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DEVELOPMENT OF FORMULATIONS FOR SPONGE CAKES MADE FROM ORGANIC RAW MATERIALS USING THE PRINCIPLES OF A FOOD PRODUCTS SAFETY MANAGEMENT SYSTEM

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З метою управління безпечністю розроблених бісквітів з органічної сировини за принципами системи HACCP, створені дві рецептури бісквітів «Зимова насолода» та «Екзотик». Для приготування бісквітного напівфабрикату «Зимова насолода» використане борошно гречане органічне, імбир молотий органічний, цукор кленовий органічний, яйця органічні, есенція м'яти органічна. Для приготування бісквітного напівфабрикату «Екзотик» використане борошно зі спельти органічне, конопляне борошно органічне, порошок шипшини органічний, цукор кокосовий органічний, яйця органічні, есенція на основі лимону органічного. Встановлено, що розроблені продукти мають високі органолептичні властивості. З фізико-хімічних показників було визначено вологість у обох виробах, яка складала 25±2 % для напівфабрикату «Зимова насолода» та 24±2 % для напівфабрикату «Екзотик». Була визначена харчова та енергетична цінність виробів. Кількість білків складала для бісквіту «Зимова насолода» – 14,4 г/100 г; «Екзотик» – 15 г/100 г, кількість жирів – 4,40 та 3,80 г/100 г, кількість вуглеводів – 50,41 та 55,40 г/100 г, енергетична цінність – 298,84 та 315,80 ккал/100 г відповідно.

Розроблений план HACCP для виробництва бісквітів дає змогу виготовити безпечний продукт: проаналізовані небезпечні фактори на кожному етапі виробничого процесу та встановлено 4 критичних точки контролю. Встановлено, що найвищий ступінь ризику мають біологічні фактори, які можуть вплинути на безпечність готового продукту. Встановлені критичні точки контролю, критичні межі та розроблено план HACCP. Визначені мікробіологічні та токсикологічні показники безпечності готових виробів, не перевищують допустимих меж.

Ці результати вказують на те, що використання альтернативних рецептур бісквітних напівфабрикатів на основі органічної сировини з урахуванням підходів HACCP дає змогу створювати безпечні продукти з підвищеною харчовою цінністю. Отримані результати можуть використовувати підприємства кондитерської промисловості для розширення асортименту органічних виробів. Також, враховуючи необхідність впровадження системи HACCP всіма операторами ринку харчових продуктів, результати щодо розроблення плану HACCP також можуть бути використані виробниками

Ключові слова: система управління безпечністю, органолептичні показники, фізико-хімічні показники, харчова цінність, енергетичні цінність

1. Introduction

Hazard Analysis and Critical Control Points (HACCP) is a food products safety management system that has been recognized by the international community addressing food safety as the worldwide recommendations on control over dangers related to food products [1]. This system was made public for food industry in 1971. The HACCP

approach was also adopted in the legislation of many countries, including the EU Regulation on the hygiene of foods (EC No. 852/2004). The approach to the management of food safety based on the HACCP principles has been legislatively adopted in the United States, Canada. According to Chapter 4 "Sanitary and phytosanitary measures", Ukraine must implement the equivalent of the European system of quality control and safety of food products. It has been mandatory for implementation by market operators (manufacturers) since September 2017 [2]. According to the reform of legislation on the safety of food products, Ukraine adopted in 2015 the law "On the basic principles and requirements to safety and quality of food products". One of the responsibilities for operators in the market of food products in accordance with this law is the development, implementation, and application of permanent procedures based on the principles of system analysis of dangerous factors and control at critical points. Detailed explanations regarding the application of the HACCP system by food market operators are regulated by the requirements regarding the design, implementation, and application of permanent procedures based on the principles of the Hazard Analysis and Critical Control Points system (HACCP), approved by the order from Ukraine's Ministry of Agrarian Policy. This order provides guidelines regarding the implementation of the HACCP system, including the development of programs-preconditions and direct development of permanent procedures based on the principles of the system of hazard analysis and critical control points. Harmonization of the Ukrainian food legislation with the European one implies not only a change in approaches to food safety management system, but also fundamentally new approaches to inspections of enterprises. Thus, the order from the Ministry of Agrarian Policy regulates requirements to the report compiled based on the results of auditing the market operators' compliance with the requirements of the law regarding permanent procedures based on the principles of the system of hazard analysis and critical control points. Thus, even though the HACCP system certification is voluntary, inspections from regulatory authorities will test compliance with it. The legislation established that the complete transition to the implementation of the HACCP system must be over in September 2019, which testifies to the relevance of our study.

Given that organic production is considered to be the production of safe products, minimizing the risks for such foods is especially important. These products are much pricier and consumers are confident that they are safer. Note that the HACCP concept implies measures to ensure the required level of food safety indicators in the production process [3]. The system is universal because it could be employed by raw materials suppliers, manufacturers of products, wholesale consumers of products; is cost-effective because it channels resources to the critical points in production, reduces the risk of making and selling unsafe product [4]. Thus, the main reason for the widespread acceptance of the HACCP system is the possibility to manage food safety and prevent food poisoning [5].

The above predetermines the relevance of implementing an approach to food safety management based on the HACCP system. Underlying the choice of the object of study is the fact that demand for organic pastry products is growing rapidly. Thus, in the United States there is rise in popularity of such organic confectionery products as Justin's Organic Peanut, Butter Cups, TruJoy Sweets, Organic Original Fruit Chews, as well as products based on environmentally-safe honey [6]. Scientific research revealed that organic food is a significant component of food market in the Czech Republic, with the demand for confectionery products increasing each year [7]. A survey of 1,000 Polish consumers demonstrated that they believe that organic foods are more useful for health, more environmentally friendly and tastier than conventional products. It is believed that organic products are treated with more confidence, they have better quality, exposed to stricter control than those produced in traditional way [8].

2. Literature review and problem statement

The literature contains data concerning the development of confectionery products based on organic materials. Specifically, there are substantiated approaches to making organic muffins [9]. However, this study failed to analyze approaches to safety management when making muffins.

There is a series of research regarding the analysis of safety indicators in organic products and their comparison to similar indicators for traditional products. Thus, it is proven that the organically grown raw materials have smaller residues of pesticides [10]. There are contradictory data on the comparison of nitrates in conventional and organic fruits and vegetables. Study [11] found 127 cases when the level of nitrates was higher in conventional fruits and vegetables, 43 cases when the level of nitrates was higher in organic fruits and vegetables, and 6 cases when there was no any difference. Studies into the microbiological safety indicators for organic products, reported in numerous papers, do not prove a higher safety of organic products, compared with conventional [12]. The disadvantage of the above research is the fact that the studies register only the actual values for safety indicators. From the point of view of food safety management, prevention is better than inspection. That is why it is a much more important issue to make up a plan of activities for risk analysis than state the fact of a food product contamination. Although determining safety indicators for both raw materials and finished products is also a rather important issue.

The issue on developing an HACCP plan, as well as food safety management based on the HACCP principles, has been addressed by a great number of scientific publications. Thus, study [13] devised a procedure for the development of new products, which included: selection and design of a formulation, sensory analysis, microbiological testing, the development of HACCP and a marketing plan. However, this is only a general scheme for devising new products, which does not provide any specific HACCP plan for organic confectionery. Paper [14] compiled an HACCP plan for vegetable products. The study describes a flowchart of the manufacturing process, defines hazards, analyzes critical control points, verifies and validates the process. There are scientific data about the development of a plan for the hazard analysis and critical control points (HACCP) for making potato chips under actual conditions at the enterprises in Bangladesh [15]. Study [16] developed an HACCP plan for chocolate ice cream. Article [17] considers the stage-based development and implementation of the HACCP system at a dairy plant. Using a "decision tree" helped establish critical control points at each stage of production. A monitoring system was developed for each critical point to carry out a planned order of observations and measurements, as well as the timely detection when critical boundaries are breached. However, this research does not

describe any safety management system in the production of confectionery. Because confectionery products contain such ingredients that can lead to microbiological spoilage, especially relevant is the analysis of biological factors of hazards. Thus, paper [18] noted that confectionery products require conducting, above all, a microbiological assessment of these confectionery. The microbiological hazards include *Salmonella spp., Clostridium botulinum, Staphylococcus aurous, Yersinia enterocolitica, Listeria monocytogenes, Vibrio spp., Escherichia coli, Clostridium perfringens, Bacilluscereus, Campylobacter spp., Shigella spp.* In addition, of significant concern is the allergens, which are also quite common in confectionery production. Therefore, given the above, the importance of applying a safety management system, based on the principles of the HACCP system, is absolutely obvious for the confectionery industry.

3. The aim and objectives of the study

The aim of this study is to develop a plan to manage safety of sponge cakes made from organic raw materials. This will make it possible to extend the range of safe organic confectionery.

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

– to design formulations for sponge cakes made from organic raw materials;

– to explore the organoleptic and physical-chemical indicators for sponge cakes;

– to explore the food and energy value of sponge cakes;

– to devise activities to manage safety when making sponge cakes considering the principles of the HACCP system;

– to explore safety indicators for the finished products.

4. Materials and methods to study quality and safety of the developed sponge cakes

The objects of research were the developed sponge cakes "Winter delight" and "Exotic". Study into the quality and safety indicators for the developed products was described in detail in paper [19].

To develop an HACCP plan, the generally accepted procedures were applied. General principles of food products hygiene are established by the international organization "Commission Code Alimentarius". The procedure is based on the application of technical and scientific principles to the entire food production chain: from a field (farm) – to a table [20]. We evaluated dangerous factors and performed an analysis of control critical points according to the procedure for determining the significance of dangerous factors and a decision tree to determine critical points of control, set out in the annexes to the requirements for the development, implementation, and application of permanent procedures, based on the principles of the system of hazard analysis and critical control points (HACCP).

The first stage of research implied the acquisition of information about the process and potential hazards that may arise in the process of making organic sponge cakes; a flowchart of production was devised. We considered each stage of selling and technological processes in detail in order to obtain more information. Our work started by compiling a list of dangerous factors (physical, biological, chemical) that are relevant to the safety of products.

Dangerous biological factors of food origin include such microorganisms as bacteria, viruses, fungi, and algae. Chemical contaminants in foods can be of natural origin or those introduced when processing a food product. The most common physical risks are the occurrence of glass, metal, stones, leaves, trees, pests, jewelry, in food products [21].

When establishing hazardous factors, one should take into consideration the composition of a product, the process of processing, instructions for consumer, all kinds of hazards. The probability of occurrence of biological, chemical, and physical hazard factors at each technological stage is estimated based on an analysis of regulatory requirements, scientific and technical documentation, as well as the experience of an enterprise. A HACCP group defines precautionary measures for each essential dangerous factor, which make it possible to prevent or reduce the risk to acceptable level. Procedure for estimating dangerous factors is given in Table 1.

Table 1

Procedure for estimating dangerous factors

Probability	Severity of consequences				
	Insignificant (no effect)	Small (causing discomfort)	Significant (can cause disease)	Serious (can cause serious diseases)	Critical (can cause death)
Very high (weekly)	Medium	High	High	High	High
High (monthly)	Medium	Medium	High	High	High
Medium (half a year)	Low	Medium	Medium	High	High
Low (yearly)	Low	Low	Medium	Medium	High
Very low (less than once per year)	Low	Low	Low	Medium	Medium

When determining critical control points (CCP), we were guided by the method of risk analysis, responding to 4 consecutive questions:

– whether, at this stage, control measures for this dangerous factor are available;

– whether this stage of the process was specifically designed to eliminate a dangerous factor or reduce the likelihood of its occurrence to an acceptable level;

– whether the probability of occurrence of a dangerous factor exceeds the permissible level, or whether a dangerous factor can reach unacceptable level;

– whether a dangerous factor would be eliminated at the next stage of the process, or whether the likelihood of its occurrence would decrease to an acceptable level [22].

5. 1. Results of studying the organoleptic, physical-chemical quality indicators of the developed sponge cakes, and their food and energy value

To expand the range of organic flour-based pastry products, we developed 2 formulations for the sponge cakes "Winter delight" and "Exotic". Description of the products is given in Table 2.

When developing a new product, much attention focuses on the organoleptic indicators as they are essential to the consumer. In addition, when assessing organoleptic parameters, we were guided by the requirements from the national standard DSTU 4803:2007 "Cakes and pastries

general specifications", according to which the physical appearance should be specific to a given product, the surface – uniform and well-baked, the shape – diverse, but without breaks. Evaluation of products based on the organoleptic indicators was described in detail in paper [19]. Thus, in terms of organoleptic indicators, the developed samples meet DSTU 4803:2007 "Cakes and pastries general specifications" and can be highly appreciated by consumers. However, an important step during evaluation of quality of the newly created products is to investigate their physical and chemical indicators. Given this, we determined moisture content of the created products, which amounted to 25±2 % for the semi-finished product "Winter delight" and 24±2 % for the semi-finished product "Exotic". Such parameters are acceptable for sponge cakes.

Table 2

Consolidated formulations for the developed organic semi-finished products "Winter delight" and "Exotic" per 1 kg of the finished product

Raw material	"Winter delight"	"Exotic"
	Quantity (g) per 1 kg	Quantity (g) per 1 kg
Organic buckwheat flour	260	–
Organic spelt flour	–	125
Organic hemp flour	–	125
Organic powdered ginger	90	–
Organic powdered dog-rose	–	100
Organic maple sugar	650	
Organic coconut sugar	–	640
Organic hen eggs	4 pcs.	4 pcs.
Organic peppermint essence	4.0	–
Organic lemon-based essence	–	3.5
Yield	1,000	1,000

Nutritional and energy value are important indicators for consumers. Flour-based pastry products are characterized by a high percentage of carbohydrates while the share of proteins is relatively low. One of the ways to improve consumer properties of flour-based pastry products is to develop new products with reduced energy and enhanced nutritional value by using various types of alternatives [23]. Thus, as an alternative for a raw material to make sponge cakes, we proposed organic buckwheat flour, organic spelt flour, organic, organic hemp flour, organic powdered ginger and dog-rose, organic maple sugar, organic coconut sugar. Note that both types of sugar are less energetically valuable unlike the traditional sugar and have a somewhat lower amount of carbohydrates. Similarly, the proposed organic flour differs by lower energy value as opposed to wheat flour. Results of studying the nutritional and energy values are given in Table 3.

Table 3

Nutritional and energy value of sponge cakes

Product name	Proteins, 1/100 g	Fats, g/100 g	Carbohydrates g/100 g	Energy value, kcal/100 g
"Winter delight"	14.40	4.40	50.41	298.84
"Exotic"	15.00	3.80	55.40	315.80

Therefore, based on the data from Table 3, the developed sponge cakes differ by a somewhat lower content of carbohydrates – 50.41 and 55.40 g/100 g, respectively, and a relatively reduced energy value due to replacing the high-calorie raw material. Thus, the calorie-content of the sponge cake "Winter delight" was 298.84 kcal, that od "Exotic" – 315.80 kcal.

5. 2. Results of the elaboration of activities to manage safety in the production of sponge cakes considering the principles of the HACCP system

It should be noted that in addition to quality indicators, of particular importance is the safety indicators. Therefore, an important part of our study is the compilation of an HACCP plan in order to control the safety of sponge cakes made from organic raw materials. According to the regulations of Codex Alimentarius, drafting an HACCP plan must consist of consecutive steps. Preparatory steps before applying the HACCP system include:

1. Creation of a group of HACCP.
2. Description of the product.
3. Definition of the proposed technique to consume the product.
4. Development of a flowchart of the technological process.
5. Checking the flowchart of the technological process.

The principles of the HACCP system are as follows:

Principle 1. Analyze dangerous factors.

Principle 2. Determine the critical control points (CCP).

Principle 3. Establish critical limits.

Principle 4. Establish a system for monitoring CCP.

Principle 5. Establish corrective actions that should be applied when monitoring indicates that a specific CTC is out of control.

Principle 6. Establish procedures to verify the certainty that the HACCP system works effectively.

Principle 7. Develop methods for documenting all procedures and accounts related to the application of these principles [24].

Based on the developed formulations (Table 2), one can prepare a description of the products, which is implied by the HACCP plan. Description of the products is given in Table 4.

Therefore, Table 4 gives information that describes the developed products. This information will be used in an analysis of hazards during technological process. The flowchart of the technological process includes the following stages:

– obtaining raw materials for the preparation of sponge cakes;
– storage of raw materials;
– mixing and sifting of ingredients;
– kneading;
– mixing of dough;
– shaping the dough;
– baking;
– cooling;
– aging and maturation;
– packaging;
– labeling;
– storage.

Based on these data, as well as data from Table 3, we defined dangerous factors in the production of sponge cakes made from organic raw materials. The analysis of dangerous factors involved the consideration of the probability of their occurrence and the seriousness of the danger. If all occurring possible dangerous factors are defined at all stages, then we defined the actions and procedures to prevent the occurrence of hazards [25]. An analysis of dangerous factors is given in Table 5.

Table 4

Description of sponge cakes "Winter delight" and "Exotic"

Official product name	Sponge cake based on the organic raw material "Winter delight"	Sponge cake based on the organic raw material "Exotic"
Normative document in line with which a product is produced	Under development	
List of raw materials and materials used during production	organic buckwheat flour, organic powdered ginger, organic maple sugar, organic eggs, organic peppermint essence. All raw materials must be certified as organic.	organic spelt flour, organic hemp flour, organic powdered dog-rose, organic, coconut sugar, organic eggs, organic lemon-based essence. All raw materials must be certified as organic.
Physical-chemical characteristics	Mass fraction of moisture 22–26 % according to the formulation.	
Safety requirements	According to DSTU 4803:2007 "Cakes and pastries general specifications" (aflatoxins, mycotoxins, toxic elements, microbiological indicators)	
Consumer packing	BOPP-film, non-transparent	
Transportation packaging	boxes, cardboard tare	
Labeling requirements	According to DSTU 4803:2007 "Cakes and pastries general specifications", subject to certification of the organic product – designation by a certification authority.	
Conditions and shelf life	7 days when at relative humidity 65–70 % and temperature 18±3 °C	
Sale	Wholesale and retail, specifically at stores that sell organic products	
Information about a potential consumer and specific group of consumers	The product can be consumed by children and adults, except for people with diabetes, and with allergies to ingredients contained in the product	
Potentially possible use for other purposes	Impossible	
Consuming technique	As a ready-made product	

Table 5

Analysis of dangerous factors

No.	Stage in technological process	Danger code	Danger description	Danger substantiation	Preventive measures
1	2	3	4	5	6
1	Acceptance of raw materials	B	Contamination of eggs and flour, as a result of improper transportation, by microorganisms MAFAM, coliforms *Salmonella, Bacillus, Staphylococcus, Listeria Monicytogenes*	Cause food poisoning, salmonellosis, intoxication. *Listeria Monicytogenes* can cause miscarriages in pregnant women.	Implementation of program-precondition on specification and control of suppliers. Compliance with the instructions for acceptance of starting raw materials
2	Acceptance of raw materials	C	Contamination of raw materials with toxic (cadmium, lead, zinc, arsenic, mercury; aflatoxin B_1) elements and radionuclides (cesium, strontium). Contamination with pesticides.	Lead disrupts the function of the nervous and vascular systems, accumulates in the body Cadmium affects the liver. Arsenic, accumulated in the body, affects the nervous system. Mercury affects the nervous system, liver, kidneys. Especially harmful for pregnant women. Aflatoxin can cause cancer. Radionuclides are accumulated in the body and have a negative impact on all tissues. Pesticides accumulate in adipose tissue, have a negative effect on pregnant women.	Implementation of program-precondition on specification and control of suppliers. Availability of certificates confirming that the raw materials are organic. Compliance with the rules of acceptance control.
3	Acceptance of raw materials	C	Presence of allergens in the raw material.	Allergic reaction in the form of rhinitis, angioedema, anaphylactic shock.	Indication of allergens on labels
4	Storage of raw materials	B	Contamination of eggs and flour, due to improper storage, by microorganisms MAFAM, coliforms *Salmonella, Bacillus, Staphylococcus, Listeria*	Negative consequences are described in paragraph 1	Compliance with regimes and terms of storage
5	Storage of raw materials	B	Contamination of flour, powdered dog-rose, ginger, eggs with pests as a result of improper storage – lesser grain borer, grain moth, collar weevil	Toxins produced as a result of pests' life activities can cause poisoning	Implementation of program-precondition on specification and control of suppliers. Compliance with the rules of acceptance control, mode and terms of storage

Continuation of Table 5

1	2	3	4	5	6
6	Mixing ingredients to knead	P	Foreign objects from personnel, equipment (plastic, glass, metal parts). Foreign objects from loose products' packaging	Penetration of non-sharp objects, less than 1 mm, can be unpleasant. If the items are larger in size, they can cause damage to teeth, oral cavity, stomach, respiratory tract	Compliance with the instructions for the preparation of raw materials. Using sieves for sifting loose objects. Compliance with a program-precondition for staff hygiene.
7	Dough kneading	P	Foreign objects from equipment (plastic, glass, metal parts). Foreign objects from loose products' packaging	Negative consequences are described in paragraph 6	Compliance with the instructions for the preparation of raw materials. Compliance with a program-precondition for staff hygiene.
8	Dough kneading	C	Contamination with chemicals from equipment (sanitizers, paints and coatings)	Toxic effect of acids that are part of the disinfectant solutions	Compliance with the instructions for use of the disinfectants. Control over equipment vendors.
9	Dough kneading	B	Contamination with microorganisms in the event of personnel's failure to comply with hygiene requirements. Carriers of nasal secretions *S. aureus,* people infected with the hepatitis A, or a virus by Norvolk, or carriers of dysentery, open wounds and cuts, infected with *Streptococcus* or other pathogens	Negative consequences are described in paragraph 1. Transmission of viral diseases through food.	Compliance with programs-preconditions for staff hygiene and cleanliness of surfaces. Carrying out medical examinations. Compliance with the instructions for the admission of staff.
10	Dough shaping	P	Foreign objects from personnel, equipment (plastic, glass, metal parts). Foreign objects from loose products' packaging.	Negative consequences are described in paragraph 6.	Compliance with the instructions for the preparation of raw materials
11	Dough baking	B	Development of resistant microorganisms	Negative consequences are described in paragraph 1.	Observance of temperature regimes and timing of baking
12	Cooling	B	Contamination with microorganisms in the event of personnel's failure to comply with hygiene requirements and cleanliness of surfaces – by Norvolk virus, or carriers of dysentery, open wounds and cuts, infected with *Streptococcus* or other pathogens	Negative consequences are described in paragraph 1.	Compliance with a program-precondition for staff hygiene and cleanliness of surfaces. Carrying out medical examinations. Compliance with the instructions for the admission of staff.
13	Packing	C	Contamination of product with chemicals from packaging materials – plasticizers, printing inks and ink	Chemical compounds can cause poisoning	Ranking the suppliers of packaging materials
14	Storage	B	Contamination with microorganisms in the event of personnel's failure to comply with hygiene requirements and cleanliness of surfaces – Norvolk virus, or carriers of dysentery, open wounds and cuts, infected with *Streptococcus* or other pathogens. Development of resistant microorganisms	Negative consequences are described in paragraph 1.	Compliance with regimes and terms of storage, personnel's hygiene and compliance with the instructions for cleaning and disinfection of surfaces

Thus, the largest number of hazards during sponge cakes production based on organic raw materials is associated with biological factors. Note that it is the most dangerous to human health. The assessment of severity of hazards is given in Table 6.

An analysis of the severity of hazards has allowed us to identify hazards with a high level of consequences, which may significantly affect the safety of the product. Guided by the information on dangerous factors with a high degree of severity, we established critical control points during production, which are given in Table 7.

Based on a detailed analysis, we found 4 control critical points at the satage of storage of raw materials, mixing dough, baking, and storage of the finished product. It was stablished that critical control points at the stage of storage are related to biological hazardous factors – microbiological contamination of raw materials and an infestation with pests. At the stage of dough kneading, penetration of foreign objects is possible. When baking, it is important to prevent the development of resistant microorganisms and to maintain temperature regimes. When storing products, it is important to comply with regimes and terms of storage. The next stage in drafting an HACCP plan is to establish critical limits, which are given in Table 8.

Establishment of critical limits is needed to determine specific numerical values that must be controlled to prevent the contamination of a food product. The next stage implied by HACCP is the development of an HACCP plan. Development of an HACCP plan is given in Table 9.

Table 6

Assessment of the severity of hazards during production of sponge cakes from organic raw materials

Hazardous factor	Probability of occurrence	Severity of consequences	Risk degree
Biological factors			
Microbiological contamination of eggs and flour as a result of improper transportation	High	Serious	High
Contamination of flour, dog-rose powder, ground ginger, eggs with pests, as a result of improper storage	Medium	Significant	High
The presence of allergens in raw materials	High	Significant	High
Foreign objects from personnel, equipment (plastic, glass, metal parts)	Low	Low	Low
Contamination with chemicals from equipment	Low	Low	Low
Contamination with microorganisms in the event of personnel's failure to comply with hygiene requirements	High	Significant	High
Development of resistant microorganisms	High	Serious	High
Contamination of product with chemicals from packaging materials	Low	Small	Low
Contamination of product with microorganisms during storage	High	Serious	High

Table 7

Establishment of critical control points during production of sponge cakes from organic raw materials

Agent name	Name of hazardous factor	Question No. 1: are there, at this stage or later stages, preventive measures for this dangerous factor?	Question No. 2: can this stage reduce the level of dangerous factor to the acceptable level?	Question No. 3: is there a possibility, at this stage, for the emergence of a dangerous factor or for its increase it to the unacceptable level?	Question No. 4: does the next stage warrant the elimination of a dangerous factor or a decrease to its acceptable level?	Number of a critical control point
Acceptance of raw materials						
Eggs, sugar, flour	Biological (microbiological contamination)	Yes. Entrance control, product certification	No	Yes	Yes. Yes. Entrance control, product certification	–
Storage of raw materials						
Eggs, sugar, flour, powdered dog-rose, ground ginger	Biological (microbiological contamination, contamination with pests)	Yes. Compliance with storage mode	No	Yes	No	CCP1
Dough kneading						
Flour	Biological (contamination with microorganisms in the event of personnel's failure to comply with hygiene requirements)	Yes. Obtaining raw materials for the preparation of dough that are not contaminated with microorganisms	No	Yes	Yes	-
Dough	Physical (foreign objects from personnel, equipment (plastic, glass, metal parts). Foreign objects, from loose products' packaging)	Yes. Using sieves for sifting loose raw materials	Yes	–	–	CCP 2
Dough baking						
Dough	Biological (development of resistant microorganisms)	Yes. Obtaining raw materials for the preparation of dough that are not contaminated with microorganisms	Yes	Yes	No	CCP3
Storage						
Ready sponge cake	Biological (microbiological contamination)	Yes	Yes	–	–	CCP 4

Table 8

Establishment of critical limits

Ingredient name	CCP No.	Critical limits
Storage of raw materials		
Flour	1	Optimum air humidity in the room should not exceed 7 %. The most favorable temperature for this product is 5–18 °C, but not higher than 20 °C, not longer than 8 months. Contamination with pests – 0.
Sugar	1	Store at temperature +17 °C and relative air humidity 70 % up to 1 month.
Eggs	1	Store at refrigerating chambers at temperature from 0 to 4 °C separately from heavily smelling products. Number of broken eggs, eggs with spots – 0. Contamination with pests – 0.
Dough kneading/loose products	2	Presence of impurities on a sieve
Dough baking	3	Baking duration – 20–30 min. Temperature mode – 190–200 °C
Storage/ ready sponge cake	4	7 days at relative humidity 65–70 % and temperature 18±3 °C

Table 9

Development of HACCP plan

Process stage	CCP	Critical limits	Description of hazardous factor	Monitoring procedures	Corrective actions	Protocols of HACCP
Storage of raw materials	1	Flour. Flour. The optimum air humidity in the room should not exceed 70 %, The most favorable temperature for this product – 5–18 °C, but not higher than 20 °C, not longer than 8 months. Sugar. Store at temperature +17 °C and relative air humidity 70 % up to 1 month. Eggs. Store at refrigerating chamber at temperature from 0 to 4 °C separately from the heavily smelling products. Number of broken eggs, eggs with spots – 0. Storage conditions are similar. Contamination with pests – 0.	Contamination with microorganisms and pests	Trained staff checks products when receiving for storage, controls a storage mode, monitors storage terms.	One must not accept for production the products contaminated with pathogenic microorganisms. Tainted flour and powdered ginger and dog-rose are to be sent to decontamination. This is achieved by sifting, at exposure at low (–5 °C) or high temperature (50–55 °C). Then the product is purified from any pests	Journal of registration of products' batches. Journal of monitoring of pests
Dough kneading	2	Presence of impurities on a sieve	Penetration of foreign objects	Visual inspection of the sieve by a baker 1–2 times per hour	Do not use loose raw materials if they contain foreign supplements: test a given batch	Protocol of review of the sieve
Dough baking	3	Duration of baking – 20–30 minutes, temperature mode – 190–200 °C	Development of resistant microorganisms	Control over temperature modes and duration of baking. Visual inspection of the finished product	Unbaked products are not no be sold. Calibration of technological equipment in case of inconsistencies in temperature regimes.	Technological scheme of production. A check-list for making a sponge cake.
Storage	4	7 days at the relative humidity 65–7 % and temperature 18±3 °C	Contamination with microorganisms	Measurement of temperature and relative humidity by a person who is responsible for storage. Compliance with the terms and modes of storage	Stop selling in the case of inconsistencies in modes of storage or storage expiration	Journal to register temperature modes

Therefore, the implementation of HACCP plan requires the participation of all qualified personnel employed in manufacturing at all stages. In addition, a logical and adjusted plan of HACCP could help operators in the market of food products to improve the level of food products safety management [26].

5. 3 Results of studying the safety indicators for the developed sponge cakes based on organic raw materials

Taking into consideration the above-described system to manage safety, we prepared the developed sponge cakes "Winter delight" and "Exotic" from organic raw materials. Considering the HACCP principle 6 to establish procedures for testing, we conducted microbiological and toxicological tests. Microbiological testing is ineffective for monitoring critical control points. They are not applied as a means to control the process due to duration of the procedures and impossibility to provide results in real time. However, they are essential to verify the effectiveness of an HACCP plan. Thus, the finished products were tested in terms of safety indicators in line with the regulations. Results from determining the microbiological indicators are given in Table 10.

Table 10

Microbiological indicators for the developed sponge cakes

Indicator title	Norm	"Winter delight"	"Exotic"
Mesophilic aerobic and facultative-anaerobic microorganisms, CFU per 1 g, not exceeding	5×10^2	1×10^2	80
Bacteria from the group of intestinal sticks (coliforms) (mass of product (g/cm^3, in which they are not allowed)	1	not detected	not detected
Pathogenic microorganisms, including bacteria of the genus Salmonella (mass of product (g/cm^3, in which they are not allowed)	25	not detected	not detected

Therefore, in accordance with Table 10, the microbiological indexes for products meet the norm. No less important, especially given the fact that the products were made from organic raw materials, is the content of toxic elements and aflatoxin B_1. The study was carried out in accordance with the methods described in paper [19]. Specifically, copper, zinc, lead, and cadmium were determined by the atomic-absorption method, arsenic – by the colorimetric method, mercury – by the method of flameless atomic absorption, aflatoxin B_1 – by the fluorescent method. Results of research are given in Table 11.

Table 11

Toxicological safety indicators for sponge cakes

Toxic element name	Permissible levels, mg/kg, not higher	Actual values, mg/kg	
		"Winter delight"	"Exotic"
Lead	0.5	0.1	0.1
Cadmium	0.1	0.02	0.03
Arsenic	0.3	0.1	0.1
Mercury	0.02	0.002	0.002
Copper	10.00	7.6	7.2
Aflatoxin B_1	0.005	0.003	0.003

Based on data from Table 11, all samples meet the national standard of Ukraine for sponge cakes in terms of the content of toxic elements and aflatoxin B_1. It should be noted that all indicators are significantly lower than the permissible norms. Since the introduction of HACCP system in production implies control over raw materials and the existence of written specifications, we conducted preliminary control in the form of an organoleptic estimation and verification of supporting documentation. Thus, only the certified organic raw materials were selected for the production of sponge cakes. This may explain the fact that the toxicological indicators were lower than the permissible norms.

6. Discussion of the results of the study on the introduction of a safety system for the production of biscuits from organic raw materials

The development of formulations for sponge cakes based on organic raw materials and the management of safety of products applying the HACCP principles is a continuation of research work aimed at organic production of finished products in Ukraine. The first stage was the study into the evaluation of export potential of the State in the market of organic food products, as well as the study into the structure of organic farming in Ukraine; the second stage was the development of cupcakes based on organic raw materials with an elevated amino acid composition.

The results obtained give reason to believe that organic raw materials are promising to create safe products under conditions of applying the HACCP principles during their production. Alternative types of flour: organic buckwheat, organic hemp, organic spelt flour, as well as substitutes to traditional sugar – coconut and maple sugar, make it possible to reduce the content of carbohydrates and energy value of the finished product. Moreover, the applied types of flour do not contain gluten, which would make it possible to extend the range for patients with celiac disease. This confirms the scientifically proven fact that coconut sugar can be used as an alternative sweetener, and for health food products as well [27]. It also confirms the data from research regarding the chemical structure and properties of spelt-based flour. Paper [28] proved that spelt flour, when compared with wheat, contains fewer own sugars, has lower sugar-forming ability and larger autolytic activity. Although there are data on that the flour from spelt adversely affects the quality of baked bread [29], the research into quality of the semi-finished sponge cakes did not reveal significant differences. The application of buckwheat flour for making sponge cakes was addressed in [30] where it was stated that buckwheat flour contains more, when compared with other kinds of flour, vitamins B_6, B_2, PP and E, calcium and iron, as well as lecithin, which reduces the level of cholesterol in the blood. Application of buckwheat flour helps improve quality, increase the nutritional value, and reduce the energy value of flour-based pastry products.

Approaches to development of HACCP plan for the production of sponge cakes from organic raw materials confirm data on the management of food products safety, which were published regarding the safety of tomato crisp bread for gerontology- nutrition purpose [31], production of bakery products [25], cookies [32].

The data obtained could serve a basis for the development of not only the organic sponge cakes, but other flour-based pastry or bakery goods applying alternative raw materials. In addition, the data acquired could be useful to enterprises in confectionery industry to implement a system for managing safety of food based on the HACCP principles. The main disadvantage of this study is the lack of data on the content of fat, acid, vitamins, and amino acids in the developed products, which will be a further step of research in this direction. A significant constraint for expanding the range of organic products is their high price, which is justified by the necessity for certification and a long transition to organic production. In addition, a possible problem in the production of the proposed products relates to the fact that the used raw materials are grown in different countries. However, given current trends in the development of environmentally-friendly consumption, such products could be present in the market and have demand.

7. Conclusions

1. We have developed formulations for sponge cakes based on organic certified raw materials. To make the semi-finished sponge cake "Winter delight", we used

organic buckwheat flour, organic ground ginger, organic maple sugar, organic eggs, organic peppermint essence. To make the semi-finished sponge cake "Exotic", we used organic spelt flour, organic hemp flour, organic powdered dog-rose, organic coconut sugar, organic eggs, organic lemon-based essence.

2. It was established that the developed products have high organoleptic properties. Among the physical and chemical indicators, we determined moisture content for both products, which was 25±2 % for the finished product "Winter delight" and 24±2 % for the finished product "Exotic".

3. We determined the nutritional and energy value of products. The amount of proteins was for the sponge cake "Winter delight" was 14.4 g/100 g; "Exotic" – 15 g/100 g, fat – 4.40 and 3.80 g/100 g, carbohydrates – 50.41 and 55.40 g/100 g, energy value – 298.84 and 315.80 kcal/100 g, respectively.

4. Taking into consideration the HACCP principles, we described the developed sponge cakes, a flowchart of production, analyzed hazardous factors and severity of their consequences. We identified critical control points at the stages of production of sponge cakes, critical limits, which underlies the compiled plan of HACCP.

5. Among the microbiological indicators, we determined the content of MAFAM, coliforms and bacteria from the genus *Salmonella*. The content of MAFAM was 100 and 80 CFU per 1 g for the sponge cakes "Winter delight" and "Exotic"; no other microorganisms were found. All samples meet the national standard of Ukraine for sponge cakes in terms of the content of toxic elements and aflatoxin B_1.

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