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DETERMINING CRITICAL CONTROL POINTS FOR PROCESSING MELON FRUITS

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To properly ensure the quality of products from melon fruits, it is necessary to develop a production technology with the introduction of the HACCP (Hazard Analysis and Critical Control Points) system. Methods for prolonging the shelf life of freshly cut melon have been considered in this paper. The stages of processing technology and risks were considered; methods for improving the quality of melon processing products have been proposed.

The objects of this study were melon fruits. Melon is a low-calorie fragrant fruit, with juicy pulp and thin skin; it is a seasonal product. Consequently, its shelf life is short. Due to its juiciness, melon perfectly quenches thirst, supports work of the nervous system.

A study has been conducted to determine the level of microbial contamination and establish critical control points associated with melon processing. Samples were collected in the Southern regions of the Republic of Kazakhstan. Selected samples of melons were subjected to microbiological analysis. Microbiological parameters are affected by the temperature and duration of treatment. Thus, it is determined that when processing melon without refrigeration, it is not possible to save the product. A condition for the storage of the product is the pre-cooling of melon fruits before processing to refrigeration temperature.

The results were used to assess the relevant critical control points, in relation to raw materials, contamination, process requirements and contact of ingredients with equipment. The observed contaminants common to all specimens and regardless of producers were staphylococci aureus, Salmonella spp, Bacillus spp. and Aspergillus fumigatus. The study has found that the monitoring and control of critical control points (CCP) ensures the quality of melon products. The measures taken were effective; based on the studies carried out, a technological scheme for processing melon fruits was developed.

A relevant issue is to ensure the availability of melon products all year round; ensuring the safety of these products is the most important task and the goal of the study. The most important risk to human health when eating melon and processed products from it is poisoning caused by microorganisms, therefore, the greatest risk is microbiological contamination of fruits during processing. The results can be used in the production of long-term storage products from melon fruits, to better ensure the quality and safety of the finished product and are recommended in canning and juice production

Keywords: control critical points, melon microbiology, processing technology, heat treatment of melon, HACCP

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1. Introduction

Melon, being a valuable food product, while also having medicinal properties, can be used as a raw material for the preparation of various meals and semi-finished products. With food, significant amounts of substances that are dangerous to the health can enter the human body. Therefore, there are acute problems associated with increasing responsibility for the effectiveness and objectivity of food quality control, which guarantee their safety for the health of the consumer. Food producers, regardless of the stage of the food chain in which they operate, are fully responsible for the quality and safety of food products produced and supplied by them to the consumer market [1]. When changes are made to a product, process, or one of the stages of production, food industry enterprises revise the HACCP system and make the necessary adjustments to it. Some enterprises, when implementing systems such as HACCP, most often implement it only at the level of documentation of this system, forgetting about the scientific approach, actual monitoring, and information collection for further adjustment of measures. The latest version of ISO 22 000:2018 encourages businesses to take a scientific approach. Parameter limits should be set and observed to confirm that the critical control point is under control. Determining the critical limit to which a biological, chemical, or physical parameter in CCP must meet to prevent, eliminate, or reduce the hazard to food to an acceptable level. The result is this: a measurable value that separates acceptability from unacceptability, with the following notes: critical limits are set to determine whether a critical checkpoint remains under control (within a valid range of values). If the critical limit is exceeded or does not meet the norm, products that are affected as a result should be considered potentially unsafe [2].

For all CCPs, critical limits can be set for one or more parameters. As a rule, such parameters in the processing of plant raw materials are time, temperature, pH, humidity, acidity, etc. In the literature on the production of long-term storage products from melon, generalized critical limits are usually given for PDA "heat treatment (danger: the development of Rhizopus sp., Penicillium sp. etc.)" – the temperature inside the pieces is not lower than 90–95 °C. Of course, it is easy to measure the temperature in the center of the pieces and in the syrup using measuring equipment (thermocouples, etc.) but questions remain, since there are cases when microorganisms at 90–95 °C turned into spore species and led to spoilage of the canned product. That is, there are not enough theoretical official data on the parameters that would make it possible to kickstart further research and other studies.

Food production requires the use of mathematical equations and statistics to predict the behavior of intermediate production processes over time. Many of these modeling techniques could be transferred to food [3]. The development of a quality control system requires the study and research of food products. For this purpose, chemical, physical, and microbiological methods of control are widely used.

A relevant issue is the development of technology for processing melon fruits, which ensures the safety of finished products. Detection of CCTs will make it possible to prevent the risk of obtaining inappropriate products, thereby controlling risks and taking measures will ensure that a safe and useful product is produced. Melons are not processed on an industrial scale and remain in the fields; the processing of such fruits can increase economic performance and give access to vitamins and nutrients to the population all year round.

2. Literature review and problem statement

Melon is one of the widespread representatives of melon crops. The pulp of melon contains sugar (as a rule, up to 16–18 % but there are also up to 20 %), vitamin B9, P, C, carotene, provitamin A, the large quantities of folic acid and iron, fats, pectin substances, mineral salts. The pulp and seeds of melon contain oil (39–52 %), which is suitable for use in food. In addition, melon has a beneficial effect on the digestive process. The folic acid contained in the fruit contributes to hematopoiesis [4].

However, melons are also associated with frequent poisoning. Food poisoning due to consumption of fresh fruit contaminated with bacteria raises concerns about food safety. Several researchers have documented cases of foodborne illness associated with the consumption of fresh fruits and vegetables [3, 4] that point to the need to develop microbiological control measures for a specific product and technology. Most often, the diagnosis of salmonellosis and listeriosis is reported. These diseases have their consequences. The solution would be hygiene, compliance with the rules for storing freshly chopped pieces of melon at home. The cause of poisoning can be microbiological contamination and infection during cutting and processing. In addition, the reasons for the rapid spoilage of fruits can be the content of nitrites and nitrates in the fruits of melon.

Biological hazards include harmful bacteria, viruses, and parasites (*Salmonella*, BGKP). Paper [5] confirmed that *Salmonella* can grow rapidly and reach high concentrations when stored in cut melon at room temperature, with no visible signs of spoilage.

According to [6], the cause of bacterial contamination of melon surfaces is mainly due to frequent contact with soil, insects, animals, or people during cultivation or harvesting, as well as in processing plants. The solution would be to control the acceptance of fruits into retail chains, in accordance with regulatory documents and ensure proper storage of fruits. The authors of work [7] on the development of juice technology based on melon offer a technology for processing and obtaining melon juice, a comprehensive waste-free technology, without considering shelf life and safety.

The results of study [8] proved the importance of the initial microflora, the treatment of the surface of the melon with hydrogen peroxide, and the immediate cooling of the products. Although this does not exclude re-infection if one does not follow the requirements of hygiene in workplace.

Paper [9] analyzed the use of natural antimicrobial drugs – olive extract, oregano oil; the authors identified the potential of using these drugs to inactivate *Salmonella* and *L. monocytogenes*. However, the effect on the microflora differed in the regions of the United States where melon was grown, which indicates the need for additional investigations on the treatment of the surface of the fruit. Fresh sliced pieces made from melons and directly inoculated with *L. monocytogenes* (3.48 log CFU/g) were stored under the same conditions listed above. Populations of *L. monocytogenes* and five classes of native microflora were studied. The results of that study show that the native microflora of whole melon inhibits attachment to the surface of the crust, as well as the survival and growth of *L. monocytogenes* on the surface of melon and homogenized freshly cut pieces. Thus, *L. monocytogenes* re-infection of melons with reduced levels of native microflora after disinfection treatment can be a food safety problem.

Paper [10] proposes steam treatment for 180 seconds when processing freshly cut pieces of melon in order to exclude the likelihood of developing microbiological contamination. Whole melons were inoculated with 10^7 CFU/ml Salmonella, Escherichia coliO157:H7, and Listeria monocytogenes to achieve 4.8; 4.5; and 4.1 log CFU/cm^2, respectively, on the surface of the melon. Inoculated melons were steamed for 180 seconds before cooking the freshly cut pieces. Microbial safety was studied, and the overall appearance and acceptability of freshly cut pieces were investigated by trained experts. All treated melon surfaces immediately after treatment and during storage showed no visual signs of physical damage. All freshly cut pieces of treated melons were found to be negative for bacterial pathogens while aerobic mesophilic bacteria were isolated. The appearance and overall acceptability of freshly cut pieces of processed melons for 6 days at 5 °C differed slightly ($p<0.05$) from control pieces prepared from fresh melons but they differed significantly ($p<0.05$) from unprocessed pieces from day 0 under the same storage conditions for 14 days.

The effect of malic acid and essential oils (EO) of cinnamon, palmaris, and lemongrass and their main active compounds as natural antimicrobial substances included in the food coating based on alginate, on the shelf life and safety of freshly cut melon "Piel de Sapo" (Cucumis melo *L.*) was investigated in work [11].

The effect of the calcium treatment temperature on cut melon fruits during storage has been determined. Fruits soaked in calcium solution at 4°C had lower respiration rates and moisture loss than processed fruits at ambient temperature [12].

When processing melon fruits, an important stage is the washing of fruits. In this regard, it is worth mentioning the results of the studies reported in work [8], where the use of hydrogen peroxide for the treatment of melon is proposed. Hydrogen peroxide was used alone (2.5 %) or in combination (1 %) with nisin (25 μg/ml), sodium lactate (1 %), and citric acid (0.5 %) (HPLNC). The natural microflora of freshly cut melons was also significantly reduced by the treatment of whole melons by HPLNC. The results show that HPLNC can be used to disinfect the entire surface of melon and thus improve the microbial safety and quality of freshly cut melons. The number of both pathogens decreased by 3–4 log CFU/cm^2 on both types of whole melon. The study also showed that the natural microflora of the whole melon surface inhibits the growth of bacteria, and it is sufficient to use hot water to treat the surface of melons to exclude contamination. There would be no re-contamination [13].

Malic acid was found to be effective in increasing the shelf life, microbiologically estimated, to 9.6 days and physicochemical evaluation to 14 days compared to an uncoated sample. Adding essential oils and malic acid together increased the shelf life to 21 days, however, some characteristics such as hardness and color were affected. Palmarosa essential oil at a concentration of 0.3 % was well received by panelists and also maintained fruit quality as it inhibited the growth of native flora and reduced the population of *Salmonella enteritidis*. According to the literature [11, 14–18], essential oils derived from spices and aromatic plants have antimicrobial activity against *Listeria monocytogenesis*, *Salmonella typhimurium*, *Escherichia coli*, *Shigella dysenteriae*, *Bacilus cereus,* and *Staphylococcus aureus*.

The effect of calcium lactate treatment associated with low temperature (4 °C) on freshly processed melon is described in [19]. Pieces immersed in a calcium solution at 4 °C had a lower respiratory rate and less moisture loss than products treated at 25 °C. The effect of calcium chloride, calcium lactate, and calcium propionate (0.5 and 1 % at 60 °C) in minimally treated melon cell tissue. With such treatment, stabilization of hardness was observed, which occurs due to the activation of the enzyme pectin methyl esterase and the presence of calcium. Both lactate and calcium chloride maintained the integrity of the cell wall. Treatment with propionate and control provided less tissue elasticity [20].

The approach to preventing enzymatic darkening is divided into physical and chemical methods. Physical methods for regulating enzymatic darkening include heat treatment, preventing exposure to oxygen, using low temperature, and irradiation. Heat treatment, such as blanching, can easily suppress enzymatic activity as enzymes made up of proteins are denatured. When blanching is not possible, the darkening reaction can be suppressed by removing oxygen. Replacing air with an inert gas (N_2 and CO_2), using impermeable packaging films, edible coating, and immersing food in sugar are used to avoid contact with oxygen. Chemical methods to inhibit PPO activity include acidification or reduction using antioxidants, chelating agents, or natural extracts Antioxidants can react with oxygen, inhibiting the onset of browning.

They are also able to react with intermediate products, thereby disrupting the chain reaction and inhibiting the formation of melanin [21].

Thus, research is needed to develop a technology for processing melon fruits into safe products using HACCP. The development of processing technology using HACCP will make it possible to eliminate problems such as contamination of products, spoilage, darkening, etc. Melon products should be checked for nitrite content, first of all, before acceptance and then accepted for processing, however, there is a problem of identifying CCPs during melon processing. By developing a HACCP plan and introducing it into production, while complying with all regulations and monitoring, such issues can be avoided.

3. The aim and objectives of the study

The purpose of this study is to determine CCPs in the processing of melon fruits, which enables the production of a safe food product. This will make it possible to determine the risks of infection and, when monitoring CCPs, to reduce the risks of contamination of products during the processing of melon.

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

– to analyze the microflora of melon fruits at all processing processes;

– to identify risks in the processing of melon fruits;

– to determine CCPs in the processing of melon fruits and devise corrective actions.

4. The study materials and methods

The object of this study is two critical control points for the production of food from melon, which, in turn, affect the indicator of microbiological quality and safety of finished products.

The subject of the study is microbiological seeding in the processing of melon fruits.

The working hypothesis of the study assumes that determining the influence of the technique for washing fruits, thermal preparation, and processing of fruits on the microbiological purity of the finished product can reduce the risks of contamination of products during the processing of melon.

Raw materials: melons (*Cucumis melon*) of the 'Torpedo' variety were grown in the south of Republic of Kazakhstan where there is enough light and heat. The average weight of the fruit was 4,225 kg (pulp – 62.6 %; peel – 31.24 %; placenta – 4.97 %; seeds – 1.18 %). Melon fruits (whole) were washed with water, cleaned from the peel and seeds. After cutting, part of the slices was put immediately in the refrigerator (5±1 °C), some were aged for 3 hours and then put in the refrigerator. Active acidity was determined using the pH-meter testo 206-pH2.

Microbiological analysis: the total number of plates and yeast was determined at each stage of processing: production, washing, cleaning, cutting, processing, and in the finished product (jam). This has been done twice: first, in traditional processing, where the fruit was processed immediately after being received from the field, and second, in the treatment after the introduction of additional steps to control safety. These steps include cooling the melon before processing, washing in hot water, adding sugar, and heat treatment followed by rapid cooling. The total number of microorganisms on the plates was estimated in accordance with ISO 4833-1:2014 "Microbiology of the food chain" – Horizontal method of counting microorganisms. The yeast was determined according to the method described in ISO 21527-2:2088 Microbiology of Food and Animal Feed – A horizontal method for counting yeast and mold. Microbiological data were expressed as a logarithm of the number of colony-forming units per gram of the sample (log CFU/g).

Sliced melon slices were divided into 2 groups. The part was stored at room temperature of 24±1 °C, the second part was stored at 4±2 °C. Every 2 hours, samples were taken from both groups (room and refrigeration temperature) and sent for analysis of the total number of microorganisms. Data processing was carried out by regression analysis using Statistica 12.0 software (USA). As the main factors affecting the storage capacity of the slices before processing, the storage temperature (T, °C corresponds to the input variable x) and the duration of storage (t, h – corresponds to the input variable y) were selected. The total number of microorganisms (KOE) is accepted as the output variable. The choice of intervals for changing factors is due to the technological conditions of the process. Table 1 gives values of the input variables in their natural form.

Table 1

Experiment planning matrix

Planning conditions	Limits of factors change	
	T, °C	t, h
Lower level	4	0
Upper level	24	6
Variation interval	10	3

Hazard analysis of melon processing operations: a review of the scientific literature was conducted to study the hazards at each stage of production. Chemical hazards refer to substances that can cause danger immediately or after a certain period of time. They can form naturally in the product or come from outside during processing.

Next, each stage of production is analyzed and investigated. Stages of production at which the degree of risk is recognized as high are recognized as critical control points. Determining them should minimize the possibility of hazards in food production, eliminate them, or reduce them to an acceptable level. On the basis of experimental and theoretical studies, critical control points have been identified.

Statistical analysis: the results obtained from the microbiological analysis of the product after each processing step were statistically analyzed using the Statistica 12.0 software employing analysis of variance (ANOVA) and the t-criterion with 95 % confidence.

With improper use of melon fruits, there are cases of poisoning. Therefore, an important problem is to comply with the rules of consumption and ensure the correct storage conditions for whole fruits, freshly cut pieces, and products of melon processing. With the help of a mathematical model, the critical limits of critical control points (CCPs) have been determined – in the processes of cutting and cooling melon slices. Continuous monitoring measures have been identified for the two CCTs and critical limits have been developed. Thus, the presentation of the results of the development of critical control limits and critical points of production of long-term storage products from melon fruits using mathematical modeling is a theoretical beginning of further research.

5. Results of the study of melon processing processes

5. 1. Analysis of melon microflora

The results of the analysis are given in Table 2.

Table 2

Average number of aerobic bacteria CFU/g and the number of fungi during cooking

Technological operations	Total number of plates, log CFU/g	Yeast, log CFU/g
Acceptance	4.65±0.02[c]	2.60±0.02[b]
Washing	4.78±0.01[b]	2.69±0.02[ab]
Cleaning	4.85±0.02[a]	2.69±0.02[ab]
Cutting	4.87±0.01[a]	2.80±0.01[a]
Treatment	2.34±0.05[e]	1.67±0.02[c]
Final product	2.54±0.04[d]	1.75±0.09[c]

Note: The data are the mean ± standard deviation (n=3). Different superscript letters in the same column indicate significant differences at p<0.05, t-criterion

Immediately after cutting, the pH values of the melon averaged 6.2 and no significant changes were observed under different storage conditions. No significant (p>0.05) changes in pH were observed during refrigeration storage. At the same time, populations of aerobic mesophilic bacteria increased during this waiting period and were significantly higher (p<0.05) than the values in pieces that were placed immediately in the refrigerator. Samples that were aged for three hours, and then placed in the refrigerator, thermostated, were used to determine the number of anaerobic bacteria. The results showed that there were no significant (p>0.05) changes in the population in the samples. As shown in Fig. 1, the growth of bacteria is associated with the temperature and duration of storage of melon slices by a linear relationship.

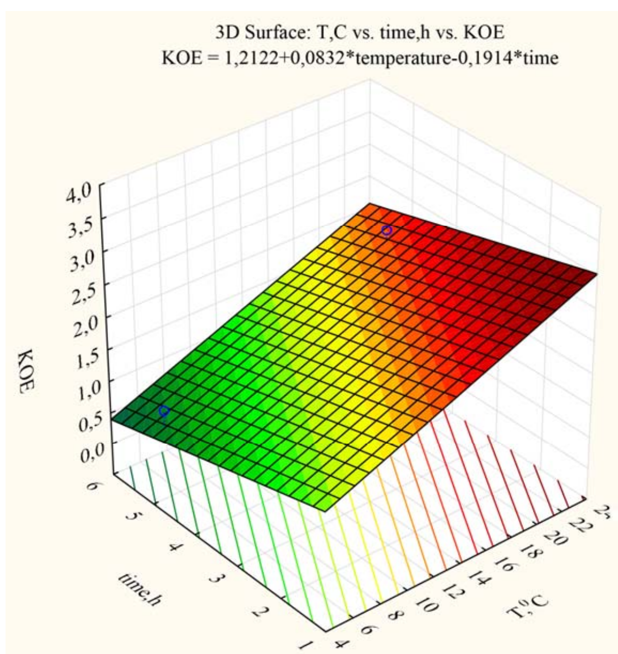

Fig. 1. Response surface of this experiment

Since the revealed dependence is linear, when processing melon fruits, it is not recommended to cut freshly harvested fruits immediately at room temperature. It is recommended before processing the fruits, to place them in refrigeration storage to a temperature in the thickness of the melon up to 5 °C, and only after that to carry out further processing. This measure will reduce the contamination of fruits before the start of processing.

5. 2. Identification of risks in the processing of melon fruits

In accordance with the requirements of sanitary-hygienic and other regulatory documents, Table 3 contains a list of potentially dangerous factors in the production under consideration.

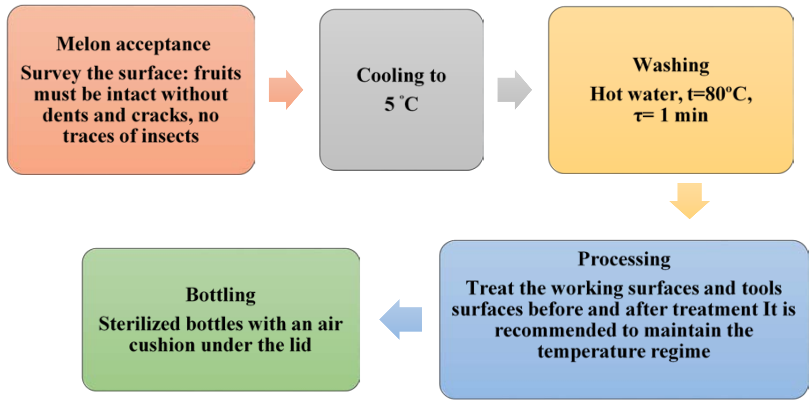

Fig. 2. Diagram of risks in melon processing processes and measures taken

Table 3

Potentially dangerous factors in the processing of melon fruits into food

Production stage	Risk	Risk degree
Acceptance of raw materials	– non-compliance with the norms of transportation of raw materials, improper condition of transport (dirt, smell); – contamination with microtoxins, heavy metals, pesticides, nitrates, etc.; – spoilage of raw materials, poor appearance, smell, violation of the integrity of the fruit	Not high
Weighing raw materials	– contamination of raw materials due to non-compliance with the standards of the conveyor, scales; – non-observance of hygiene by workers carrying out weighing	Not high
Storage of raw materials	– dirty warehouses, dusty air; – the presence of rodents, mice, insects in warehouses; – unfavorable indicators of humidity, temperature in places of storage of raw materials	Not high
Loading raw materials	– contamination during loading; – damage to the integrity of the fetus	High
Cleaning of peel and seeds	– contamination of the pulp, the transition of bacteria from the surface of the peel into the pulp; – dirty surfaces of tools; – air pollution in the working area; – poor water quality during washing	High
Heat treatment	– insufficiency of the mode for removal of bacteria	High
Storage of finished products	– non-compliance with temperature regimes	High

When analyzing the literature [6–10], characteristic types of hazards for processing melon fruits were revealed, which are given in Table 3. The average number of aerobic bacteria CFU/g and the number of fungi obtained during processing are summarized in Table 4.

In addition, according to the microflora of the melon pulp, it is clear that some bacteria are not amenable to heat treatment, therefore, it is necessary to carry out combined temperature treatment, cooling, heating, and sharp cooling to stop the growth of bacteria. A diagram of the recommendation is shown in Fig. 2.

The diagram describes the corrective actions required during heat treatment to stop the growth of bacteria.

Table 4

Types of microbiological hazards found in melon processing products

No. of entry	Name of the hazard	Brief description
1	Salmonella	Pathogenic microorganisms. An indirect indicator of the presence of gram-negative bacteria. Cause of salmenella
2	Shigella	Pathogenic microorganisms. Cause of dysentery
3	Bacilli	Cause damage to raw materials, auxiliary materials, finished products, forming an unpleasant odor

5. 3. Identification and justification of control critical points

At each stage, the effectiveness of CCP control measures was checked. In the course of CCP studies, corrective actions were carried out, as a result of which, due to pre-cooling, the growth of bacteria was stopped. Thus, with the relevant processing of melons from the fields, there is an increase in bacteria, yeast, and mold in the finished product on the first day. There is a bulging of products. In this regard, CCPs at the acceptance stage were considered, it is recommended to necessarily cool the fruits before processing to 5 °C. This will reduce the growth of bacteria and fungi.

The results of our study show that for the surface of the fruits of whole melon it is enough to wash it with warm water before processing.

In general, the population of *L. monocytogenes* is reduced on the surface of treated and unprocessed whole melons and on freshly cut pieces for 15 days of storage at checked temperatures.

Based on the above review of literature on the surface treatment of melons, the question of the adequacy of treatment when washing the surface of melons was considered. It turned out that no pathogens were found on the peel of melons from the fields after washing in chlorinated water. This made it possible to exclude CCPs when treating the surface of the melon with chlorinated water. In addition, the room before storing the fruits was treated with bactericidal lamps, after washing and drying the floors.

The next step was to clean the melon fruit from the peel and seeds. The study showed that the most dangerous is this process because the pulp of the melon comes into contact with the equipment and personnel. The greatest probability of seeding of the product was revealed at this stage. The greatest growth of bacteria was detected on semi-finished products of freshly cut melons. On pieces of melons, processed and cooled, the growth of bacteria decreased. It was also found that during heat treatment, pieces of freshly cut and not cooled melons have the resistance of bacteria to heat treatment, pieces of melons cooled to heat treatment showed the best result, molds and yeast were not detected.

After heat treatment and bottling in sterilized cups, the growth of bacteria resumed and the products bulged. In order to improve the processing technology, it was decided to introduce natural preservatives into the product.

Therefore, as a recommendation, the need to comply with the developed technology when processing melon fruits into any kind of products should be highlighted. A diagram of the technology is shown below in Fig. 3.

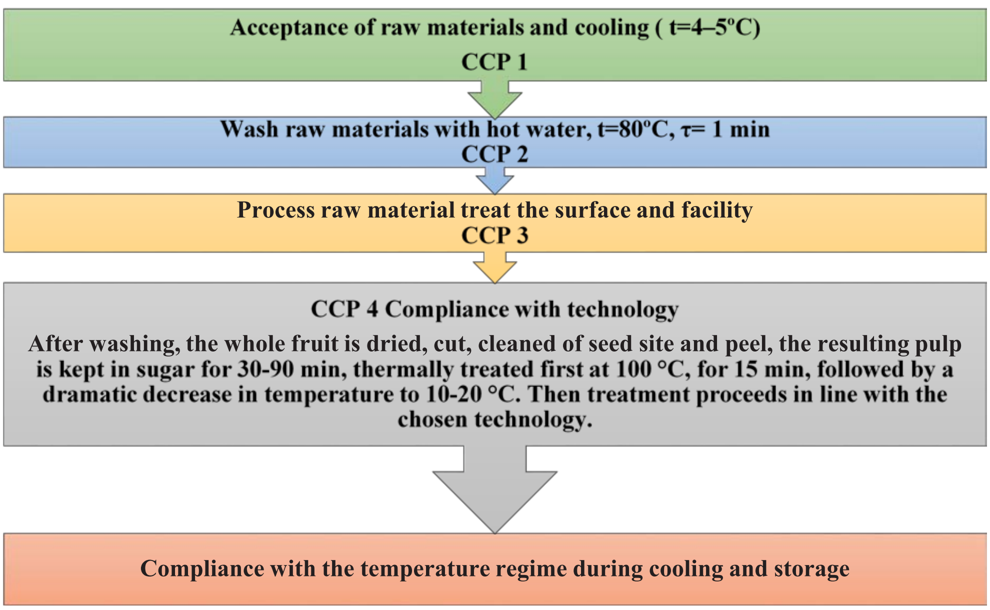

Fig. 3. Critical Point Control (CCP) technology diagram

The change in microflora after the introduction of control critical points (CCP) and their monitoring is given in Table 5.

Table 5

Average number of aerobic bacteria CFU/g and the number of fungi obtained during cooking (after measures taken)

Technological operations	Total number of plates, log CFU/g	Yeast, log CFU/g
Acceptance	4.65 ± 0.02^{a}	2.60 ± 0.02^{a}
Washing	4.59 ± 0.08^{ab}	2.51 ± 0.09^{ab}
Cleaning	4.53 ± 0.04^{b}	2.55 ± 0.05^{a}
Cutting	4.48 ± 0.06^{b}	2.51 ± 0.03^{b}
Treatment	1.40 ± 0.35^{c}	ND
Resulting product	ND	ND

Note: The data are the mean ± standard deviation (n=3). Different superscript letters in the same column indicate significant differences at p<0.05, t-criterion. ND – below the detection limit

Table 5 demonstrates that according to the results of the measures taken, the number and growth of bacteria are declining, yeast and mold were not found in the finished product.

Chilled and prepared melon fruits (whole) were washed with hot water, cleaned of the peel and seeds. Before the fruit was cleaned, all working surfaces and tools were treated. The room is treated with bactericidal lamps. At the same time, populations of aerobic mesophilic bacteria during this waiting period were significantly ($p<0.05$) lower than values in pieces that were not properly prepared. During processing, the content of bacteria and mold was minimized. In the finished product, no population was detected on day 2.

6. Discussion of results of studying the development of technology for obtaining safe products from melon

Fig. 1 illustrates that the microbiological parameters are affected by temperature and duration. Thus, it was determined that when processing melon without refrigeration, it is not possible to save the product. A condition for the storage of the product is the pre-cooling of melon fruits before processing to refrigeration temperature.

Based on the data given in Table 2, the risk of contamination is very high at all stages of processing but especially when slicing and peeling the flesh from the peel and seeds. Table 3 provides information on the identified pathogenic microorganisms. Thus, it is obtained that most often the raw material is infected with bacilli, shigella. Since losses of vitamin C and minor losses of folic acid were found after heat treatment, it was decided to add ascorbic acid. Ascorbic acid is widely used as an anti-darkening agent. The mechanism underlying ascorbic acid's activity against darkening appears to be based on its reducing activity. Although ascorbic acid does not interact directly with the PPO enzyme, it inhibits enzymatic darkening by reducing oxidized substrates [22].

Table 5 demonstrates that according to the results of the measures taken, the number and growth of bacteria are declining, yeast and mold were not found in the finished product.

Our results can be used in the production of long-term storage products from melon fruits, to better ensure the quality and safety of the final product. The practical application of the results is limited to the research method (express methods for identifying pathogenic microflora are needed). In this study, we considered only the preparation for processing into any products, in the future it is planned to identify the risks for each type of product taking into consideration the storage process. Therefore, the expedient further development of the current study is the development of technology for each type of finished melon product.

7. Conclusions

1. When searching for hazardous factors at each stage of food production from melon, a microbiological analysis was carried out, which showed a high growth of aerobic bacteria CFU/g and the number of fungi. Thus, when cutting, the number of aerobic bacteria reaches an average of $7.4*10^4$ CFU/g and, when cleaning, $7.1*10^4$ CFU/g. 4 CCPs were detected, while the most dangerous is the process of processing (cleaning, cutting) during heat treatment, the amount decreases, but spores are formed, which further lead to the bulging of products, therefore, CCP1 is no less important.

2. To determine the hazards in the production of food from melon fruits, microbiological hazards are recognized. Most melon foods are subject to factors such as infection with pathogenic microflora: bacilli, shigella, salmonella.

3. In determining control critical points and their monitoring, the acceptance of raw materials is recognized as a preventive action. Rule 1, developed during the development of technology for processing melon fruits, states that the fruits must be accepted in accordance with regulatory documents and must correspond in quality (compliance with the level of nitrites according to GOST, without damage, dents, with a dry surface, etc.). Rule 2 – after accepting the fruits, cool whole melons to 4–5 °C.

CCP 1 – monitoring the integrity and temperature of the fruit before processing. Control measure: temperature measurement before processing. This measure reduces seeding and reduces the risk of spore formation during heat treatment.

CCP 2 – processing, wash with hot water. Control measure. Water temperature. This measure reduces the risk of pathogens moving from the melon peel during further processing.

CCP 3 – before processing, clean and irradiate all surfaces and equipment. The measure will reduce the risk of contamination during cleaning and slicing. The number of fungi and anaerobic bacteria is reduced by almost 2 times.

CCP 4 – if the technological regimes are observed, there is a sharp decline in the number of bacteria and fungi. Control measure: control active acidity, temperature regimes, microbiological analysis.

After microbiological analysis at each stage, a clean and safe product was obtained under the observance and control of each point.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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