To improve the fatty acid and amino acid composition, as well as the organoleptic characteristics of flour confectionery products, new formulations for wafers "Summer Temptation" and "Coconut Delight" with fillings made from organic raw materials have been developed. Both products' formulations contain pure organic raw materials. The composition of "Summer Temptation" wafers includes buckwheat flour, cane sugar, butter, skimmed milk powder, sea buckthorn oil, and lemongrass powder. Rice flour, coconut sugar, dry coconut milk, coconut oil, lemongrass powder are added to the composition of "Coconut Delight" wafers. The developed products have excellent organoleptic characteristics that are confirmed by the conclusions from a tasting board. Safety indicators also comply with regulatory requirements. Both samples are distinguished by a lower content of heavy metals compared to control. Since the fatty base and flour were replaced in the new samples in comparison with the control formulation, the fatty acid and amino acid compositions of the products were investigated. The sample, based on organic buckwheat flour, demonstrated the best amino acid composition. The content of essential amino acids in the sample "Coconut Delight" increased slightly. The content of saturated fatty acids decreased by almost 1.5 times in both developed products. At the same time, the content of unsaturated fatty acids in both types of wafers increased by almost 4 times in comparison with control.

These results indicate that the use of organic raw materials in the production of wafers with fillings improves their consumer properties. The addition of unconventional organic oils to the fillings improves the fatty acid composition while the replacement of flour in wafer sheets improves the amino acid composition. The obtained results can be used at enterprises in the food industry to expand the range of organic products

Keywords: amino acid composition, fatty acid composition, organic products, pastry, wafers with fillings

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DEVELOPMENT OF WAFERS WITH FILLINGS MADE FROM ORGANIC RAW MATERIALS WITH IMPROVED CONSUMER PROPERTIES

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1. Introduction

The trend of healthy nutrition and the new tendencies in consumer food choice encourage the expansion of the product range, in particular, flour confectionery. Based on data in neurobiology, gastrophysics, and molecular gastronomy, the scientific institutes in Great Britain, Ireland, and other countries are searching for new food formulations [1]. It should be noted that flour products have a wide range, such as bread, rolls, and cakes, which have been in high demand worldwide for the last 150 years [2]. The increased working population in the world and the growth of disposable income have led to an increase in the consumption of "ready to eat" products. These include, in particular, flour confectionery. Moreover, increasing consumer consciousness and awareness leads to the need to search for alternative ingredients in flour products. Specifically, gluten-free, lactose-free, low-calorie products, products with low carbohydrate and fat content are gaining popularity among consumers. The demand for organic products is also growing in the world. In the future, the world flour market is expected to continue its moderate growth during 2020–2025 [3]. However, the

search for alternative formulations for flour products is a challenge for the modern confectionery industry.

Wafers occupy an important place among the range of flour confectionery; they are characterized by a diverse composition, appropriate organoleptic properties, and unequal stability during storage [4].

A significant shortcoming of wafers is the low content of important biologically active substances – vitamins, minerals, dietary fiber [5]. Wafer products require a significant correction of the chemical composition in terms of vitamins and minerals, dietary fiber while reducing their energy value [6]. Therefore, the relevance of research in this area is predetermined by the need to expand the product range of wafers with fillings with improved consumer properties.

2. Literature review and problem statement

Wheat flour is a traditional ingredient for the production of flour products. However, it is low in nutrients. During study [7], gluten-free wafer formulations were developed by using corn, rice, and buckwheat flour, xanthan, and guar gum as an alternative product for patients with celiac disease. There are data on the use of gluten-free types of flour in the production of wafer sheets, but they affect the viscosity of the dough in different ways, although in general, the impact on the consumer properties of wafer sheets is positive [8]. Scientists are very much interested in studying the effect of legume flour on the amino acid composition of confectionery. It was established that chickpea flour in flour products also improves their organoleptic characteristics [9]. However, when developing organic products, a significant problem is that the range of organic flour in the market is limited. Promising in this direction is the expansion of the range of organic products that can serve as the raw materials for the production of flour products.

Sea buckthorn berries are a source of many different bioactive compounds. The high content of vitamins, minerals, natural antioxidants, and fatty acids attracted the most attention. Sea buckthorn is valued for its antioxidant, cardioprotective, antidiabetic, hepatoprotective, anticancer, immunomodulatory, antiviral, antibacterial, anti-inflammatory, and vasoconstrictive effects [10]. The effect of sea buckthorn oil on the fatty acid composition of flour confectionery is little known. However, it has been scientifically proven that sea buckthorn oil has a balanced ratio of omega-3 and omega-6 fatty acids, and, in terms of -linolenic acid, it ranks second among vegeTable oils after flaxseed oil [11]. That is why the use of sea buckthorn oil is promising in the production of wafers.

The use of medicinal herbs is important in expanding the range of flour products. Study [12] found a positive effect of medicinal herbs on increasing the shelf life and slowing down the oxidation of wafers' fatty fillings. However, the study did not prove the effect of herbs on the consumer properties of wafers. The new samples of wafers with fillings "Honey Gift", "Summer Colors", and "Healing" are offered [13]. The increased content of skimmed milk powder (11.0 %), pollen (2.0 %), and walnut oil (1.9 %) were used as raw materials and additives that help increase the nutritional and biological value of wafers. The formulation for wafers "Honey Gift" contains skimmed milk powder (9.4 %), natural honey (7.2 %), extruded bean flour (3.0 %), and black elderflower powder (2.1 %). A model of the wafer formulation " Summer Colors" includes cranberry powder (6.1 %), powders of linden flowers (3.7 %), and bergamot (1.4 %). A comprehensive assessment of the quality of new samples of wafers is 17–30 % higher than that of the control sample due to the improvement of organoleptic characteristics, increasing the nutritional and biological value of products. Clinical studies have confirmed the positive effects of products on the human body. Lemongrass has a pleasant citrus-ginger aroma with a hint of almond flavor. Lemongrass includes an essential oil that contains about 80 % of citral, 20...30 % of citronellol and geraniol, 15 % of geranial, 10 % of neral, 5 % of citronellal, a small amount of miocene [14]. This statement proves the feasibility of introducing non-traditional raw materials to known wafer formulations.

A significant problem in the production of flour confectionery is their high sugar content. Coconut sugar has great potential as an alternative to synthetic sweeteners [15]. The modern range includes many brands of organic cane and coconut sugars. Organic cane sugar is available in the market from Wholesome Sweeteners, Inc.; Vita Natura (Poland); Diet Food (Poland), and others. Coconut sugar brands include the following: Superfood (Indonesia), Gaggery. However, the effect of these organic sugars on the quality of flour confectionery is little known.

As food safety is of great importance, organic raw materials were chosen for the production of the proposed samples. Earlier works of the author addressed the development of new cupcakes, biscuits, cakes based on organic raw materials. It is proven that products made from organic raw materials have a higher biological value and contain less toxic substances. However, the study of the developed wafers made from organic raw materials is undertaken by the author for the first time. Data on the scientific development of wafers based on organic raw materials are quite limited in the literature. That is why the search for new formulations for these products is a promising task of food science and practice.

3. The aim and objectives of the study

This study aims to develop wafers with fatty fillings made from organic raw materials with improved consumption properties. This will expand the range of flour products with enhanced biological value.

To achieve the set goal, the following tasks were solved:

– to study the organoleptic parameters of the developed wafers;

– to estimate the nutritional value of the developed products;

– to determine the safety parameters of the finished products;

– to analyze the amino- and fatty acid composition of the developed products.

4. Materials and methods to study consumer properties of the developed products

The wafers "Summer Temptation" and "Coconut Delight" made from organic raw materials were the objects of this research.

The materials of the research are organic raw materials, such as organic rice flour by Bio Planet TM (Italy), organic buckwheat flour by Organic country TM (Ukraine), organic

cane sugar by Diet Food TM (Poland), organic coconut sugar by Superfood TM (Indonesia), organic butter by "Organic Milk" TM (Ukraine), organic skimmed milk powder by PJSC "Zhytomyr Dairy Plant" (Ukraine), organic coconut milk powder, organic coconut oil by Cocomi Bio TM (Sri Lanka), organic sea buckthorn oil by Elitfito NVF TM (Ukraine).

Mathematical modeling of wafer compositions was used to develop their formulations.

Restrictions on the total content of ingredients in a formulation were determined by the following formula:

$$\sum_{i=1}^{j} x_i = 1{,}000,$$

where x_i, i=1, 2, ..., j is the unknown quantity of raw material of the i-th type (g).

The technological conditions for ensuring the required moisture content in the products were as follows:

$$0.05\sum_{i=1}^{j} x_i \le \sum_{i=1}^{j} \lambda_i x_i \le 0.1\sum_{i=1}^{j} x_i,$$

where x_i, i=1, 2, ..., j is the unknown quantity of raw material of the i-th type (g); λ_i is the moisture content in 1 g of the i-th ingredient.

The organoleptic evaluation of the quality of the new wafers was performed based on the quality evaluation scale reported in earlier studies [4, 15]. In addition to the standard indicators, such as the appearance, color, quality of filling, taste, and smell, the new ones were added, that is, aftertaste and harmony. Each parameter was evaluated on a 5-point scale. The scoring system implies such estimates as "excellent", "good", "satisfactory", and "unsatisfactory" for all sensory characteristics.

The fatty acid composition was determined by a gas chromatography method at the gas chromatograph HP 6890 (Czech Republic). The amino acid composition was determined by the method of ion-exchange liquid column chromatography at the automatic amino acid analyzer T339 manufactured by "Microtechnics", Czech Republic. The nutritional and energy values were studied by an estimation method.

Based on the national standard DSTU 4033:2018 "Wafers", the following physical and chemical parameters are normalized: moisture content, a mass fraction of fat in terms of dry matter, a mass fraction of sugar, a mass fraction of ash insoluble in solution with a mass fraction of 10 % of hydrochloric acid. Reference [16 EUREKA] gives the results of the qualimetric assessment of wafer quality based on a comprehensive quality indicator. The physical and chemical parameters of the developed products met the requirements of the regulatory document.

Among the microbiological indicators, we identified the following: mesophilic aerobic and facultative-anaerobic microorganisms; bacteria of the *Escherichia coli* group. Mesophilic aerobic and facultative anaerobic microorganisms, CFU per 1 g, were estimated by calculating the colonies that grow on a solid nutrient medium after incubation at a temperature of 30 °C. Bacteria from the *Escherichia coli* group (coliforms) were determined by a method based on the properties of *Escherichia coli* bacteria (ECGB) to break down glucose and lactose. The detection of bacteria from the genus *Salmonella* in food is based on the detection of characteristic colony growth on the agar differential-diagnostic media. To study the content of toxic elements in the products, we used standard procedures: copper, zinc, lead, and cadmium were determined by an atomic absorption method, arsenic – by a colorimetric method, mercury – by the flameless atomic absorption [15].

5. Results of studying the nutritional properties of the developed wafers

5. 1. Results of studying the organoleptic parameters of the developed wafers with fillings

To expand the range of organic flour confectionery, 2 wafer formulations were developed, with the fillings "Summer Temptation" and "Coconut Delight". In the formulation for wafers "Coconut Delight", when baking wafer sheets, wheat flour was completely replaced by organic rice flour. The study of the chemical composition of flour is essential for baking technologies when developing new products, including gluten-free ones. The characteristic feature of rice flour is a low protein content (up to 6 %). However, compared to the proteins of other cereals, rice protein has a higher biological value, it is balanced in terms of the amino acid composition and is well absorbed by the human body (absorption rate is 95.9 %). Rice flour has a high content of B vitamins, tocopherol, biotin, zinc, iron, magnesium, potassium, calcium, and phosphorus [17]. Buckwheat flour is recognized as a promising protein enrichment of flour products. It contains about 13 % of proteins, which, by their amino acid composition, are close to the products of animal origin, and are characterized by a significant amount of organic acids, minerals, vitamins [18]. That is why this type of flour is used in the formulation of "Summer Temptation" wafers. The main difference of the developed wafers is that they are made entirely of the organic raw materials. It is proposed to replace fatty fillings in the developed samples with organic butter in combination with non-traditional oils. All formulations of the developed wafers based on organic raw materials are given in Table 1.

Table 1

Characteristics of wafer formulations with fatty fillings (% per wafer formulation)

Raw material	«Summer Temptation»	«Coconut Delight»
Organic buckwheat flour	30.10	0.00
Organic rice flour	0.00	32.00
Organic cane sugar	15.00	0.00
Organic coconut sugar	0.00	15.00
Kitchen salt	0.10	0.10
Baking soda	0.10	0.10
Organic butter	27.00	26.20
Organic skimmed milk powder	13.00	0.00
Organic coconut milk powder	0.00	13.60
Organic sea buckthorn oil	9.40	0.00
Organic coconut oil	0.00	8.70
Organic lemongrass powder	5.2	4.2

Organoleptic indicators are of great value to consumers. The results of the consolidated tasting evaluation of wafers based on indicators such as "appearance", "color", "quality of filling", "smell", "taste", "harmony", "aftertaste" are shown in Fig. 1.

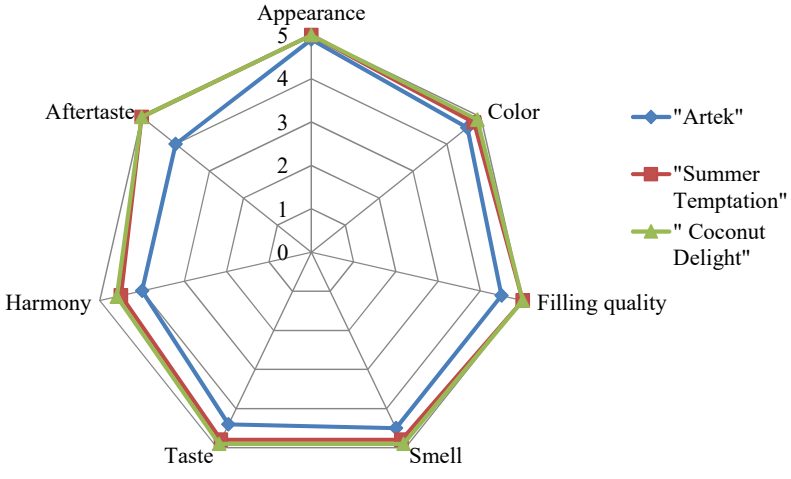

Fig. 1. Results of the consolidated tasting evaluation of wafers

The data in Fig. 1 show that in terms of the indicator "filling quality" the developed samples significantly outperformed control. Both samples were given 5 points while the control was given only 4.5. Significantly higher are also the estimates based on the indicator "taste". The sample "Summer Temptation" gained 4.8 points, the sample "Coconut Delight" – 4.9. The control sample gained only 4.4 points.

5. 2. Results of studying the nutritional and energy value of the developed wafers with fillings

The results of studying the nutritional and energy value of the developed wafers with fillings are given in Table 2.

Table 2

Results of studying the nutritional and energy value of the developed wafers

Sample name	Content, g/100 g				Energy value, kcal/100 g
	Fat	Protein	Carbohydrates	Moisture	
Control	30.4	3.2	65.0	1.8	546.4
«Summer Temptation»	27.2	6.2	54.3	4.3	486.8
«Coconut Delight»	25.5	4.9	55.0	5.2	469.1

The excessive consumption of carbohydrates and trans fats leads to an increase in obesity and type 2 diabetes. That is why one of the important tasks of the food industry is to find alternative formulations with lower energy value. By replacing the fat base in wafer fillings and adding alternative types of flour and milk powder and coconut milk powder to new products, their nutritional value was improved. Thus, the fat content in the new samples decreased in the sample "Summer Temptation" by 11 %, and in the sample "Coconut Delight" – by 17 %. The protein content of the "Summer Temptation" wafers almost doubled. The amount of carbohydrates in both samples decreased by almost 17 %. The energy value decreased in the sample "Summer Temptation" by 11 % and in the sample "Coconut Delight"– by 14 %.

5. 3. Results of studying the safety parameters of the developed wafers with fillings

Since our products are made from organic raw materials, the content of toxic elements is an important indicator. The study was performed according to the methods described in reference [15]. The content of toxic elements in the test samples is given in Table 3.

Table 3 shows that the content of heavy metals is lower than that of the normative indicators and the control sample in products made from organic raw materials. It should be noted that according to the results reported in earlier studies [19] the content of heavy metals in organic vegetables, grains, and legumes was lower than that in traditional ones. The only exception was cadmium, whose content was larger in organic products. According to data in Table 2, the cadmium content, although slightly, is less than that of control, which is not significant. Therefore, these data confirm the previously obtained research results.

Table 3

The toxic elements' content in the developed wafers

Title of toxic element	Permissible level, mg/kg, not exceeding	Control sample	«Summer Temptation»	«Coconut Delight»
Lead	0.5	0.4	0.2	0.21
Cadmium	0.1	0.1	0.09	0.08
Arsenic	0.3	0.28	0.12	0.13
Mercury	0.02	0.02	0.001	0.001
Copper	10.00	9.7	9.2	9.4

The content of the microbiological parameters in the developed wafers, based on the study results, is given in Table 4.

Table 4

The content of microbiological indicators in the studied wafers

Sample name	MAFAM, CFU/g, not exceeding	ECGB (coli-forms)	Pathogenic microorganisms, in particular, *Salmonella*	Mold, CFU/g
Normative values according to standard	5×10^3	not allowed	not allowed	–
Control sample	2×10^3	not found	not found	not found
«Summer temptation»	2×10^3	not found	not found	not found
«Coconut delight»	2×10^3	not found	not found	not found

Based on the data in Table 4, all samples comply with regulatory documents [20] in terms of their microbiological indicators. This indicates the safety of developed products.

From the point of view of food safety, the content of heavy metals and microbiological contaminants is a significant factor that affects the consumer properties of products. Organic production implies the abandonment of agrochemicals; however, it is impossible to exclude the content of toxic elements in the product. Cadmium is found in fuel oil, diesel fuel, and is released during combustion. As a result, much of it gets into the air. That is why the content of this toxic element cannot be significantly reduced even in organic

products. At the same time, the main source of lead in food is the pesticides that contain lead, and packaging. Arsenic is widely distributed in soils, but with the use of a transition period for the certification of organic production, its content is significantly reduced. It should be noted that the contamination of food with metallic mercury is a very rare phenomenon. Seafood is mostly contaminated. Thus, this study confirms the expediency of expanding the range of organic products in terms of food and environmental safety.

5. 4. Studying the amino acid and fatty acid content of the developed wafers made from organic raw materials

Insufficient consumption of proteins with low biological value leads to protein deficiency in the human body, which negatively affects the vital processes of the body. Essential amino acids play an important role in the human body because their deficiency in food affects the regeneration of proteins [21].

The content of essential amino acids was determined in the developed wafers made from organic raw materials and in the control sample (Fig. 2).

According to data in Fig. 2, the content of essential amino acids improved in both samples. However, the sample based on buckwheat organic flour demonstrated the best amino acid composition. The lysine content significantly increased, compared to control, by 15.5 %. In the sample "Summer Temptation", the content of threonine also significantly increased, by 25 %. The content of essential amino acids in the sample "Coconut Delight" did not increase significantly; it even decreased slightly. However, the amount of lysine increased, compared to the control sample, by 22 %. The best amino acid composition of buckwheat-flour-based wafers is because buckwheat flour has a richer amino acid composition compared to rice and wheat.

Instead of confectionery fat, butter in combination with milk powder and sea buckthorn oil was introduced to the fatty filling of the organic wafers "Summer Temptation". Coconut oil and organic coconut milk powder were used in the lipid base of the "Coconut Delight" wafers. The replacement of the fat fraction in the product prompted a study into the fatty acid composition. The study results are given in Table 5.

Table 5

The fatty acid composition of wafers

Fatty acids (FA)	«Artek»	«Summer Temptation»	«Coconut Delight»
	mg/100 g	mg/100 g	mg/100 g
Quantity of saturated FA	23800.00	16190.00	15988.00
Laureleic acid (C12:1)	0.00	12.50	15.09
Myristoleic acid (C14:1)	5.00	21.90	23.90
Palmitoleic acid (C16:1)	199.00	167.00	162.00
Heptadecene acid (C17:1)	0.00	12.90	13.10
Oleic acid (C18:1)	17.50	25.05	26.03
Gondoic acid (C20:1)	0.00	61.20	69.07
Gadoleic acid (C20:1)	262.15	0.00	0.00
Erucic acid (C22:1)	0.00	43.00	51.40
Nervonic acid (C24:1)	0.00	27.10	32.01
Linoleic acid (C18:2)	1100.00	5589.00	5287.00
Linolenic acid (C18:3)	39.24	51.28	95.00
Octadecatetraenoic acid (C18:3)	0.00	13.20	15.20
Arachidonic acid (C20:4)	3.80	27.40	24.30
Docosatetrainic acid (C22:4)	32.00	34.00	25.40
Tetradecane acid (C40:2)	0.00	11.64	14.72
Quantity of unsaturated FA	1658.69	6097.17	5854.22

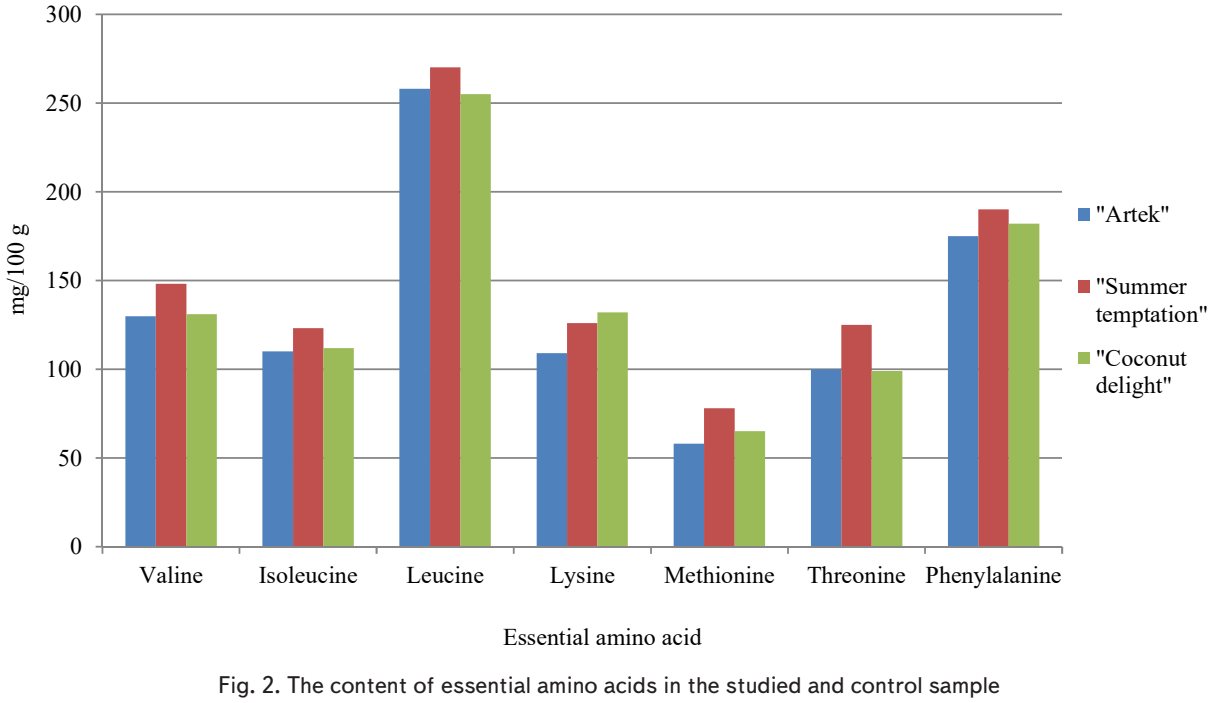

Fig. 2. The content of essential amino acids in the studied and control sample

Table 5 shows that the fatty acid composition of samples is better than the control sample due to the introduction of sea buckthorn oil. Thus, the content of saturated fatty acids in both samples decreased by almost twice while the content of monounsaturated fatty acids and polyunsaturated fatty acids increased. Oleic acid increased in both samples by 1.5 times. The content of linolenic acid in the sample "Summer Temptation" increased by 5 times and in the sample "Coconut Delight" – by 4.8 times. The content of linolenic acid increased in the sample "Summer Temptation" by 1.3 times and in the sample "Coconut Delight" – by 2.4 times. These data indicate the expediency of introducing such organic raw material as butter in combination with non-traditional oils to the fat base of wafers.

6. Discussion of results of studying wafers with fillings made from organic raw materials with improved nutritional properties

The obtained results testify to the prospects of using organic raw materials in the production of flour confectionery. This is due to that organic raw materials are produced without the use of agrochemicals and demonstrate better safety performance indicators. In addition, non-traditional raw materials for the production of flour confectionery have a positive effect on consumer properties. This relates to that wheat flour, sugar, and lipid base, which are traditional in the production of wafers, have a less balanced chemical composition.

A special feature of this study is the development of the fundamentally new formulations of wafers based on organic raw materials. The "Summer Temptation" wafers' composition included buckwheat flour, cane sugar, butter, skimmed milk powder, and sea buckthorn oil, lemongrass powder. Rice flour, coconut sugar, coconut milk powder, coconut oil, and lemongrass powder were added to the "Coconut Delight" wafers.

Considerable attention that is paid today to the development of the market of the environment-friendly, biofortified, and organic products encourages the new search for alternative raw materials. Consumption of organic food can reduce the risk of allergic diseases, overweight, and obesity. But the data are not convincing due to the likely incomplete understanding as consumers of organic food tend to lead a healthy lifestyle in general. However, animal-based experiments suggest that the same feed of organic and traditional production have different effects on growth and development [22]. Moreover, retail trade research shows a steady increase in consumer demand for organic products [23]. This encourages research into the consumer properties of products based on organic raw materials, as well as expanding their range. However, the main limitation of this study is the lack of consumer awareness about the benefits of the organic product. Another caveat of the study is the relatively small range of organic products that can be used as raw materials.

This study is a continuation of scientific work in the area of safety and quality management of flour confectionery made from organic raw materials [24, 25].

Future research is planned to address changes in the quality of the developed products during storage.

7. Conclusions

1. The "Summer Temptation" wafers' composition includes buckwheat flour, cane sugar, butter, skimmed milk powder, and sea buckthorn oil, and lemongrass powder. Rice flour, coconut sugar, coconut milk powder, coconut oil, lemongrass powder are added to the composition of the wafers "Coconut Delight". In terms of the "filling quality", the developed samples significantly outperform control. Both samples were given 5 points while the control – only 4.5. The estimates for the indicator of "taste" are significantly higher as well. The "Summer Temptation" sample gained 4.8 points, the "Coconut Delight" sample – 4.9. The control sample was given only 4.4 points.

2. By replacing the fat base in the wafer fillings and by adding alternative types of flour and milk powder and coconut milk powder to the new products, their nutritional value has been improved. Thus, the fat content in the new samples decreased; in the sample of "Summer Temptation" – by 11 %, and in the sample of "Coconut Delight" – by 17 %. The protein content of the "Summer Temptation" wafers almost doubled. The quantity of carbohydrates in both samples decreased by almost 17 %. The energy value decreased in the sample of "Summer Temptation" by 11 %, in the sample of "Coconut Delight" – by 14 %.

3. The content of heavy metals is lower than the normative indicators and that of the control sample in the products made from organic raw materials. The content of microbiological indicators of the product is within normal limits.

4. The results of studying the amino acid composition show the growth of essential amino acids in the new products. The lysine content significantly increased, compared to control, by 15.5 %. In addition, in the sample of "Summer Temptation", the content of threonine significantly increased, by 25 %. The content of essential amino acids in the sample of "Coconut Delight" did not increase significantly, and of some – even decreased slightly. However, the amount of lysine increased, compared to the control sample, by 22 %. The content of saturated fatty acids in both samples decreased by almost twice while the content of monounsaturated fatty acids and polyunsaturated fatty acids increased. Oleic acid increased in both samples by 1.5 times.

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