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COMPARISON OF CERTAIN SAFETY AND QUALITY INDICATORS OF DEVELOPED CHOCOLATE PASTE WITH ORGANIC AND INORGANIC RAW MATERIALS

The object of the research is the developed chocolate spreads from organic raw materials. The problem to be solved is to compare the quality and safety indicators of organic and inorganic food products. The composition of the "Sea Buckthorn" chocolate paste includes almonds, natural cocoa powder, cocoa butter, cane sugar, sea buckthorn oil, powdered milk, and flax bran. The "Hemp" chocolate paste differs in that instead of sea buckthorn oil, it contains hemp oil. The organoleptic evaluation of the pastes was carried out using a 35-point scale developed. The mass fraction of moisture was determined by drying to constant mass. The fatty acid composition was determined by gas chromatography. The content of heavy metal salts was determined by the colorimetric method and the flameless atomic absorption method. Biological, chemical, and physical hazardous factors were analyzed at each stage of the production of chocolate pastes. The results of the organoleptic evaluation indicate that all samples meet the "excellent" quality level. No significant differences were found between organic and inorganic chocolate spreads made according to the same recipes. The mass fraction of moisture in the developed products was within the normal range and did not exceed 3%. More fats were found in organic chocolate spreads than in inorganic ones. In the "Sea Buckthorn Organic" chocolate spread – by 1.48 g/100 g; in the "Hemp Organic" chocolate spread – by 1.86 g/100 g. The results of the study show that the content of polyunsaturated fatty acids in chocolate spreads made from organic raw materials significantly exceeds the content of similar acids in inorganic chocolate spreads. The content of linolenic acid is higher by 0.58 g/100 g in "Organic Sea Buckthorn Organic" paste and by 1 g/100 g in "Organic Hemp" chocolate paste compared to similar pastes made from inorganic raw materials.

The lead content is 2.77 times lower in "Organic Sea Buckthorn" oil; 2.45 times lower in "Organic Hemp" oil than in similar inorganic chocolate spreads. A very significant difference is noted in the cadmium content: 3 and 4.5 times lower, respectively. The critical control points of production are sterilization of containers and heat treatment of chocolate spreads.

Keywords: *organic food products, chocolate spreads, food safety, sea buckthorn oil, hemp oil.*

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1. Introduction

According to the national standard of Ukraine DSTU 7374:2013 [1], chocolate spread is a food product made from cocoa products and fat. The spread is often made with the addition of milk, nuts, sugar, etc. and has a creamy consistency. In the European Union, the safety and labeling requirements for chocolate products are regulated by Directive 2000/36/EC of the European Parliament and of the Council of 23 June 2000 on cocoa and chocolate products intended for human consumption [2]. Ukraine has implemented the Order of the Ministry of Health and Family Welfare "On Approval of Requirements for Cocoa and Chocolate Products" [3], which is fully harmonized with the EU Directive. The term "gianduja" is used to designate chocolate spreads. "Gianduja" chocolate is obtained from milk chocolate with nuts, a product obtained from milk chocolate containing dairy products obtained by complete or partial dehydration of whole milk and nuts. Almonds, hazelnuts or other types of nuts can be either whole or chopped. The total amount of added nuts should not exceed 60% of the weight of the finished product.

One of the promising areas in this segment is the development of organic chocolate spreads, which can become an alternative to traditional high-calorie creams and chocolate spreads containing artificial food additives. The implementation of European organic legislation in Ukraine began in 2018, which is dictated by the requirements of the Association Agreement between Ukraine and the EU. And with Ukraine gaining the status of a candidate country for accession to the EU, starting from June 23, 2022, Ukraine joins all strategic initiatives of the European Union in the field of organic production. The first goal of the "Food Security Strategy of Ukraine for the period until 2027" is to fill the food market by promoting the sustainable development of agricultural and food production, which includes increasing the share of organic food products [4].

Organic chocolate spread is made from cocoa beans grown without the use of synthetic fertilizers or pesticides, and is becoming increasingly popular among consumers.

In modern scientific research related to improving the technology of chocolate spreads, little attention has been paid to the development of an organic product range. For example, in the study [5], a functional chocolate-nut spread with the addition of probiotics and structured triglycerides was created, which contributes to improving intestinal health. Article [6] describes the development of chocolate spreads with a reduced fat content, using emulsions of the "water in oleogel" type, which preserve the taste qualities of the product. The study is devoted to the creation of chocolate spread without added sugar and allergens, using sweet potatoes, dried fruits and chickpeas, which increases its nutritional value. Article [7] investigated the fatty acid and amino acid composition of the protein-fat composition for the production of chocolate-nut spread using stevia extract. The study [8] is devoted to the use of pumpkin malt as a filler in the production of chocolate paste. The influence of this ingredient on the nutritional value and organoleptic properties of the product is considered. However, all the above-described scientific research is aimed at developing chocolate pastes with improved consumer properties from inorganic raw materials. The comparison of consumer properties of organic and inorganic chocolate pastes is not covered in modern scientific works.

Therefore, the development of new recipes for organic confectionery pastes is a promising area of research, given the relevance of expanding the range of organic products in the context of European strategic initiatives. However, it should be noted that an important scientific task is not only the development of chocolate pastes from organic raw materials, but also the expansion of the range of organic pastes with improved consumer properties. For this purpose, promising ingredients are substitutes for traditional sugar – syrups, cane sugar, stevia; vegetable oils with a balanced fatty acid composition – sea buckthorn and hemp, bran. However, it remains unclear to what extent the use of organic raw materials can improve product quality and safety indicators. The lack of such data complicates the choice of the optimal technological approach for manufacturers and reduces consumer awareness. Thus, this study addressed the problem of the lack of detailed comparative data on organoleptic, physicochemical indicators, fatty acid composition and heavy metal content in chocolate spreads made from organic and inorganic raw materials according to identical recipes.

The aim of research is to compare individual safety and quality indicators of chocolate spreads with organic and inorganic raw materials.

2. Materials and Methods

2.1. Mathematical modeling of recipes for organic chocolate spreads

The object of research was organic and inorganic chocolate spreads "Sea Buckthorn" and "Hemp".

To develop recipes for organic chocolate spreads, mathematical modeling of recipe compositions was used.

There are known methods of mathematical modeling for developing recipes for confectionery products, taking into account a significant number of parameters, in particular the relationships between groups of nutrients – calcium, fat, phosphorus and magnesium, the conditions for enriching diets and products with deficient nutrients. When considering the construction of a mathematical model of such a problem, it is necessary to introduce the notation – the amount of the i-th type ingredient (g) in the recipe for a confectionery product. Since chocolate spreads contain vegetable oils, the basis of mathematical modeling of recipes is the optimization of the fatty acid composition in accordance with dietary standards. The task of optimizing the content of ingredients in a new product being designed is to determine the vector = $(x_1, x_2, ..., x_j)$, which maximizes the objective function provided that the coordinates of this vector satisfy the systems of inequalities and equations.

The restrictions on the total content of ingredients in the recipe were determined by the formula

$$\sum_{i=1}^{j} x_i = 1000, \quad (1)$$

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

Ensuring the required moisture content was determined by the formula

$$0.05\sum_{i=1}^{j} x_i \le \sum_{i=1}^{j} \gamma_i x_i \le \sum_{i=1}^{j} x_i, \quad (2)$$

where x_i, $i = 1, 2, ..., j$ – unknown amount of raw material of the i-th type (g); λ_i – water content in 1 g of the i-th ingredient (g).

Ensuring the required content of proteins, fats, carbohydrates was determined by the formula

$$\left(1a:1b:4c\right)^1 = \sum_{i=1}^{j} x^i, \quad (3)$$

where a – protein content, b – fat content, c – carbohydrate content; x_i, $i = 1, 2, ..., j$ – unknown amount of raw material of the i-th type (g); λ_i – water content in 1 g of the i-th ingredient (g).

The fatty acid composition of the product will be

$$\sum_{i=1}^{j} b_i = 23y + 1.6f + 6.4p + 69z = 100\%, \quad (4)$$

where x_i, $i = 1, 2, ..., j$ – unknown amount of raw material of the i-th type (g); λ_i – water content in 1 g of the i-th ingredient; b – fat content; y – monounsaturated fatty acid content; f – ω-3 polyunsaturated fatty acid content; p – ω-5 polyunsaturated fatty acid content; z – saturated fatty acid content.

The problem was solved in the MatCad program. The product recipe is presented in Table 1.

Table 1

Recipe of developed products

Ingredient	"Sea Buckthorn" chocolate paste	"Hemp" chocolate paste
Content per 100 g of product		
Almonds	35.00	35.00
Natural cocoa powder	10.00	10.00
Cocoa butter	8.00	8.00
Cane sugar	20.00	15.00
Agave syrup	10.00	15.00
Sea buckthorn oil	10.00	0.00
Hemp oil	0.00	10.00
Milk powder	4.00	4.00
Flaxseed	1.50	1.50

2.2. Evaluation of organoleptic indicators

To develop a scoring scale for evaluating organoleptic indicators of chocolate pastes, the following parameters were used: consistency (P_1), surface (P_2), appearance (P_3), aroma (P_4), taste (P_5), flavor (P_6), aftertaste (P_7). To determine the weighting factors for the purpose of developing a 50-point scale, the expert evaluation method was used. Each indicator was evaluated with points: 1.5 – very significant, 1 – significant, 0.5 – insignificant, 0 – should not be included in the scale. The indicators were evaluated by 7 experts, and the value of the significance coefficient was calculated by the formula

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$$K_i = \sum \frac{P_{iy}}{y}, \qquad (5)$$

where K_i – weighting factor; P_{iy} – assessment of the i-th indicator by the y-th expert; y – number of experts.

The results of evaluating the weighting factors of organoleptic indicators of cupcakes are presented in Table 2.

Based on the evaluation of the weighting coefficients of organoleptic indicators, a 35-point scale for the organoleptic evaluation of chocolate spreads was developed, which is presented in Table 3.

Table 2

Results of evaluation of the weighting coefficients of organoleptic indicators of chocolate paste

Expert number	Organoleptic quality indicators						
	P_1	P_2	P_3	P_4	P_5	P_6	P_7
1st	1.5	0.5	1.0	1.5	1.5	0.5	0.5
2nd	1.0	1.0	1.0	1.5	1.5	1.0	1.0
3rd	1.0	0.5	1.0	1.5	1.5	1.0	1.0
4th	1.0	0.5	1.0	1.5	1.5	0.5	0.5
5th	1.0	0.5	1.0	1.5	1.5	1.5	0.0
6th	1.0	0.0	1.0	1.5	1.5	1.5	0.0
7th	1.0	0.5	1.0	1.5	1.5	1.0	0.5
Sum of points	7.5	3.5	7.0	10.5	10.5	7.0	3.5
Weight coefficient	1.0	0.5	1.0	1.5	1.5	1.0	0.5

Table 3

A 35-point scale for the evaluation of organoleptic indicators of chocolate spreads was developed

Indicator	Weighting factor	Maximum sum of points taking into account weighting factors
Consistency (P_1)	1.0	5.0 / 5.0
Surface (P_2)	0.5	5.0 / 2.5
Appearance (P_3)	1.0	5.0 / 5.0
Aroma (P_4)	1.5	5.0 / 7.5
Taste (P_5)	1.5	5.0 / 7.5
Flavor (P_6)	1.0	5.0 / 5.0
Aftertaste (P_7)	0.5	5.0 / 2.5
Total	–	35.0

The developed scale provided the following criteria for evaluating chocolate spreads: 30–35 points – "excellent", 25–29 points – "good", 20–2439 points – "satisfactory", below 20 points – "unsatisfactory".

2.3. Methods of research of physicochemical parameters of chocolate pastes

The mass fraction of moisture was determined by drying to constant mass at a temperature of 105°C according to DSTU 4910:2008. Confectionery. Methods of determination of mass fraction of moisture and dry matter [9]. The fatty acid composition was studied by gas-liquid chromatography on a Hewlett Packard HP-6890 gas chromatograph (USA) using a capillary column HP-88 (88%-cyanopropyl aryl-polysiloxane, Agilent Technologies) 100 m long, with an internal diameter of 0.25 mm and a stationary phase thickness of 0.2 μm under the following conditions: carrier gas flow rate – 1.2 ml/min, flow separation ratio – 1:100, evaporator temperature – 280°C, detector temperature (FID) – 290°C, column temperature regime – gradual heating from 60°C to 230°C [10]. The study of the fatty acid composition allows determining the ratio of saturated, monounsaturated and polyunsaturated fatty acids [11].

2.4. Methods of studying the safety indicators of chocolate pastes

Copper, zinc, lead and cadmium were determined by atomic absorption method at wavelengths (nm): cadmium – 228.8; lead – 283.3; copper – 324.7; zinc – 324.7 (device – PinAAcle900T, USA). Arsenic was determined by colorimetric method. Mercury – by flameless atomic absorption method [12].

2.5. Safety management of the production of developed chocolate pastes

The HACCP system is based on the requirements of Regulation (EC) 852 / 2004 of the European Parliament and of the Council on compliance with general hygiene standards for all foodstuffs [13]. The HACCP system must comply with the requirements of the Law of Ukraine "On the Basic Principles and Requirements for the Safety and Quality of Food Products" [14] and the Order of the Ministry of Agriculture and Food Industry "On Approval of Requirements for the Development, Implementation and Application of Permanent Procedures Based on the Principles of the Food Safety Management System (HACCP)" [15]. In order to manage the safety of the developed chocolate spreads, a production flowchart was developed [16]. Hazardous factors were analyzed and critical control points were established using the decision tree method [17].

3. Results and Discussion

3.1. Organoleptic evaluation of chocolate spreads

The results of the organoleptic evaluation show that all samples meet the "excellent" quality level. However, it can be stated that the overall quality assessment of organoleptic samples compared to inorganic analogues, although somewhat higher, is not significant (Fig. 1).

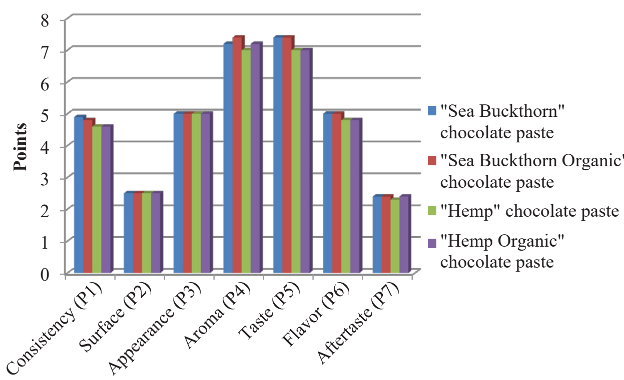

Fig. 1. Organoleptic evaluation of the developed chocolate pastes

The data in Fig. 1 show that organic samples prevailed over inorganic samples only in terms of "aroma". This proves the hypothesis that there are no significant differences between the organoleptic indicators of organic and inorganic products.

3.2. Research on the nutritional value and physicochemical indicators of chocolate pastes

In chocolate pastes, the mass fraction of moisture is standardized, which should not exceed 3%. The results of the study are given in Table 4.

Table 4

Results of the study on the mass fraction of moisture in chocolate pastes

Sample name	Mass fraction of moisture, %
"Sea Buckthorn" chocolate paste	2.8 ± 0.01
"Sea Buckthorn Organic" chocolate paste	2.8 ± 0.01
"Hemp" chocolate paste	2.9 ± 0.01
"Hemp Organic" chocolate paste	2.95 ± 0.01

As can be seen from Table 4, the mass fraction of moisture in the developed products is within the normal range. Other physicochemical parameters in chocolate pastes are not normalized.

The nutritional value of the developed pastes is presented in Table 5.

Table 5

Nutritional value of the developed chocolate pastes

Paste	Protein (g)	Fat (g)	Carbohydrates (g)	Energy value (kcal)
"Sea Buckthorn" chocolate paste	10.59	35.71	38.28	527.81
"Sea Buckthorn Organic" chocolate paste	10.59	37.19	38.00	530.19
"Hemp" chocolate paste	10.40	35.63	37.08	517.54
"Hemp Organic" chocolate paste	10.45	37.49	36.08	523.53

Thus, no significant difference in the amount of proteins and carbohydrates was found between organic and inorganic chocolate pastes. However, the fat content differed slightly. In organic chocolate pastes, they were found to be higher. In the "Sea Buckthorn Organic" chocolate spread – by 1.48 g/100 g; in the "Hemp Organic" chocolate spread – by 1.86 g/100 g. This fact prompted further research – analysis of the fatty acid composition of chocolate pastes, which had hemp and sea buckthorn oil as the lipid base (Table 6).

Table 6

Fatty acid composition of chocolate pastes

Fatty acid name	"Sea Buckthorn" chocolate paste	"Sea Buckthorn Organic" chocolate paste	"Hemp" chocolate paste	"Hemp Organic" chocolate paste
Capric (C 10:0)	0.00	0.00	0.00	0.00
Lauric (C 12:0)	0.04	0.03	0.03	0.03
Myristic (C 14:0)	0.14	0.14	0.12	0.11
Pentadecanoic (C 15:0)	0.00	0.00	0.00	0.00
Palmitic (C 16:0)	3.90	3.76	3.45	3.30
Margarine (C 17:0)	0.01	0.01	0.01	0.01
Stearic (C 18:0)	3.80	3.70	3.60	3.45
Arachidonic (C 20:0)	0.02	0.02	0.02	0.02
Total NFA	7.91	7.66	7.23	6.92
Palmitoleic (C 16:1)	0.90	0.95	0.90	0.91
Oleic (C 18:1)	13.2	13.7	12.5	12.36
Total MFA	14.1	14.65	13.4	13.27
Linoleic (C 18:2)	12.2	12.8	13.3	14.6
Linolenic (C 18:3)	1.5	2.08	1.7	2.7
Total PUFA	13.7	14.88	15.00	17.3
Total	35.71	37.19	35.63	37.49

The research results show that the content of polyunsaturated fatty acids in chocolate pastes made from organic raw materials significantly exceeds the content of similar acids in inorganic chocolate pastes. Thus, the content of linolenic acid is higher by 0.58 g/100 g in the "Sea Buckthorn Organic" spread, and by 1 g/100 g in the "Hemp Organic" chocolate spread, respectively. In addition, there is a difference in the content of monounsaturated oleic acid in the "Sea Buckthorn Organic" chocolate spread (by 0.5 g/100 g). At the same time, palmitoleic, erucic, gondolic and nervonic acids are contained in comparable quantities in organic and inorganic chocolate pastes.

3.3. Research on the safety indicators of chocolate pastes

According to the results of [18], the main toxic metals that enter food products are arsenic (As), cadmium (Cd) and lead (Pb). Rice, seafood, cocoa and leafy vegetables are the main sources of these metals in the human diet. Particularly high concentrations of cadmium were found in cocoa products and rice, with the permissible limits being significantly exceeded in some regions. Cocoa products are the main raw material for the production of chocolate pastes, so the determination of the content of heavy metal salts is mandatory. Since pesticides and chemical fertilizers are not used in organic production, an important scientific issue is to compare the content of heavy metal salts in organic and inorganic food products (Table 7).

So, from the data in Table 7 it is clear that in all parameters, except for hydrargium, organic chocolate pastes are safer. The hydrargium content is almost not noticeable in all samples. The lead content is lower in "Sea Buckthorn Organic" oil by 2.77 times; in "Sea Buckthorn Organic" by 2.45 times than the content of this substance in similar inorganic chocolate pastes. A very significant difference is noted in the cadmium content: by 3 and 4.5 times, respectively.

Table 7

Content of heavy metal salts in chocolate pastes

Name	"Sea Buckthorn" chocolate paste	"Sea Buckthorn Organic" chocolate paste	"Hemp" chocolate paste	"Hemp Organic" chocolate paste
Pb	0.25	0.09	0.24	0.11
Cd	0.09	0.03	0.09	0.02
As	0.20	0.10	0.20	0.10
Hg	< 0.001	< 0.001	< 0.001	< 0.001

3.4. Safety management of the production of developed chocolate pastes

When developing a new product, an important step is the analysis of the expected risks. The main risks in food safety include biological, chemical and physical risks. Biological risks are the most significant, since exceeding the permissible content of pathogenic microorganisms can lead to food poisoning. A comparison of the microbiological quality of organic and conventional vegetables in Malaysia showed that the total levels of aerobic mesophilic bacteria, yeasts, molds and coliforms were similar in both types of produce. However, Listeria monocytogenes was found more frequently in organic vegetables (9.1%) compared to conventional ones (2.7%) [19]. Analysis of vegetables from organic and conventional farms in Poland showed that organic produce, in particular lettuce, had higher levels of total bacteria, coliforms and Enterobacteriaceae. This may be due to the use of organic fertilizers such as manure, which potentially increases the risk of microbiological contamination [20]. Previous studies by the author have not found significant differences between the microbiological indicators of organic and inorganic food products produced in Ukraine. However, it is a proven fact that chemical hazards are more significant in inorganic food products due to the use of agrochemicals. Physical hazards pose the same threat regardless of the production method.

One of the first steps in implementing the HACCP system is to draw up a process flow chart. It is shown in Fig. 2.

The flow chart shows the critical control points of production – sterilization and heat treatment. Based on the developed flow chart, an analysis of hazardous factors in the production of chocolate pastes from organic raw materials was carried out (Table 8).

Thus, the most significant hazardous factors were identified as the content of pathogenic microorganisms, foreign inclusions and the presence of allergens (nuts, dairy products). Critical control points in the production of chocolate pastes were established at the stage of sterilization and heat treatment.

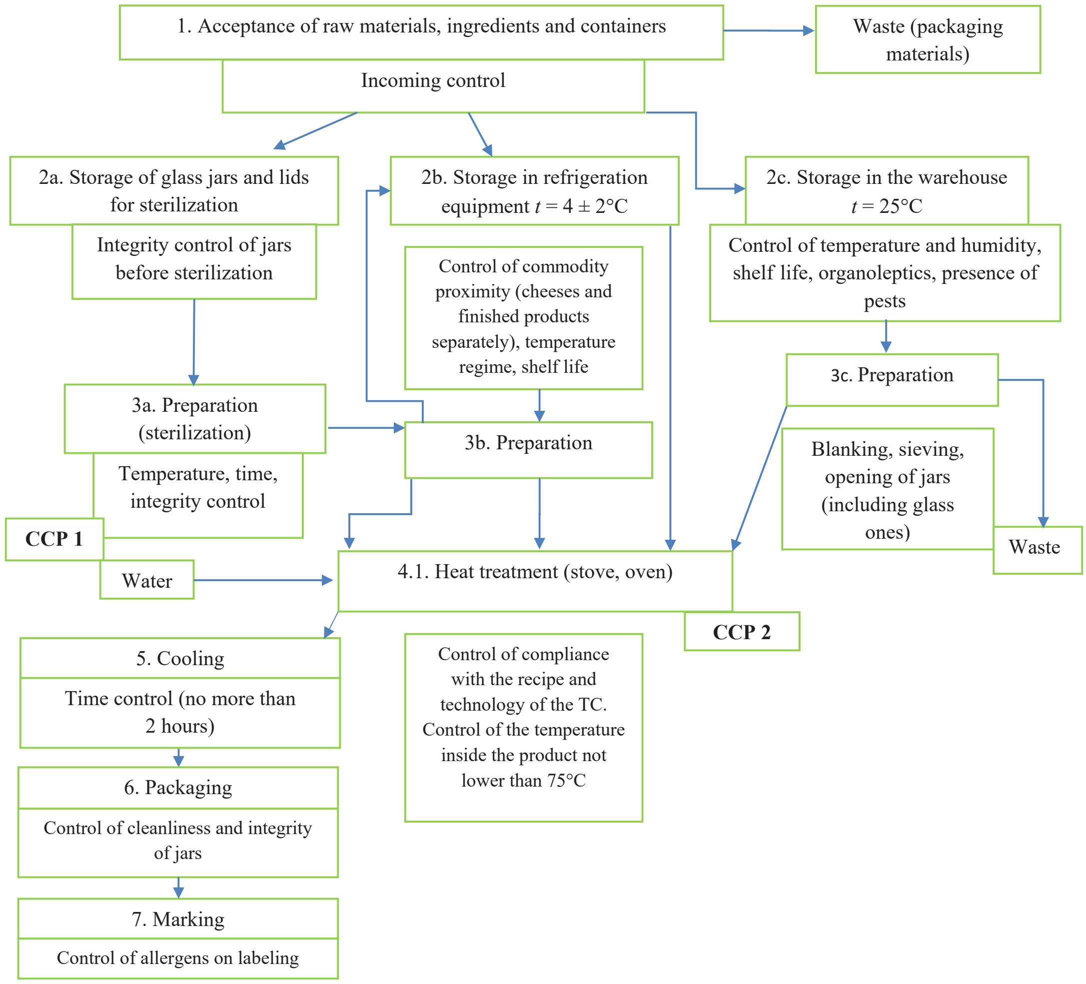

Fig. 2. Flowchart of chocolate paste production

Table 8

Analysis of hazardous factors in the production of chocolate pastes from organic raw materials

Stage name	Dangerous factor	Probability of occurrence P	Seriousness of harmful effect S	Estimation of dangerous factor ($K = P \times S$)
Raw material reception	Pathogenic microorganisms: *Salmonella, Bacillus cereus, Listeria monocytogenes, Staphylococcus aureus, Campylobacter spp., E. coli O 157:H7, St. Aureus* (biological factor)	$P = 0.1$	$S = 3$	$K = 0.3$
	Toxic elements, radionuclides, antibiotics, mycotoxins, dioxins (chemical factor)	$P = 0.1$	$S = 2$	$K = 0.2$
	Foreign inclusions, stones, sand, bones, glass, etc. (physical factor)	$P = 0.1$	$S = 2$	$K = 0.2$
	Allergens (list in Appendix 1 of the Law of Ukraine "On Providing Information to the Consumer about Food Products" No. 2639) (allergenic factor)	$P = 0.1$	$S = 3$	$K = 0.3$
Storage of raw materials and packaging materials	Pathogenic microorganisms: *Salmonella, Bacillus cereus, Listeria monocytogenes, E. coli O 157:H7, St. Aureus, QMAFAnM, Coliform bacteria* (biological factor)	$P = 0.1$	$S = 3$	$K = 0.3$
	Mycotoxins, mold, yeast (biological factor)	$P = 0.1$	$S = 2$	$K = 0.2$
	Toxic elements from packaging materials (chemical factor)	$P = 0.1$	$S = 2$	$K = 0.2$
	Foreign inclusions (physical factor)	$P = 0.1$	$S = 3$	$K = 0.3$
	Allergens (list) (allergenic factor)	$P = 0.1$	$S = 3$	$K = 0.3$
Preparation	Pathogenic microorganisms: *Salmonella, Listeria monocytogenes, E. coli O 157:H7, St. Aureus, Bacillus cereus, QMAFAnM, Coliform bacteria* (biological factor)	$P = 0.2$	$S = 3$	$K = 0.6$
	Glass during the preparation of glass containers (physical factor)	$P = 0.3$	$S = 3$	$K = 0.9$
Heat treatment	Pathogenic microorganisms, in particular *Salmonella, Listeria monocytogenes, E. coli O 157:H7, St. Aureus* (biological factor)	$P = 0.3$	$S = 3$	$K = 0.9$
Cooling	Spore microorganisms, pathogenic microorganisms *Salmonella, Listeria monocytogenes, E. coli O 157:H7, St. Aureus, QMAFAnM, Coliform bacteria* (biological factor)	$P = 0.1$	$S = 3$	$K = 0.3$
Packaging	Pathogenic microorganisms, in particular *Salmonella, Listeria monocytogenes, E. coli O 157:H7, St. Aureus, QMAFAnM, Coliform bacteria* (biological factor)	$P = 0.2$	$S = 3$	$K = 0.3$
	Allergens (list in ZU 2639, Appendix 1) (allergenic factor)	$P = 0.3$	$S = 3$	$K = 0.9$
Finished product packaging	Pathogenic microorganisms *Salmonella, Listeria monocytogenes, E. coli O 157:H7, St. Aureus, QMAFAnM, Coliform bacteria* (biological factor)	$P = 0.2$	$S = 3$	$K = 0.3$

3.5. Discussion of the research results

The obtained data confirm the results of [21], which prove a higher content of polyunsaturated fatty acids in organic products compared to inorganic ones. Data from studies of the fatty acid composition of organic and inorganic chocolate pastes indicate that the content of linolenic acid is higher in organic fat-containing products than in inorganic ones. This difference may be due to the rejection of herbicides in organic production. Some herbicides (e. g. glyphosate, paraquat) inhibit enzymes or processes that indirectly affect the biosynthesis of fatty acids in chloroplasts. This leads to a decrease in the content of polyunsaturated fatty acids (especially linoleic, linolenic). Herbicides can cause excessive formation of free radicals and cause degradation of polyunsaturated fats. In addition, herbicides can change the activity of key enzymes desaturases. These are enzymes that form unsaturated fatty acids. The obtained data encourage further in-depth research. They consist in determining the content of the amount of herbicides applied, their effect on the fatty acid composition of the grown raw material and comparing it with the fatty acid composition of raw materials of similar variety and growing conditions using the rules of organic production [22]. Such studies will allow to establish the relationship between the method of cultivation (organic or traditional) and fatty acid composition.

A lower content of heavy metal salts in organic chocolate pastes compared to inorganic ones has been established. This fact confirms the author's previous studies. The relationship between the method of growing raw materials and safety indicators is due to the fact that during the application of nitrogen fertilizers, 174 mg/kg of lead and 1.3 mg/kg of cadmium can enter the soil, and during the application of phosphorus fertilizers, 138.1 mg/kg of lead and 2.7 mg/kg of cadmium [21]. Organic production excludes the application of nitrogen fertilizers. The absence or limitation of their use in organic farming significantly reduces the risk of accumulation of heavy metal salts in plant products. In addition, factors affecting the content of heavy metal salts are the type and condition of soils. Organic soils have a higher sorption capacity, which reduces the bioavailability of heavy metals for plants. Multicomponent crop rotation and ecological fertilizers can contribute to reducing the concentration of heavy metal salts in organic products.

The practical significance of research lies in the possibility of using the developed recipe by chocolate paste manufacturers to expand the range of products with improved consumer properties. In addition, in the context of comprehensive support and development of organic production, the results of the study will contribute to the development of the organic goods market. This will allow manufacturers to enter European markets and expand the range of consumers of their products.

The limitations of the research are, firstly, that only certain types of organic and inorganic raw materials were used, which does not allow extrapolating the results to other options. In addition, the results are affected by the geographical origin of the raw materials. The results may be relevant only for raw materials from a certain region or manufacturer, which does not provide a global picture. The lack of long-term conclusions is that the impact of regular use of such products on the health of consumers in the long term has not been studied.

The conditions of martial law in Ukraine affected the conduct of experimental studies, since the raw material supply of organic raw materials has significantly decreased due to a decrease in the volume of its cultivation. This is due to the conduct of military operations in some regions of Ukraine.

Prospects for further research include conducting comparative studies of the consumer properties of organic and inorganic food products and developing a new range of organic confectionery products.

4. Conclusions

Formulations of "Sea Buckthorn" and "Hemp" chocolate pastes were developed using the method of mathematical modeling. The composition of chocolate paste "Sea Buckthorn" includes almonds, natural cocoa powder, cocoa butter, cane sugar, sea buckthorn oil, powdered milk, and flax bran. "Hemp" chocolate paste differs in that instead of sea buckthorn oil, it contains hemp oil. The results of organoleptic evaluation show that all samples correspond to the "excellent" quality level according to the 35-point scale developed by the authors. No significant differences were found between organic and inorganic chocolate pastes made according to the same recipes. More fats were found in organic chocolate pastes than in inorganic ones. In "Sea Buckthorn Organic" chocolate pastes – by 1.48 g/100 g; in the "Hemp" chocolate pastes by 1.86 g/100 g. The protein content in the organic and inorganic "Sea Buckthorn" chocolate pastes is the same and is 10.59 g/100 g. The protein content in the organic and inorganic paste "Hemp" is almost the same. The carbohydrate content also does not differ significantly. The results of the study show that the content of polyunsaturated fatty acids in chocolate pastes made from organic raw materials significantly exceeds the content of similar acids in inorganic chocolate pastes. The content of linolenic acid is higher by 0.58 g/100 g in the "Sea Buckthorn Organic" paste, and by 1 g/100 g in the "Hemp Organic" chocolate paste, respectively.

In terms of safety parameters, organic chocolate pastes are better than inorganic ones. The lead content is lower in the "Sea Buckthorn Organic" oil paste by 2.77 times; in the "Hemp Organic" by 2.45 times than the content of this substance in similar inorganic chocolate pastes. A significant difference is noted in the cadmium content: by 3 and 4.5 times, respectively.

The most significant hazardous factors were determined to be the content of pathogenic microorganisms (*Salmonella*, *Listeria monocytogenes*, *E. coli O 157:H7*, *St. Aureus*), foreign inclusions and the presence of allergens (nuts, dairy products). Critical control points in the production of chocolate pastes are established at the stage of sterilization of containers and heat treatment.

Conflict of interest

The authors declare that they have no conflict of interest in this research, including financial, personal, authorial or other, which could affect the work and its results presented in this article.

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Data availability

Data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in creating the presented work.

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