted on two opposite sides with a paper strip, polyethylene tape with a sticky layer, or the box with muffins is packed in a heat-dissipating airtight film. Bags made of cellophane or polymer film for packing muffins in them must be heat-sealed or tied with a ribbon, alum cord or sealed with a label with the trademark of the manufacturer. On the artistically decorated polyethylene film, the colors must be durable and not transfer to the surface of the products, and must also be approved for use by the Central Executive Authorities in the field of health care. It is acceptable to pack muffins in folding packs with flaps without gluing.	
Color solution	According to the assortment	
Integrity of perception	Complete	
Corporate identity	Yes	
Environmental indicators		
Packaging material	Polymer materials, films based on polyolefins, cardboard boxes (micro-corrugated cardboard)	
Safety indicators		
Marginally permissible content of toxic elements and mycotoxins	Meets the requirements of the order of the Ministry of Health of Ukraine dated July 19, 2012 No. 548; Order of the Ministry of Health of Ukraine No. 368 of May 13, 2013	

Continuation of Table 7

Marginally permissible content of microorganisms	Meets the requirements according to DSTU 8446:2015; DSTU 8447:2015; DSTU EN 12824:2004; GOST 30518-97; DSTU EN ISO 22118:2019
Value indicators	
Estimated cost per 500 g of product (September 2022), UAH	81.24
The overall economic result of the development and introduction of a new technology into current production	Obtaining additional profit due to improving quality, increasing output or saving raw materials, fuel and energy, labor or other types of resources in the process of manufacturing products.
The economic effect from the implementation of innovative products can be obtained at the expense of:	Increasing the volume for muffins sales under the conditions for demand elasticity; the growth of revenue from the sale of muffins under the influence of the price factor; an increase in the mass of profit (under conditions of constant profitability) as a result of sold products increase; release of working capital invested in stocks of raw materials.

Thus, higher quality parameters of products compared to similar products increase its value for consumers and make it possible to increase the volume of products sold and profit, both due to quality, expansion of the assortment and increased price level. The economic effect of the proposed technology for muffins can be ensured both at the stage of bringing products to the market and during further implementation.

Conclusions

Summarizing all of the above mentioned, it can be concluded that the prospect of using carob powder and sweetener in the technology of muffins using natural raw materials and the relevance of the production of these products has been theoretically justified, experimentally and economically proven, which will significantly contribute to the choice of a consumer of a certain segment of the market.

The technology of flour confectionery with functional raw materials has been improved and the recipe of muffins has been suggested by completely replacing sugar with sweetener and cocoa powder with carob in a different percentage ratio of 5 : 10 : 15 to the flour mass.

It has been established that the optimal addition of carob to the recipe of muffins, which gives them qualities close to the control sample, is a muffin based on natural raw materials with the addition of 15% for carob. The data obtained during research indicate that muffins based on natural raw materials with carob in the amount of 15% for the flour mass best meet the requirements of the current standard, they provide high nutritional value of products with sufficiently good organoleptic and physicochemical indicators, it has been noted that the addition of carob helps to reduce the humidity of products, as well as a slight decrease in alkalinity, the positive effect of the components is especially noticeable on the indicator of lifting force.

The social and economic effect of the introduction of the developed muffins has been determined. The calculation of the nutritional and energy value, mineral and vitamin composition of muffins showed an increase in nutrients, a high content of dietary fibers and certain mineral substances. Due to the complete replacement of sugar with a sweetener and cocoa powder with carob, the calorie content of products is reduced, the calorie content of muffins based on natural raw materials with 15 % carob decreased by 64.2 kcal.

Thus, a significant adjustment of the muffin recipe, which made it possible to reduce their calorie content by 16...26 % compared to the control, was carried out in the work. In addition, the changes in the recipe made it possible to increase the content of dietary fibers by 1.65...1.95 times, which by 10...15 % will provide the daily norm of their consumption in terms of healthy eating.

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