APPLICATION OF THE PRINCIPLES OF INTERNATIONAL STANDARDS TO ENSURE QUALITY AND SAFETY IN THE DEVELOPMENT OF TECHNOLOGY OF BAKERY PRODUCTS OF INCREASED NUTRITIONAL VALUE

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Abstract

In order to manage quality and safety in the development of technology for new types of bakery products of increased nutritional value, the HACCP system was used.

Marketing research has shown that consumers would like to see more nutritious breads with natural additives on store shelves. Juniper (*Juniperucommunis L*) is one of the traditional crops growing in Kazakhstan and characterized by a high content of biologically active substances. In this regard, 3 % of crushed juniper fruits were added to the bread recipe.

In the course of research, a HACCP plan was developed for a new type of bread with increased nutritional value with the inclusion of juniper. As a result of the analysis of the bread production process, hazardous factors were identified and safety management measures were determined. Three critical control points were identified – during preparation (cleaning and grinding) of juniper fruits, during dough fermentation, and during storage of finished products. Once risk factors were identified, critical limits were identified, a monitoring procedure was established, and corrective actions were developed. The developed HACCP plan was tested at an enterprise for the production of bakery products, which led to an increase in the safety of products, and, accordingly, to an increase in its competitiveness in the consumer market of Kazakhstan.

Keywords: baked products, quality, safety, juniper, international standards, HACCP safety management plan, critical control point.

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1. Introduction

The problem of quality and safety of bakery products has always been and remains relevant. This is due to the fact that the reduction in consumption of many important types of food is offset by the consumption of bread and bakery products. So, it is this product that is included in the traditional diet of most of the inhabitants of our country. In this regard, the bakery industry is one of the strategic and socially significant sectors of the economy of Kazakhstan, with special attention paid to the quality and safety of products [1].

For this purpose, the international security system HACCP (Hazard Analysis and Critical Control Points) is used. This system covers all stages of the product life cycle, from the quality of

raw materials used to the moment a product is used by a consumer. In world practice, HACCP is recognized as the most effective system for ensuring food safety [2–4].

Ensuring food safety is associated with the absence of toxic, carcinogenic, mutagenic, allergenic or other adverse effects on the human body [5]. For this purpose, legislative acts and normative documents [6], which regulate the requirements for food products, the processes of their production, storage, transportation, and disposal,were developed.

Also, for the first time, a requirement was established that a manufacturer, when carrying out food production, is obliged to create, introduce and promote procedures, formed on the principles of HACCP [6].

On the basis of the Almaty Technological University, research was carried out to develop a new type of bread with increased nutritional value. According to the results of marketing research, it was revealed [7], that consumers would like to see on store shelves bread with a high content of nutrients and biologically active substances (BAS), enriched with natural additives traditional for Kazakhstan. Juniper is one of the traditional crops growing in Kazakhstan and characterized by a high content of biologically active substances.

Juniper fruits are rich in: essential oils (up to 2 %), the main components of which are terpenoids (α-pinene, cadinene, camphene, α-terpinene, dipentene, sabinene, borneol, isoborneol, α-fellandrene, juniper camphor, etc.), and also sugars (up to 40 %), resin (up to 10 %), organic acids (formic, acetic and malic), flavonoids, pectins (pentosans), vitamin C, dyes (uniperine), macro and microelements (manganese, iron, copper, aluminum, etc). The substance podophyllotoxin is isolated from the fruits of the juniper, which has a strong anticarcinogenic property. Juniper needles are characterized by a high content of vitamin C (up to 0.3 %), as well as terpenoids and phenolic resins. The bark contains essential oils (up to 0.5 %) and tannins (up to 8 %), while wood contains diterpene alcohols (ferruginol and sigiol) [8–10].A pleasant peculiar aroma, sweetish, spicy taste of juniper remains after drying. As a result, as well as because of the high content of biologically active substances, juniper is used to improve the quality of finished food products, namely, to improve organoleptic characteristics and extend the shelf life.

The aim of the research is to draw up a HACCP plan for an enterprise for the production of new types of bakery products of increased nutritional value with the inclusion of juniper.

To achieve this goal, the following tasks were completed:

– to determine critical control points (CCP) in the production of new bakery products, followed by an analysis of the bread production process, the identification of hazardous factors and the selection of measures for managing control points;

– development of a HACCP plan to ensure quality and safety in the production of bread with juniper.

2. Materials and methods

Bread containing juniper fruits (Juniperuscommunis L) was used as an object for the research. Common juniper fruits were preliminarily cleaned and crushed to a particle size of 1–2 mm. According to the pre-calculated recipe, all the prepared initial components (baking wheat flour of the 1st grade, crushed juniper fruits, drinking water, pressed yeast and table salt) were dosed. Next, the dough was prepared (kneaded), fermented, cut, finished, steamed and baked according to the standard method for the baking industry [11].

This study was carried out at the enterprise for the production of bakery products LLP “Almaty-Nan” (Kazakhstan). The HACCP plan was developed on the basis of the HACCP standards ISO 9001: 2015 and ISO 22000, as well as using the standards of the Republic of Kazakhstan ST RK 3.53-2004 “Quality management system. The procedure for certification of the quality management system based on the principles of risk analysis and critical control points (HACCP)”, ST RK 1179-2003 “Management system. Food quality management based on HACCP principles. General requirements”and ST RK ISO 22000-2019 “Food safety management systems. Requirements for all organizations in the food production and consumption chain”, which ensure the implementation of the HACCP plan at enterprises.

Drawing up a HACCP plan is based on the methodology of hazard analysis, determination and control of critical control points (CCP), implementation of a program of preventive measures (PPM) [11, 12].

3. Results and discussion

In accordance with the set task, the object of the research is the production of bread with juniper of increased nutritional value.

In the course of the research, we carried out the preliminary work on the development of a recipe for bread with the inclusion of 3.0 % of crushed juniper fruits [7]. The organoleptic analysis of the obtained samples revealed that the bread has a light brown hue, a somewhat convex top crust, without large cracks and tears, the crumb is not wet to the touch and elastic.

The taste and aroma of the bread is pleasant, there is a slight smack of juniper, which is due to its chemical composition, namely, the presence of aromatic and organic substances [13]. Technical specifications were developed for bread with the inclusion of 3 % juniper ST AO-990840000359-01-2020, which standardizes the requirements for organoleptic, physicochemical, microbiological indicators of new products. The requirements are presented in **Table 1.**

Table 1

The quality indicators of bread with the addition of 3 % juniper in accordance with ST AO-990840000359-01-2020

Indicator	Characteristic
Organoleptic indicators	
Outlook: form	Corresponds to the bread pan in which it was baked, with a convex upper crust
crust color	Light brown
surface	Without large cracks and tears
Crumble condition:	Uniform, well developed, without voids and seals
Knead	Without clots, well kneaded
Baking degree	Thoroughly baked, not wet to the touch, elastic
Taste	Inherent in this type of bread, with a juniper flavor
Smell	Inherent in this type of bread, with a juniper aroma
Physical-chemical parameters	
Crumble moisture, %, no more	43.0
Crumble acidity, degrees, no more	3.0
Crumble porosity, %, no less	68.0
Microbiological indicators	
QMAFAnM, CFU/g, no more	$5*10^3$
Mold, CFU/g, no more	50
Yeast, CFU/g, no more	0.1

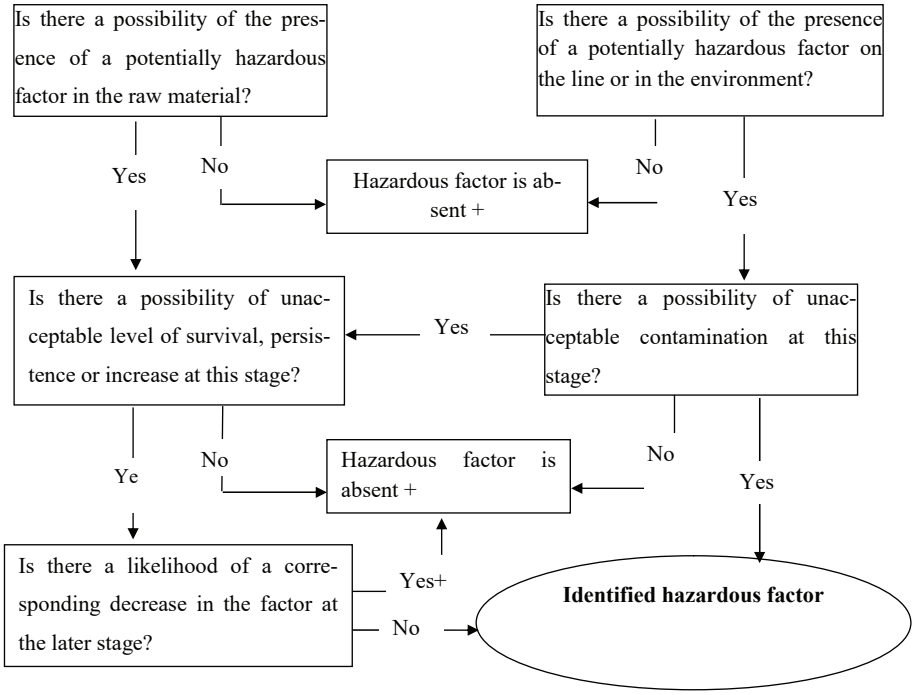
In accordance with the task at hand, according to the algorithm shown in **Fig. 1** [6] the presence of critical control points (CCP) in the production of new bakery products was determined. The use of the "Decision Tree" helped to establish CCP at every stage of production. For each CCP, a monitoring system was developed that allows for the planned procedure of observations and measurements, as well as timely detection of cases of violation of critical boundaries.

Hazard analysis involves consideration of the likelihood of factors occurrence and the severity of the concrete hazard [14]. If all the possible hazardous factors that arise are identified at all stages of the production technology, then in the future we determine the actions and procedures to prevent the occurrence of these hazards.

A HACCP plan should cover the following types of hazards: biological, chemical and physical [1, 6, 11].

Food products can be endangered by biological hazards, such as microorganisms that can be introduced with raw materials or during production from the external environment.

Along with biological factors in food production, it is important to identify chemical hazards. These are substances that can be naturally formed in the product (aflatoxins) or come from the external environment (pesticides, herbicides, veterinary drugs, mercury, arsenic, preservatives, etc.). Foreign objects in food (metal, glass, wood chips, etc.) that can harm the human body are classified as physically dangerous factors.



+ There is no hazardous factor that is controlled at this stage.

++ The stage of reducing the level of the hazardous factor becomes CCP.

Fig. 1. Decision tree for determining hazardous factors

All hazardous factors are controlled in accordance with the documents:

– the production program of mandatory preliminary measures (PPMPM) in order to prevent or reduce a significant danger, threatening food safety, to the acceptable level, allows to control the operation of technological equipment, purchased materials, measures to prevent rodents, insects, birds, animals from entering production facilities;

– the HACCP plan for each CCP, containing procedures for managing the relevant hazards using monitoring and corrective actions.

The results of the analysis of the production process of new bread, the establishment of hazardous factors and the choice of measures for the management of control points (CP) and CCP are given in **Table 2.** In accordance with the methodology for developing the HACCP plan [12], the following questions were posed:

1. Question 1 – are preventive actions against identified hazards taken?

2. Question 2 – is this stage decisive for eliminating a hazardous factor or reducing it to epy acceptable level?

3. Question 3 – can pollution with identified hazards occur in excess of the acceptable level, or can it increase to the unacceptable level?

4. Question 4 – will the next step eliminate the identified hazards or reduce the likelihood of their occurrence and the acceptable level?

The analysis revealed that the greatest number of hazardous factors in the production of bread with the addition of juniper is associated with biological factors, namely, the presence of microorganisms.

Based on the data of the analysis of the bread production process (**Table 2**), the need to identify three CCPs was established. The choice of CCT 1 when cleaning and grinding juniper fruits is due to the appearance of physical hazards, namely the presence of impurities, leaves and stems of juniper. The choice of CCT 2 during dough fermentation is due to the emergence of biological risks of the dough due to the appearance of biological risks that may arise due to a violation of time and temperature regimes during dough fermentation. This is because, compared to traditional production modes for wheat bread, the inclusion of juniper speeds up the fermentation process. Failure to follow the fermentation regimes can lead to a biological hazard. The choice of CCT 3 during storage of finished products is explained by the risk of premature staling and biological growth of microorganisms if the storage conditions and modes are not followed.

Table 2

The analysis of the production process of the new type of bread with juniper and the need to establish CCP

Operation name	Hazardous factor, danger	Question 1	Question2	Question 3	Question 4	CCP or prevention measures
Acceptance of raw materials (flour, juniper fruits, table salt, yeast, water)	Physical:presence of stones, waste products of rodents and insects, sand, glass, impurities	yes	no	no	–	CP PPMPM
	Biological: MAFAnM, E. COLI, Salmonella, Staphylococcusaureus, yeast, mold	yes	no	no	–	
	Chemical: Heavy metals. Remaining chemicals	yes	no	no	–	
Preparation and dosing of the raw materials	Physical: presence of impurities	yes	no	–	–	CT PPMPM
Cleaning and grinding of juniper	Physical: presence of impurities	yes	yes	no	–	**CCT 1** Plan HACCP
Preparation of dough	Physical: presence of side inclusions	yes	no	no	–	CT PPMPM
Fermentation of dough	Biological: MAFAnM, E. COLI, Salmonella, Staphylococcus aureus, yeast, mold	yes	yes	no	no	**CCT 2** Plan HACCP
Butchering	Physical: presence of impurities	yes	no	–	–	CT PPMPM
Keeping	Biological: MAFAnM, E. COLI, Salmonella, Staphylococcus aureus, yeast, mold	yes	no	–	–	CT PPMPM
Baking	Physical: presence of impurities	yes	no	–	–	CT PPMPM
Cooling	Biological: MAFAnM, E. COLI, Salmonella, Staphylococcus aureus, yeast, mold	yes	no	–	–	CT PPMPM
Packing and labeling	Physical: presence of side inclusions	yes	no	–	–	CTPPMPM
Storage	Chemical: Remaining chemicals	yes	no	–	–	**CCT 3** Plan HACCP
	Biological: MAFAnM, E. COLI, Salmonella, Staphylococcus aureus, yeast, mold	yes	no	yes	no	

The following measures were used as controlled ones: for CCT No. 1 – checking sieves and magnets for the presence of impurities; for CCT No. 2 – checking the time and temperature modes of dough fermentation; for CCT No. 3 – checking the conditions and terms of storage of finished products in the warehouse. Data on the results of monitoring CCP should be recorded in control logs (records).

Establishing critical limits is necessary to determine the specific numerical values that must be controlled to prevent food contamination. A step-by-step block diagram of the technological process of bread production with the inclusion of 3 % juniper with the designation of the established measures for the management of the CCP is shown in **Fig. 2**. The purpose of constructing this technological scheme is to create a clear sequence of operations, including all stages of the

technological process (from the receipt of raw materials to the delivery of finished products and their sale to the consumer).

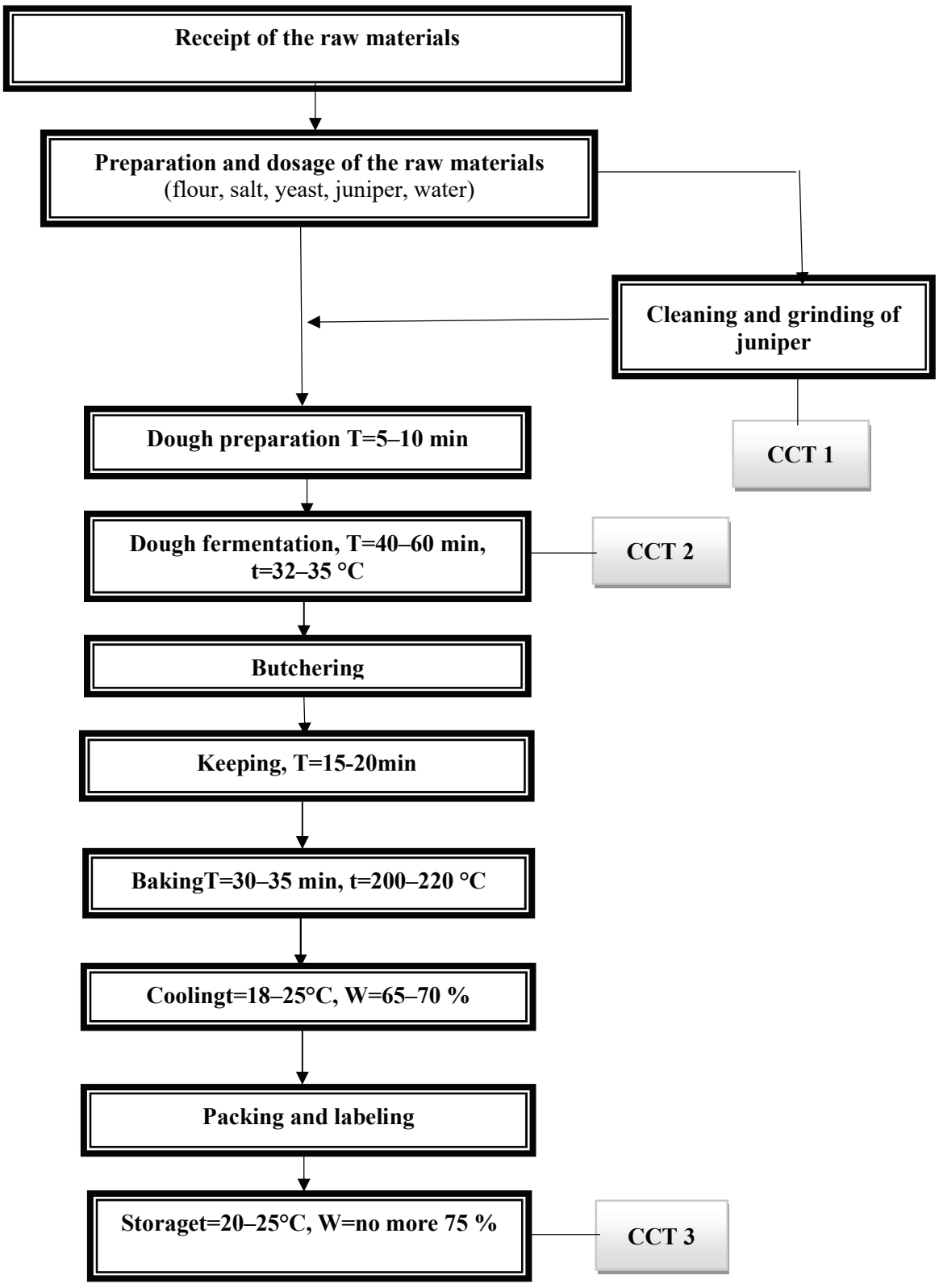


Fig. 2. Block-scheme of the technological process for the production of bread with juniper

After identifying risk factors, determining critical limits and establishing a monitoring procedure, as well as developing corrective actions, the HACCP plan was developed for the production of bread with juniper (**Table 3**).

Table 3
The juniper Bread Safety Management Plan (HACCP Plan)

No.	Product, process, operation	Controlled parameter	Limit values	Monitoring methods			Corrections and correcting actions	
				Monitoring procedure and periodicity	Responsible person	Fixing document	Procedure	Procedure for assessing the monitoring effectiveness
1	Cleaning and grinding of juniper	Presence of impurities	no	Each batch visually and by a metal detector	Head of a shift	Control log	Repeated visual check	At internal audit
2	Fermentation	time temperature	40–60 min 32–35 °C	Visually by the device Each batch	Technologist	Control log for technological parameters	Rejection Equipment regulation	At internal audit
3	Storage	Temperature Relative air humidity	20–25 °C, no more 75 %	Visually by the device twice a shift	Head of a shift	Control log for technological parameters	Rejection Restoration of temperature and humidity modes	At internal audit

The presented HACCP plan is advisable to apply in the production of bread with the inclusion of juniper. Together with PPMPM, this plan helps to ensure that the risks of product hazards are eliminated or reduced to the acceptable level in order to produce high quality products.

Based on the results of the HACCP plan (**Table 3**), the periodicity and order of monitoring for the main processes of obtaining bread were established, which indicates the controllability of managing actions. The established procedure ensures the timely determination of the excess of the permissible limits, which ensures the possibility of preventing the product from reaching its final consumer.

Planned corrections and corrective actions for CT are specified in the HACCP plan. The implementation of the developed plan requires the participation of all personnel, involved in all stages of bread production.

In addition, a logical and proven HACCP plan helps food operators improve their food safety management [14]. Our proposed HACCP plan was tested at the Almaty-Nan LLP (Kazakhstan), an enterprise for the production of bakery products, which led to an increase in the safety of the products, and, accordingly, to an increase in its competitiveness in the consumer market of Kazakhstan.

4. Conclusion

In the course of the studies carried out, a HACCP plan was developed for a new technology for the production of bread with increased nutritional value with the inclusion of juniper. As a result of the analysis of the bread production process, hazardous factors were identified, three critical control points (CCP) were established and safety management measures were determined. Once risk factors were identified, critical limits and monitoring procedures were established, and corrective actions were developed.

The advantage of the developed HACCP plan is to ensure the safety of the production of bread with the addition of natural supplements at the entire stage of its life cycle from the raw material to the consumer. The proposed quality and safety management system can be used in the production of bakery products of increased nutritional value with the inclusion of natural improving supplements, taking into account additional CCP.

The prospect of further research is to study the storage process and to establish the guaranteed shelf life for a new type of bread.

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