Стаття присвячена комплексному дослідженню раціональних режимів низькотемпературного зберігання та отримання продуктів переробки айви японської з високими споживними показниками шляхом дослідження кінетики заморожування та вивчення мікробіологічних показників зразків.

Проведено дослідження поведінки представницької частини айви японської в процесі низькотемпературного зберігання. Встановлено, що зі збільшенням циклів заморожування-центрифугування спостерігається збільшення маси рідкої частини і зменшення маси твердої частини.

Проведено кріоскопічні дослідження продуктів переробки айви японської за допомогою низькотемпературного калориметра, який дозволяв регулювати температуру та швидкість заморожування, а також безперервно реєструвати температуру зразків. Встановлено, що масова частка виморожененої вологи збільшується від 84,8 % до 87,0 % для рідкої частини, від 63,7 % до 64,9 % – для твердої частини.

Кількісно визначено перший та другий діапазони температур кристалізації та плавлення вимороженої вологи в продуктах переробки айви японської. Відмічено, що заморожування при мінус 20±2 °С сприяє повному консервуванню продукції.

Проведено дослідження змін мікробіологічних показників якості та безпечності продуктів переробки айви японської впродовж 270 діб зберігання за температури –18±2 °С. Визначено, що кількість МАФАнМ, дріжджів та плісеневих грибів не перевищує вимог ДСТУ 6029:2008 «Напівфабрикати фруктові та ягідні (подрібнені та пюреподібні) швидкозаморожені». Отримані дані свідчать про безпечність споживання даних продуктів протягом усього строку зберігання.

Отримані дані дозволяють обґрунтовано визначати оптимальні режими низькотемпературного зберігання продуктів переробки айви японської та отримати певні ефекти від впровадження у виробництво. Це дасть можливість розширювати асортимент замороженої продукції

Ключові слова: айва японська, заморожена продукція, кінетика заморожування, дефростація, мікробіологічні показники

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DETERMINING THE RATIONAL MODES FOR LOW-TEMPERATURE STORAGE AND FOR OBTAINING PRODUCTS OF JAPANESE QUINCE PROCESSING WITH HIGH CONSUMER PROPERTIES

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1. Introduction

The issue of enrichment of food products with natural ingredients is relevant, since the impact of adverse environmental factors, deficiency of biologically active substances in food rations leads to deterioration of human health and, consequently, reduction in life expectancy.

One of the directions of development of the food industry is to expand the production of functional foods with an elevated content of biologically active compounds. This can be achieved by the rational use of stocks of vegetable raw materials, their maximum extraction and enrichment with the natural complex of biologically valuable substances [1].

Japanese Quince is a seasonal fruit with a special morphological structure. It has no analogues when it comes to the content of the organic and fatty acids, pectins, aromatic substances, vitamins, phenolic compounds, essential oils, and amino acids. High technological and treatment-and-prophylactic properties of Japanese Quince make it possible to recommend it as raw material for medical-prophylactic and balanced nutrition. It is a promising raw material as a source of pectin substances and organic acids.

Fruit and berry raw materials are characterized by a short storage term, which determines the need to study the ways of processing for the year-round supply of population with the given products [2]. One of the unique ways to preserve food and biological value of fruits and berries is low temperature freezing.

Freezing is one of the best methods of long-term storage of fruit. Freezing preserves the original color, aroma, and

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nutritional value of most fruits. Fresh fruit after harvesting continue to be exposed to chemical, biochemical and physical changes that can cause such reactions as aging, enzymatic disintegration, chemical disintegration, and microbial growth. The freezing process decreases the rate of these degradation reactions and inhibits microbiological activity. The processes of freezing, low-temperature storage and defrosting are crucial for getting high quality fruit after freezing and defrosting [3].

The formation of crystalline and glass-like structures plays an important role in freezing and storage of food products. Frozen foods may contain phases that do not freeze, which is explained by the effect of the concentration of solutions due to a decrease in the amount of water in them, which turns into the ice form. However, some processes, such as enzymatic hydrolysis and ice re-crystallization may occur in the non-frozen phases of water even at low temperatures, which as a result leads to a decrease in the quality of frozen food products.

In addition, the use of artificial cold in preservation technologies makes it possible to save the original properties of the product, its quality, nutritional and biological value, and to reduce the weight loss during refrigeration preservation and storage.

2. Literature review and problem statement

Freezing is a well-organized process of preserving food products, as a result of which their shelf life is extended. However, freezing is not suitable for all food products and can lead to physical and chemical changes in some products, which in turn reduces the quality of the de-frosted material or of the finished product. Freezing is based on a change in temperature lower than the cryoscopic temperature, which terminates or suspends most physical, biochemical, and microbiological processes. In paper [4], the optimal mode parameters for freezing the fruit desserts were determined. However, the paper does not present the calculations of criterion equations, porosity of a bulk layer, the air temperature at the outlet of the unit and the duration of product freezing. It would be advisable to calculate density and porosity of the product by its weight and volume of the layer. It is appropriate to calculate the average time of the product being in a freezing chamber by the fixed weight of the layer and different speed of berries loading. These results would help determine the mode parameters and the kinetics of the freezing process, as well as to develop technologies of freezing in quickly freezing units with the directional movement of the cooling agent.

Paper [5] deals with the extension of the scientific fundamentals of formation of quality of poly-disperse food systems during freezing. It is found that when there are theoretical understanding and practical developments, there appears the opportunity to compile a kind of marketing passport for the assortment of frozen products and its particular kinds. It was determined that the control of reversibility of thermodynamic properties of raw materials will make it possible to substantiate scientifically the choice of the rational technological operations, which will ensure approximation of marketing properties of frozen raw material and the products to natural properties. However, the authors did not state a technological problem as for obtaining safe frozen food product according to its microbiological indicators.

Development of the nanotechnology of frozen puree from carotene-containing vegetables in the finely dispersed easily assimilable form with unique quality characteristics is described in article [6]. It was found that during the cryogenic «shock» freezing of fruits and low temperature crushing, there occurs significant cryo-destruction of complexes of carotenoids-biopolymers. The mechanism of this process was revealed. The new method of low-temperature inactivation of oxidative enzymes of carotenoid fruit during cryogenic «shock» freezing was developed. The authors did not propose the ways of the full inactivation of oxidative enzymes. They can lead to irreversible denaturation and coagulation of protein globule of enzymes and block their active centers, which prevents restoring enzymatic activity during freezing.

Research [7] deals with the innovative processes of freezing, which are currently being researched and developed all over the world to improve the conditions of freezing and product quality. The research found that the innovative processes of freezing are the improvement of the existing methods in order to achieve much higher rates of surface heat transfer than the previous system, and thus improve the products quality due to rapid freezing. However, the advantages of using this method of freezing depend on the type of the product and its dimensions, since thermal conductivity of a particular food product limits the cooling rate in large objects, rather than heat exchange between a heat carrier and a product.

The use of low temperatures is an important factor for the preservation of the fruit quality after harvest gathering and greatly affects their quality deterioration rate. The purpose of cooling is to extend the shelf life of quickly spoiling products and to decrease the metabolic activity and microbial growth. Paper [8] describes the ways of ice formation in tissues (a growth of crystals, intra- and extracellular ice), the initial point of freezing, status diagrams, and vitrification temperature. The impact of the freezing rate on fruit quality, physical and chemical modifications, nutritional properties, and microbial stability of frozen fruit are discussed. It was proved in the paper that it is reasonable to perform preparatory operations before freezing, specifically, preliminary fruit processing with the use of sugar syrups and dehydrofreezing.

One of the main tasks at each stage of freezing is to preserve good quality of products of vegetable origin. Article [9] contains the results of comparison of the influence of different ways of fruit storage. It was established that the storage technology at temperatures close to freezing (determined by the biological curve of freezing) decreased the weight loss and biological disorders during storage. As a result, changes of color, content, titrated acidity, ascorbic acid, general phenolic compounds, general flavonoids and general antocians were retarded. The content of soluble solids in fruit at temperatures close to the freezing point was approximately by 1.2...1.4 times higher than at the temperature of 0 °C during the shelf life after 80-day storage in cold. In addition, storage at temperatures close to the freezing point also strengthened the anti-oxidant property and delayed the peak value of antioxidant capacity of fruit. These results showed that storage at temperatures that are close to the freezing point can be considered as the method of fruit preservation and the way of improving the quality of post-gathering and antioxidant properties of fruit.

The scientists from the United States [10] studied endurance and sensitivity of the tissues of the selective species of Japanese Quince to the influence of low temperatures.

Within the framework of the research, the pieces of different kinds of Japanese Quince were loaded to the programmable freezing chamber and subjected to freezing at the rate of 4 °C per hour. The sample was removed after one hour at each of the five temperatures of treatment (0, minus 10; minus 20, minus 30 and minus 40 °C), incubated at 20 °C for one week; the changes in the samples were observed in a stereomicroscope. Separate areas of tissues (phloem, cambium, and xylem) were estimated according to the degree of oxidative drilling. The maximum exposure temperature with the minimum visible damage of the tissues (<25 % of destruction) was used as a sample with a minimum level of endurance. The researchers found that among 57 selective varieties of Japanese Quince, 25 % of the samples did not suffer any significant damage during freezing. These samples were able to withstand a decrease of ambient temperature to minus 30 °C, and 13 samples had low levels of drilling of tissues after the exposure to minus 40 °C. That is why it can be concluded that most varieties of Japanese Quince are suitable for low-temperature storage.

The appropriateness of the use of Japanese Quince fruit is proved by its unique sensory properties [11]. They contain many organic acids, dietary fiber, pectins and vitamin C. Japanese Quince refers to the group of fruits with the low content of monosaccharides and good ratio of glucose and fructose. Japanese Quince fruit can be used as a natural souring component. Because of the low pH value (2.4÷2.9), this raw material is not suitable for direct consumption. That is why Japanese Quince fruits are used during the production of juices, jams, purees, and candied peels. In addition, it is added to tea, yogurts, lemonades, ice-cream, cheese and confectionary products to improve their sensory properties. Japanese Quince fruit is successfully applied as a component of complex food cans because it gives them attractive original taste and aroma. The scientists [12] represented the alternative methods of extracting pectin from Japanese Quince fruit and determined the influence of selected variable factors of the process on quantitative characteristics of the resulting pectin. The fractional factor plan of the experiment was proposed, in which the following factors were taken into consideration: quince preprocessing, the drying method, conditions of acidic extraction and method of pectin extract concentration.

In paper [13], the purpose of the study was to explore the impact of different defrosting methods on the changes of the microstructure and the texture of the samples of fruit and berry raw materials. It was found that the strength of all of the defrosted samples decreased compared with the fresh samples. The suitability of defrosting conditions depends on the temperature and duration of thawing. Defrosting at 4 °C for 3 hours led to a significantly higher ($p<0.05$) stability than the other samples. Defrosting at 20 °C for 1 hour was a favorable procedure for preserving the original tissue structure of the samples. However, the authors of the paper did not provide any data on the rate of the ice formation process.

Article [14] presented the results of research into microbiological indicators of the cryopaste from quince. It is established that all the main physical-chemical, microbiological, and organoleptic indicators of the samples at the end of the storage period met the requirements. The studies of the microbiological indicators of the frozen half-finished products with the addition of vegetable raw materials showed that in the process of low-temperature storage, microbiological activity significantly decreased [15].

Thus, the conducted analysis of literature data showed that at the present level of the research into the nature of freezing and obtaining safe and high-quality food products, there are a series of problems, including:

– dependence of the freezing process on the type of produce and its size;

– restrictions of the product freezing rate by the features of its thermal conductivity;

– lack of specific data on the impact of the previous ways of preparation of raw materials to freezing on the qualitative characteristics of the finished product;

– incomplete study of the ways of inactivation of oxidative processes that do not make it possible to restore the enzymatic activity of the protein components of food products during freezing.

That is why the study of the behavior of the representative part of Japanese Quince during freezing determining the rational modes of low-temperature storage will expand the data concerning the organization of the process of freezing of these raw materials.

3. The aim and objectives of the study

The aim of this study is to determine the rational modes for low-temperature storage and for obtaining the products of Japanese Quince processing with high consuming indicators by studying the kinetics of freezing, as well as to explore the microbiological indicators of samples.

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

– to obtain experientially the representative part of Japanese Quince for constructing the models of behavior of food raw materials in the process of low-temperature storage;

– in order to determine the rational modes of storage and reaching high quality indicators, to explore the character of the process of freezing Japanese Quince and the products of its processing;

– to conduct a study of the microbiological indicators of the products of Japanese Quince processing within 270 days of low-temperature storage at the temperature of –18±2 °C in order to establish their safety.

4. Materials and methods for studying the parameters of freezing products of Japanese Quince processing

The object of the study was the fruit of Japanese Quince and the products of its processing.

Japanese Quince or Japanese henomeles (Lat. *Chaenoméles japónica*), grown in Poltava oblast (Ukraine) was used. Japanese Quince fruits were collected at the stage of complete ripeness. The fruit are transportable, and are preserved well.

Freezing was carried out using the experimental plant – a low temperature calorimeter that was developed and patented by scientists at Kharkiv State University of Food and Trade (Ukraine) [16]. This device made it possible to regulate the temperature and the freezing rate and continuously record the temperature of the samples used in the subsequent analysis. Thermo couples were put into the studied sample, which was in the vapor-proof capacity and put in the chamber of a low temperature calorimeter. Vapor of liquid nitrogen, which was mixed in a specific ratio with air to get the temperature of the gas mixture of minus 20 °C, was used as a cooling agent. The experiment ended when the same temperature was reached at the inlet and outlet of the measuring plant. The circuit of this plant and the operation principle were described in detail in scientific papers [17].

During the experiment, the temperature in the sample and the temperature of the mixture of the air and nitrogen incoming and outgoing from the chamber were controlled. Temperature was registered using the chromel-copel thermocouples, the electric driving force of which was determined by the digital potentiometer connected to the port of a PC. Statistical processing and approximation of the database was carried out using the software suite Mathcad 14.

Microbiological analysis of the studied samples was carried out in accordance with SanPIN 5061-89 «Medical and biological requirements and sanitary norms of the quality of food raw materials and food products».

Microbiological indicators were determined in the average sample of freshly prepared products of Japanese Quince processing and frozen food processing products after 30, 60, 90, 180, and 270 days of low-temperature storage at the temperature of –18±2 °C.

The study of microbiological indicators of frozen products of Japanese Quince processing in the course of low-temperature storage for more than 270 days is impractical, because the next Japanese Quince is gathered within the next three months.

5. Results of the research into behavior of a representative part of Japanese Quince in the process of low-temperature storage

According to the purpose of the study, it was proposed to introduce the operation the preliminary preparation as a result of which the experimental raw materials was supposed to have the form of a homogeneous system due to the separation of this raw material into liquid and solid parts. In this case, depending on the parameters of the environment, the transition of the components from one phase to another without the flow of chemical reactions is possible. From these positions, we proposed the method based on cyclic freezing-centrifuging of products of Japanese Quince processing, resulting into the formation of a solid and liquid parts that have the representative character of the entire object of the study.

A liquid part of Japanese Quince was obtained in advance by centrifuging the crushed raw material with the following parameters of the process: υ=5,000 rpm, τ=15 min. For more complete separation of a liquid part, raw material was exposed to additional freezing. The liquid part and crushed vegetable raw materials, obtained during separation, were frozen in freezers at the temperature of minus 18+2 °C for 2–3 hours. After this, the samples were defrosted in the air environment and again subjected to centrifuging. In this case, the liquid part, separated during centrifuging of the studied sample, was poured to the total volume of the liquid phase, and the sediment, formed during centrifuging of the liquid portion, was added to the total amount of solid phase. Operations of freezing-centrifuging were carried out cyclically.

As a result of this study, we observed common patterns for food raw materials. At an increase in the cycles of freezing-centrifuging, an increase in the weight of the liquid part and a decrease in the weight of the solid parts were observed. In addition, a sharp jump in indicators occurs after the first freezing, and the subsequent change of values has a gradual character (Fig. 1).

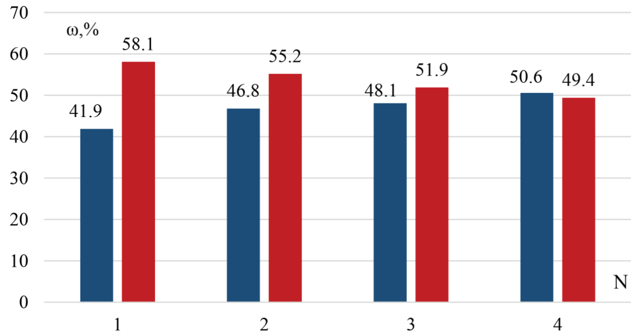

Fig. 1. Weight fraction (ω, %) of liquid (■) and solid (■) parts of crushed Japanese Quince, which were formed during the cycles of freezing (*N*) and centrifuging: 1 – without freezing, 2 – after first freezing, 3 – after second freezing, 4 – after third freezing

After each cycle of freezing-centrifuging, the weight fraction of moisture was determined in the phases of the researched samples. Relationship between the weight fraction of moisture and the number of cycles of freezing can also be significant in determining the amount of the required cycles, at which phase reversibility is achieved (Fig. 2, 3).

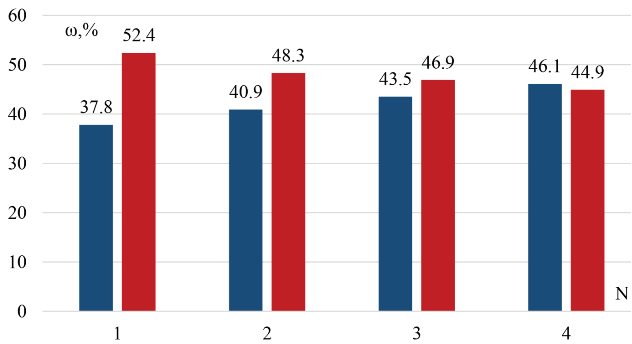

Fig. 2. Weight fraction of moisture (ω, %) in liquid (■) and solid (■) parts of crushed Japanese Quince, which were formed during the cycles of freezing (*N*) and centrifuging: 1 – without freezing, 2 – after first freezing, 3 – after second freezing, 4 – after third freezing

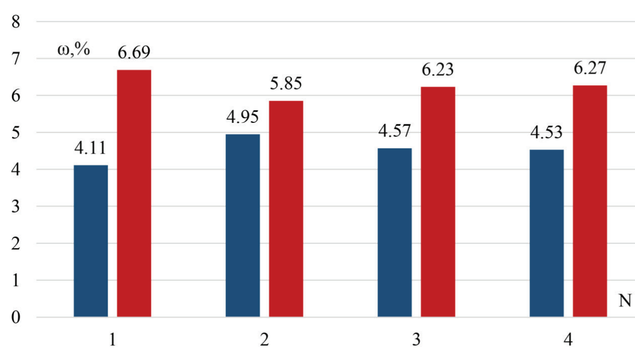

Fig. 3. Weight fraction of dry substances (ω, %) in liquid (■) and solid (■) parts of crushed Japanese Quince, which were formed during the cycles of freezing (*N*) and centrifuging: 1 – without freezing, 2 – after first freezing, 3 – after second freezing, 4 – after third freezing

In general, analyzing the data from Fig. 2, 3, it was found that the moisture content in the solid part of the studied samples decreases and in the liquid part – increases at an increase in the cycles of freezing-centrifuging. As expected, according to the law of mass conservation, the weight fraction of dry substances, in contrast, increases in the solid part and decreases in the liquid part.

6. Results of studying the nature of the process of freezing products from Japanese Quince processing

The rules of the scientific research implied studying the nature of the process of freezing freshly prepared liquid and solid parts of Japanese Quince, as well as those after 9 months of low-temperature storage. The studied samples were frozen at the temperature of minus 20 °C.

Table 1 shows the results of the analysis of the thermograms of the process of freezing-heating of the studied products of Japanese Quince processing.

It is found that the weight fraction of frozen moisture for freshly prepared liquid part is 84.8 % and for the solid part – 63.7 %. It was noted that after 9 months of low-temperature storage, the weight fraction of moisture increases.

Thus, for the liquid part, this figure makes up 87.0 % and for the solid part, it is 64.9 %. An increase in the amount of frozen moisture in the process of low-temperature storage is explained by to hydrolysis of sugars, tannates and pectins.

It was experimentally determined that each test sample has two ranges of crystallization and re-crystallization of frozen moisture. Freezing at 20±2 °C contributes to complete conservation of products.

Further keeping at the temperature within these measures enables formation of marketing properties of frozen food of processing Japanese Quince, namely, ensuring the preservation of such organoleptic indicators as consistency and elasticity.

Table 1

Results of analysis of thermograms of freezing-heating of studied products of Japanese Quince processing

Type of product of processing	*t* of freezing, °C	Weight of sample, g	Range 1 $t_{crystallization}$ of frozen moisture, °C	Range 2 $t_{crystallization}$ of frozen moisture, °C	Range 1 $t_{melting}$ of frozen moisture, °C	Range 2 $t_{melting}$ of frozen moisture, °C	Weight fraction of frozen moisture, %
Freshly prepared liquid and solid parts of crushed Japanese Quince							
Liquid part	–20	25	–1.2...–4.9	–14.8...–17.9	–12.3...–7.2	–5.1...–1.2	84.8
Solid part	–20	25	–2.6...–7.1	–15.8...–18.1	–7.1...–4.9	–2.1...–1.3	63.7
Liquid and solid parts of crushed Japanese Quince after 9 months of low-temperature storage							
Liquid part	–20	25	–2.3...–5.1	–14.3...–16.9	–10.1...–8.2	–4.1...–2.9	87.0
Solid part	–20	25	–1.1...–3.3	–15.9...–18.8	–5.1...–4.5	–1.6...–1.0	64.9

7. Results of research into microbiological indicators of the products of Japanese Quince processing

Results of research into microbiological safety of products of Japanese Quince processing before freezing and after 30, 60, 90, 180 and 270 days are shown in Table 2.

Table 2

Microbiological indicators of products of Japanese Quince processing in the course of low-temperature storage ($P \geq 0.95$; $n=3$)

Studied products of Japanese Quince processing	Indicator				
	QMAFAnM, CFU/1g of product, not more than 5×10^4	Bacteria of the colibacillus group (E.coli) in 0.1 g of product	Pathogenic microorganisms, including Salmonella in 25 g of product	Yeast CFU/in 1 g of product , not more than 5×10^3	Mold CFU/1 g of product, not more than 1×10^3
Freshly prepared products of processing (before freezing)					
Liquid part	7.2×10^2	Not found	Not found	7.5×10	8×10
Solid part	4.9×10^3	Not found	Not found	1.2×10^2	2.2×10^2
After 30 days of low-temperature storage					
Liquid part	8.7×10^2	Not found	Not found	9.3×10	9.8×10
Solid part	5.2×10^3	Not found	Not found	1.9×10^2	2.0×10^2
After 60 days of low-temperature storage					
Liquid part	8.5×10^2	Not found	Not found	8.7×10	9.5×10
Solid part	4.9×10^3	Not found	Not found	1.6×10^2	1.8×10^2
After 90 days of low-temperature storage					
Liquid part	8.3×10^2	Not found	Not found	8.6×10	9.4×10
Solid part	4.8×10^3	Not found	Not found	1.5×10^2	1.7×10^2
After 180 days of low-temperature storage					
Liquid part from Japanese Quince	7.9×10^2	Not found	Not found	8.2×10	9.0×10
Solid part from Japanese Quince	4.2×10^3	Not found	Not found	1.2×10^2	1.2×10^2
After 270 days of low-temperature storage					
Liquid part	7.8×10^2	Not found	Not found	8.0×10	8.8×10
Solid part	4.2×10^3	Not found	Not found	1.1×10^2	1.0×10^2

In accordance with the requirements of DSTU 6029:2008 Semi-finished rapidly frozen (crushed and puree-like) fruit and berry products» [18], the amount of MAFAM (CFU/1 g) should not exceed 5.0×10^4. Bacteria of the group of *E.coli* and pathogenic microorganisms are not admissible The amount of yeast CFU in 1 g of the product should not be more than 5×10^3, mold CFU/1 g of product must not be more than 1×10^3.

Based on the presented in Table 2 data, it is possible to conclude that the microbiological indicators of the studied products of Japanese Quince processing do not exceed the established standards. Thus, a decrease in total microbiological contamination of the samples was established, which indicates the negative effect of cold on the vital activity of microorganisms.

Compared with the freshly prepared products, the amount of MAFAM after 30, 60, 90, 180, and 270 days of low-temperature storage significantly decreases. The amount of yeast and mold also decreases during the storage, but the microflora does not die completely. Microbiological contamination characterizes the quality and safety of the finished product and makes it possible to judge about the unwanted processes that may occur during its storage.

Generalization of the research results made it possible to determine that low-temperature storage of products Japanese Quince processing for 270 days suppresses the vital activity of microorganisms, which guarantees microbiological safety of the product throughout the whole period of storage, so it is quite safe and suitable for consumption or further processing.

8. Discussion of results of the study into the products of Japanese Quince processing

It was found that at an increase of the number of freezing-centrifuging cycles, an increase in the weight of the liquid part and a decrease in the weight of the solid part are observed. In addition, after the first freezing, there occurs a sharper jump in the indicators, and the subsequent change of values has a gradual nature. Graphic representation of these changes is shown in Fig. 1.

It was observed that the relationships of the weight fraction of moisture and the number of cycles of freezing can be significant in determining the number of necessary freezing-centrifuging cycles. Thus, Fig. 2 shows that at each cycle the moisture content in the solid part of the studied samples decreases, and increases in the liquid part at an increase in number of cycles. However, the weight fraction of dry substances, in contrast, increases in the solid part and decreases in the liquid part, which is shown in Fig. 3. These changes are explained by the redistribution of solid substances and moisture in the studied samples under freezing and in the following centrifuging, which results in components transition from one phase to another. In this case, the general resistance of the weight fraction of moisture and dry substances in the weight portion of the studied sample is preserved, which shows the absence of flow of chemical reactions and existence of sedimentation phenomenon.

Based on the data from Table 1, it was established that the weight fraction of frozen moisture in the products of Japanese Quince processing in the course of low-temperature storage at the temperature of −20±2 °C increases. Thus, this indicator increases from 84.8 % to 87.0 % for the liquid part, and from 63.7 % to 64.9 % for the solid part.

Analysis of the data of Table 1 revealed that freezing at −20±2 °C contributes to complete preservation of the products. Their subsequent keeping in this temperature range makes it possible to form the marketing properties of frozen products of Japanese Quince processing, specifically, to ensure retaining such organoleptic indicators as consistency and elasticity.

According to the data from Table 2, we noticed a decrease in general microbiological contamination of the samples, which indicates the negative effect of cold on the vital activity of microorganisms. Compared with freshly prepared products of processing, the amount of MAFAM, yeasts and mold after 30, 60, 90, 180, and 270 days of low-temperature storage significantly decreased.

It was determined that the microbiological indicators of the studied products of Japanese Quince processing do not exceed the norms contained in DSTU 6029:2008 «Semi-finished quickly frozen fruit and berry products (crushed and puree-like)».

The obtained scientific results can be used in the development of the modes of freezing-defrosting products of Japanese Quince processing at the enterprises of food and processing industry, expanding the range of products based of the use of domestic raw materials.

It is necessary to extend the study of the influence of the products of Japanese Quince processing in combination with other components on the quality and safety of the finished product. However, it is advisable to carry out a comprehensive study with regard to the ripeness degree and climatic conditions of growing Japanese Quince, analyzing the technological process in general and indicators of the finished product.

The research into the ranges of crystallization and melting of frozen moisture in the experimental samples and its weight fraction is of special interest. The research into these indicators may provide interesting results regarding the behavior of the products of Japanese Quince processing in the course of low-temperature storage. The shortcomings of this method include the use of the experimental plant – a low temperature calorimeter, which was developed and patented by the scientists at Kharkiv State University of Food and Trade.

Obtaining semi-finished products with specific properties, proper quality and safety is a top priority in the production of food products. That is why the research into the influence of other factors is the basis for subsequent research.

9. Conclusions

1. It was established that in the process of the chosen method of preliminary preparation of the products of Japanese Quince processing by cyclic freezing-centrifuging, the redistribution of dry substances occurs and the phase equilibrium of the research samples is achieved.

2. It was determined that the weight fraction of frozen moisture in the products of Japanese Quince processing increases in the course of low-temperature storage at the temperature of minus 20±2 °C. Thus, this indicator for the liquid part increased from 84.8 % to 87.0 % and from 63.7 % to 64.9 % for the solid part. The first and second ranges of temperatures of crystallization and melting of frozen moisture in the products of Japanese Quince processing were quantitatively determined. It was noted that freezing at minus 20±2 °C contributes to complete preservation of products.

The obtained results make it possible to adjust the modes of freezing and defrosting the products Japanese Quince processing at the food industry enterprises.

3. It was determined that the amount of MAFAM, yeast and mold (CFU/1 g) in the products of Japanese Quince processing for 270 days of low-temperature storage does not exceed the requirements of DSTU 6029:2008 «Semi-finished quickly frozen fruit and berry products (crushed and puree-like)». The obtained data testify to the consumer safety of these products over the entire period of storage.

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