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ANALYSIS AND ASSESSMENT OF POTENTIAL RISKS IN THE PRODUCTION OF ENRICHED SUGAR

The object of research is the quality indicators of sugar enriched with derivatives of the processing of the fruits of wild plants (viburnum, mountain ash, sea buckthorn, black elder) and potential dangerous factors that may arise during its production. This study is aimed at the analysis and assessment of all risks that arise in the production of sugar enriched with derivatives of processing of wild raw materials. For the production of enriched sugar, pre-cleaned fruits were frozen at a temperature of −18±2 °C, and after defrosting, they were partially dehydrated by the method of osmotic dehydration. For this, a 70 % sugar solution with a temperature of 50±5 °C was used (hydromodule 1). The duration of osmotic dehydration was 1 hour. The derivative product formed as a result of osmotic dehydration of fruits (sugar solution) was used to enrich granulated sugar in the amount of 10 % by mass of sugar. After thorough mixing with the solution, the sugar was dried in a laboratory vacuum dryer and analyzed. Based on the principles of HACCP, a detailed description of the product and its use with a specific purpose has been developed. In particular, the description of all stages of production, from the initial materials to the processing and packaging processes, as well as the definition of all possible dangerous factors that can affect the safety and quality of products. The identification and assessment of all hazardous factors included the analysis of all possible threats to the safety and quality of products at each stage of production. To ensure the quality and safety of enriched sugar obtained from wild raw materials, an assessment of potential dangerous factors at all stages of production was carried out. A HACCP plan has been developed that allows effective management of critical control points and evaluation of the results of this management. This will allow potential manufacturers to produce safe and competitive products of high quality. The practical implementation of these proposals will allow bringing new products to the market-elderberry, sea buckthorn, rowan and viburnum sugar.

Keywords: *viburnum sugar, elderberry sugar, sea buckthorn sugar, rowan sugar, product quality, product safety.*

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1. Introduction

To date, the most effective system in the world that ensures the safety and quality of food products during their production, processing, storage, transportation and use is the HACCP system (analysis of hazardous factors and critical control points) [1].

Based on this system, an assessment of potential hazards that may affect the quality of food products at all stages of production, storage, sale and use [2] is carried out. These hazards include microorganisms, chemical compounds, and physical factors. The HACCP system proposes to divide the production process into separate blocks and implement a control system for potential «risks» in each of them [3]. Detailed analysis of these «risks», qualified performance of individual operations by each specialist of the enterprise and documentation of all necessary measures will reduce the probability of the occurrence of a low-quality product almost to zero [4].

The HACCP system for sugar aims to achieve four main goals. First, its goal is to completely prevent or significantly reduce the risk to the health of consumers in the event of a hazard. Secondly, the system is aimed at achieving a stable level of production quality [5]. This goal is achieved through orderly and coordinated actions aimed at managing risks at all stages of production, from procurement of raw materials to transportation to the point of sale [6]. Thirdly, HACCP promotes the development of measures to increase labor productivity and improve the technological process. And finally, the HACCP system regulates close cooperation between sugar producers and state bodies, which allows for control at the administrative level, which significantly improves the quality of manufactured products [6].

The application of the HACCP system will allow to effectively identify and analyze risks, in particular biological factors, at all stages of production, as well as manage critical control points and evaluate the results of this management. This opens up real opportunities for the enterprise to produce safe, high-quality and competitive products [7]. International organizations such as FAO, ICMSF, and IAMFES recommend the use of the HACCP system as an effective means of ensuring food safety [8].

Thus, in a number of countries where sugar is produced, products must meet quality and safety requirements [9]. This means that producers must adhere to established

standards and requirements for the production, quality of raw materials, processing and packaging of sugar. Such requirements contribute to ensuring the safety of food products for consumers both in the domestic market and for export to other countries.

Sugar quality requirements may vary depending on the country and the standards adopted there [10]. However, some general requirements are universal for many countries and include:

– *Cleanliness and safety*. Sugar must be produced without impurities and impurities that may affect its quality or safety for the consumer.
– *Microbiological safety*. Sugar must be safe for consumption, i.e. comply with regulations regarding the content of microorganisms that may pose a threat to health.
– *Marking requirements*. The product must be clearly marked with information about the manufacturer, composition, expiration date and other necessary information for the consumer.
– *Production standards*. Requirements for sugar production, such as conditions for growing and processing raw materials, may also be established to ensure the quality and safety of the product.

These requirements can be regulated by the legislation of each country, as well as the standards of international organizations such as FAO, WHO and others.

Sugar production in India uses a syrup purification system that may not be effective in terms of the safety requirements set by the Standard for various types of sugar. This system may meet basic safety standards, but not meet the high standards required by export and institutional buyers such as Coca Cola, Pepsi, Cadbury. Such companies may have their own requirements and standards regarding the quality and safety of the raw materials they use in their products, and they may require suppliers to meet these standards to ensure the safety and quality of the products they produce [11].

Thus, when producing sugar from palm sap in the Philippines [12] and destined for export, manufacturers must comply with the food legislation of the destination country. For example, if this product is intended for European countries, then it must meet the standards of the European Food Safety Agency (EFSA), or if for the United States, then the requirements of the Food and Drug Administration (FDA) [13]. In Ukraine, sugar is produced according to DSTU 4623:2023 [14]. This standard regulates the quality indicators of crystalline sugar, pressed sugar, sucrose for champagne and powdered sugar. The technology of sugar enriched with derivatives of the processing of the fruits of wild plants (viburnum, mountain ash, sea buckthorn, black elder) was developed [15] and technical conditions for its production [16]. However, there is no description of this product and a list of potential dangerous factors in its production based on the principles of HACCP.

The aim of this research is to analyze and assess all risks that may arise in the production of sugar enriched with derivatives of processing of wild raw materials. This will enable potential manufacturers of enriched sugar to produce a product of the required quality.

2. Materials and Methods

The object of the study is the quality indicators of sugar enriched with derivatives of the processing of the fruits of wild plants (viburnum, mountain ash, sea buckthorn, black elder) and potential dangerous factors that may arise during its production.

For the production of enriched sugar, pre-cleaned fruits were frozen at a temperature of –18±2 °C, and after defrosting, they were partially dehydrated by the method of osmotic dehydration. For this, a 70 % sugar solution with a temperature of 50±5 °C was used (hydromodule 1). The duration of osmotic dehydration was 1 hour. The derivative product formed as a result of osmotic dehydration of fruits (sugar solution) was used to enrich granulated sugar in the amount of 10 % by mass of sugar. After thorough mixing with the solution, the sugar was dried in a laboratory vacuum dryer and analyzed.

Based on the principles of HACCP, a detailed description of the product and its use with a specific purpose has been developed. In particular, the description of all stages of production, from the initial materials to the processing and packaging processes, as well as the definition of all possible dangerous factors that can affect the safety and quality of products. The identification and assessment of all hazardous factors included the analysis of all possible threats to the safety and quality of products at each stage of production.

3. Results and Discussion

A typical description of a food product includes information on its name, regulatory compliance, characteristics, uses, packaging conditions, expiration date, sales strategies, labeling instructions, and special delivery requirements.

The description of sugar enriched with derivatives of the processing of the fruits of wild plants is presented in Table 1.

All significant potentially hazardous factors must be controlled by appropriate measures. A hazardous factor can be characterized as a biological, chemical or physical property that may pose a risk to the consumption of a food product.

Hazardous factors for consumers can have various harmful effects, such as poisoning, diarrhea and other diseases. The main types of dangerous factors are divided into chemical, biological and physical.

Chemically dangerous factors include [2]:
– residues of detergents that can lead to poisoning;
– toxic substances in raw materials that can cause serious diseases;
– pesticides in raw materials that can cause pathogenic diseases in future generations;
– prohibited detergents – can lead to poisoning;
– high content of chlorides in raw materials – can cause disorders of the gastrointestinal tract;
– salts of heavy metals – high content can lead to poisoning and serious diseases;
– foreign mineral impurities – can cause suffocation if they enter the respiratory tract.

Biologically dangerous factors include [4]: poisonous microorganisms; microflora of mesophilic aerobic and facultatively anaerobic microorganisms; mildew; yeast.

Physical dangerous factors – particles of filters, glass, metal shavings, jewelry: can damage internal tissues or cause suffocation if they enter the respiratory tract.

Understanding these dangerous factors and their impact on health helps to avoid harmful consequences and ensure food safety.

Table 2 gives the definition of dangerous factors in raw materials, and Table 3 – HACCP plan for the production of sugar enriched with derivatives of wild raw materials.

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Table 1

Description of sugar enriched with derivatives of the processing of the fruits of wild plants

Product name	Enriched sugar with derivatives of wild raw materials			
	Sambucus nigra	Viburnum opulus	Hippophae rhamnoides	Sorbus aucuparia
Normative document	TU U 10.8-04718013-009:2023 Pressed vitaminized sugar. Specifications			
Product characteristics				
Appearance	In the form of individual pieces that have the shape of a parallelepiped, cubes, and others			
Color	From dark pink to purple	From light pink to red	Light yellow or cream	Light pink
Smell and taste	The smell is characteristic of the raw material. The taste is sweet, with the aftertaste of the raw materials from which it is made			
Mass fraction of sucrose, %	97.67	98.36	94.76	96.64
Mass fraction of glucose, %	0.20	0.04	0.21	0.09
Mass fraction of fructose, %	0.27	0.05	0.23	0.04
Mass fraction of moisture, %, not more than	0.25			
Mass fraction of ferrous impurities, %, no more than	0.0003			
Strength of sugar (temporary resistance of the parallelepiped to the crushing pressure of the Bonvech press), MPa, not less than	1.5			
Use of the product	To feed the population			
Product packaging	– with a net weight of up to 0.25 kg, in paper, polyethylene and polypropylene bags or bags made of a combined material (paper with a polyethylene or microwax coating); – pressed sugar of small packaging is wrapped in separate bags of 1, 2, 3 pieces or more. Net weight from 2 g to 50 g; – in separate artistically decorated bags made of combined material (paper with a polyethylene or microwax coating). According to the current regulatory documentation or from imported paper approved for use by the central executive authority in the field of health care			
Expiration date	2 years from the date of manufacture			
Labeling instructions	Labeling of food products is carried out in accordance with the legislation of Ukraine, in particular, in accordance with the Technical Regulation on the labeling of food products, which ensures clarity and comprehensibility of information. Packaging labels are made in accordance with current regulatory documents and applied to each product unit. The transport container also indicates the number of units of the consumer container in the unit of the transport container and the volume of each unit, as well as added manipulation marks			

Table 2

Determination of dangerous factors in raw materials

Raw materials and materials	A dangerous factor	A source of danger	Significance	Control measures and preventive actions
Water supply from a well	B: MAFAM, BGKP X: Heavy metals, residual disinfectants F: Foreign impurities	Contamination of water in the water supply, possible ingress of sewage into the water supply	Average	Control of water safety. Installation of filters and disinfection of water
Taking the fruits of wild plants	B: MAFAM, BGKP, Cryptosporidium parvum and Salmonella bacteria, molds Kh: Patulin, Khed F: Foreign and mechanical impurities	Personnel, non-compliance with conditions of transportation and storage	Average	Impurities are removed at the next stages of production
Taking sugar	B: MAFAM, BGKP, Cryptosporidium parvum and Salmonella bacteria, molds F: Foreign and mechanical impurities	Personnel, non-compliance with conditions of transportation and storage	Average	Impurities are removed at the next stages of production
Paper bags	B: MAFAM, BGKP X: Detergent residues F: Foreign impurities: dust, glass fragments, dirt	Personnel, equipment malfunction, violation of storage and transportation conditions	High	Control of packaging materials. Return to supplier

Table 3

HACCP plan for the production of enriched sugar

No.	Stage of production	Risk description	Category	Actions in case of deviation from norms
1	Taking the fruits of wild plants	Foreign impurities, mechanical damage, toxic substances, pesticides, microflora	Physical, chemical, microbiological	Correct and high-quality recipe
2	Washing and inspection	Low-quality sink, foreign microflora	Microbiological	Control of the operation of washing machines
3	Production of 70 % syrup solution	Residues from solutions for washing equipment	Chemical	Quality control of equipment washing, rinsing with clean water
4	Mixing syrup with berries	Development of microflora	Microbiological	Maintenance of the necessary sanitary condition of the equipment
5	Filtering	Residues from solutions for washing equipment	Chemical	Quality control of equipment washing, rinsing with clean water
6	Mixing granulated sugar with an osmotic solution	Residues from solutions for washing equipment	Chemical	Quality control of equipment washing, rinsing with clean water
7	Storage	Contamination by microorganisms	Microbiological	Quality control of the sanitary condition of the equipment

In order to avoid additional risks, it is advisable to accept the fruits of wild plants in batches from suppliers, only if there are documents confirming their safety and quality.

Assessment of dangerous risks and critical points in the production of enriched sugar is important to ensure product quality, consumer safety and the efficiency of production processes. After analyzing the formed plates, key aspects were found that justify the need to assess these dangerous factors:

– *Contamination*: The production of this product may face risks of contamination by chemicals, microorganisms and foreign materials.

– *Toxic substances*: during the cultivation of sugar beets, wild berries, pesticides and fertilizers are used, which must be removed during processing. Some raw materials can grow in polluted places, which in turn negatively affects the content of toxic substances.

– *Residues of detergents*: this phenomenon occurs quite often in food production, with insufficient risk assessment and non-compliance with washing conditions, it can have a negative impact on the quality and safety of the final product.

Therefore, a rather important stage in the production and launch of new sugar enriched with wild berry derivatives is precisely the assessment of all possible critical points for obtaining a high-quality and safe product.

The practical implementation of these proposals will allow bringing new products to the market – elderberry, sea buckthorn, rowan and viburnum sugar.

The limitations of this study include the lack of a sufficient amount of raw materials, namely fruits that are proposed to be used for sugar enrichment (viburnum, black elderberry, sea buckthorn, mountain ash).

In the conditions of martial law in Ukraine, ensuring the collection of the fruits of wild plants causes a number of difficulties, in particular, in the front-line regions. In addition, there is significant environmental pollution due to the use of various weapons and ammunition, which can negatively affect the quality of the fruits of wild plants.

Further research will be aimed at establishing the biological value of enriched sugar.

4. Conclusions

A description of sugar enriched with derivatives of the processing of the fruits of wild plants is presented. It was established that the mass fraction of sucrose in enriched sugar is reduced compared to category 1 white sugar. In elderberry sugar, the mass fraction of sucrose decreases by 2.03 %, viburnum sugar by 1.34 %, sea buckthorn sugar by 4.94 %, mountain ash sugar by 3.06 %. Such changes are probably associated with the transition to osmotic, and accordingly to sugar, various substances contained in the cell juice of fruits (monosaccharides, organic acids, vitamins, minerals, etc.).

To ensure the quality and safety of sugar enriched with a derivative product of wild-grown raw materials (10 % by weight), an assessment of potential dangerous factors at all stages of production was carried out.

Based on this, the HACCP plan has been developed, which allows effective management of critical control points and evaluation of the results of this management. This will allow potential manufacturers to produce safe and competitive products of high quality.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other, that could affect the study and its results presented in this article.

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Data availability

The manuscript has no associated data.

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Use of artificial intelligence

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

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