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Research Article

Study of Quality and Safety Indicators of Local Vegetable Varieties During Storage

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Abstract

New methods for the storage and processing of agricultural raw materials have been developed, aimed at obtaining high-quality functional products through the improvement of technical means and technologies. The characteristics of the consumer properties and the specific features of the chemical composition of vegetable products are described. The following raw materials were used for the experimental studies: carrot roots of the varieties “Kukcha” and “Nurli”; beetroots of the varieties “Uzbekiston 102”, “Samarkand 1” and “Kizil lavlagi”; potato tubers of the varieties “Akrab”, “Zarafshon” and “Umid”. The most common methods of long-term storage of vegetable raw materials include technologies using low temperatures and ventilated storage facilities. Storage devices that make use of natural resources were used, namely containers for storing fruits and vegetables in a frozen water body. The quality indicators of the base raw materials were studied after 0, 7, 14 and 21 days of storage. The values of active acidity of the base raw materials changed only slightly throughout the entire period of refrigerated storage – by 0.1–0.3 pH units. The values of active acidity did not exceed pH = 5.3, which corresponds to the maximum value of the quality indicators. During storage of the base raw materials for 21 days, a significant increase in titratable acidity was found, amounting to 30.6%. The sucrose content during storage of the base raw materials increased by 4.7% in the period from day 14 to day 21. The colour index during three-week storage decreased to a greater extent in the base raw materials. Its decrease amounted to 18.4%; the value of the sugar–acid ratio in the sample from the base raw materials increased from 2.0 to 2.2 conventional units during the first 7 days of storage due to the accumulation of hydrolysis products,

Keywords:

Vegetables and fruits, characteristics, storage, conditions, physicochemical indicators, changes in indicators during storage.

INTRODUCTION

At present, environmental changes observed on a global scale have a negative impact on the production of agricultural products of sufficient quantity and quality. In particular, the growth of the world's population leads to an increase in demand for food. Vegetables are the main type of food product consumed fresh by the population. This is due to the presence in vegetables of all the vitamins, minerals, pectin substances, etc. necessary for human health. However, there are many problems associated with the use of this type of product in the food industry. One of them is the problem of long-term storage. Since most vegetable products are grown during a certain period of the year, i.e. a season, the use of modern high-quality long-term storage technologies is simply necessary to supply food industry enterprises with this type of raw material throughout the year. The development of new methods for the storage and processing of agricultural raw materials, aimed at obtaining high-quality functional products through the improvement of technical means and technologies, is becoming increasingly important.

The role of the agro-industrial complex (AIC) in supplying the population's diet with healthy products will only increase in the coming years, including in the field of vegetable growing. The importance of the AIC for the economy is dictated

by the need to ensure the food security of the country, taking into account the changing foreign policy situation and the formation of a sustainable course towards food independence, which has significantly increased the importance of developing vegetable growing and ensuring the availability and price stability of vegetables on the food market. One of the strategic objectives of food security is to provide the population with high-quality agricultural products and food. According to the provisions of the Food Security Doctrine of Uzbekistan, the domestic market should be supplied with domestic agricultural products and food, for the production of which Uzbekistan has favourable conditions. In this regard, research on improving the technologies of long-term storage of vegetable raw materials is relevant and corresponds to the objectives of the state programme for the development of agriculture and the regulation of agricultural product markets.

LITERATURE REVIEW

It is known that the requirement for vegetables per person is approximately 150 kg per year (excluding potatoes) [1]. Since vegetables are a seasonal product in Uzbekistan, the preservation of vegetable products after harvesting (procurement), during storage and up to their delivery to the consumer becomes extremely relevant.

The characteristics of the consumer properties and the specific features of the chemical composition of vegetable products largely determine the extent of losses of these products during storage. Vegetables are major sources of energy owing to carbohydrates, as well as sources of physiologically active compounds that supply the human body with natural vitamins, enzymes, minerals, dietary fibre and other biologically active substances [2, 3]. It should be noted that vegetables contain a wide variety of natural antioxidants, including flavonoids, carotenoids and anthocyanins [4, 5]. Vegetables and fruits promote digestion and a more complete assimilation of food, which is of great importance for a full-fledged metabolism [6, 7].

For the normal vital activity of cells and tissues, plants must be sufficiently saturated with water. Water is the main constituent of cells during the period when vital processes are intensively taking place in them [8, 9]. The water content of cells is 70–90%.

The most common methods of long-term storage of vegetable raw materials include technologies using low temperatures and ventilated storage facilities [10, 11]. The requirements for physical factors (temperature, humidity, atmospheric pressure) affecting the duration of storage of fruit and vegetable raw materials vary depending on the type, quality indicators and quantity of the raw materials. Nevertheless, the general requirements and principles of storage are approximately the same both for refrigerated storage and for storage in ventilated warehouses [12, 13].

In addition to the well-known method of storing plant raw materials at low temperature and low air humidity [14, 15], there is a method using isostatic pressing. It is based on the sterilization of food products of plant origin by high-pressure treatment. The disadvantage of this method is not only the high cost of its industrial application, but also the large losses of valuable nutrients in the processed raw materials. Among them, there are devices for long-term storage of fruit and vegetable raw materials that operate without the use of physical or chemical factors but are improved by means of mechanical factors. For example, containers for storing fruits and vegetables with vibrating platforms, thermally insulated walls, perforated partitions, etc. [16]. Storage devices that make use of natural resources are also used, namely containers for storing fruits and vegetables in a frozen water body [17]. The main disadvantages of all the above-mentioned devices and technological methods for long-term storage of fruit and vegetable products are their unreliability, insufficient efficiency, high energy consumption and high material costs during their use.

In stored fruits and vegetables, most vital processes are endergonic, i.e. they occur only owing to an inflow of energy. The main source of energy for them is oxidative phosphorylation in the mitochondria, during which the products of photosynthesis (carbohydrates, organic acids, proteins, fats, etc.) are oxidized, releasing the energy contained in them (free enthalpy). In this process, oxygen is absorbed and carbon dioxide is released, i.e. inorganic compounds poor in energy.

The aim of the present research is directed at innovative developments in the technology of storage and processing of local agricultural raw materials.

Achieving this aim became possible through the use of certain innovative methods and devices that had never before been used in the field of storage and processing of plant raw materials.

Objects of research. The following raw materials were used for the experimental studies:

Table carrot roots (Daucus carota L.) meeting the requirements of GOST 32284-2013 “Fresh table carrots sold in retail trade. Specifications”, of the following varieties:

- table carrot roots of the economic-botanical variety “Kukcha”. A variety with good keeping quality; the roots are fresh, whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The roots are cylindrical-elongated, blunt-ended, semi-long – 100–200 mm. The flesh and core are orange, sometimes light orange;

- table carrot roots of the economic-botanical variety “Samarkand 6”. A variety with good keeping quality; the roots are fresh, whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The roots are cylindrical, often slightly tapering upwards and downwards, bright orange (the roots were bright orange both on the outside and in the core); the average length of marketable roots is 13–15 cm, the diameter is 4.5 cm (most often of approximately the same diameter along the entire length), the weight is 69–155 g. The tip is blunt, sometimes pointed. The core is faceted or rounded, orange. The crown is slightly concave, 2.6 cm in diameter. The lateral roots are filiform and numerous. The root surface is smooth. The eyes are small and smooth. The flesh is bright orange. The taste qualities of the roots are good;

- table carrot roots of the economic-botanical variety “Nurli” are whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The colour of the surface, flesh and core of the root is orange. The roots are conical with a blunt tip, 15–19 cm long, 5.8–6 cm in diameter, with an average weight of 74–252 g. The crown is concave, 3 cm in diameter. The lateral roots are filiform, medium in number; the eyes are small. The taste qualities of the roots were characterized as satisfactory and good.

Table beetroots (Beta vulgaris L.) in accordance with GOST 32285-2013 “Fresh table beet sold in retail trade. Specifications”, of the following varieties:

- table beetroots of the economic-botanical variety “Uzbekiston 102”. A variety with good keeping quality; the roots are fresh, whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The roots are rounded, up to 90 mm in diameter, dark red in colour. The flesh is dense, tender and juicy, with a high sugar content and an intense red-burgundy colour, uniform in cross-section or with faintly expressed “rings”;

- table beetroots of the economic-botanical variety “Samarkand 1”, included in the State Register of the Republic of Uzbekistan. The roots are fresh, whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The roots are rounded, with slight suberization of the crown. The flesh is red. The root weight is 220–370 g. The taste qualities are good;

- table beet of the variety “Kizil lavlagi”. Approved for use throughout the territory of the Republic of Uzbekistan. The beet of the variety “Kizil lavlagi” has flat-rounded, dark red roots, 6–8 cm long, 10–12 cm in diameter, weighing 146–220 g. The surface is smooth. The crown is medium-sized and flat. The flesh is dark red, juicy and tender, with excellent taste qualities.

Tubers of ware potatoes of early and late ripening botanical varieties and their hybrids (Solanum tuberosum L.) in accordance with the requirements of GOST 7176-2017; the following varieties were studied:

- potato tubers of the economic-botanical variety “Akrab”, which in terms of the “appearance” indicator were determined to be whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The tubers were round-oval, sometimes elongated, white, weighing 90–120 g. The eyes are small and concentrated at the apex. The flesh colour is white. The taste qualities after boiling are good. Main advantages: undemanding nature and increased resistance to common diseases and pests.

- potatoes of the variety “Zarafshon”; tuber appearance: whole, healthy, clean, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The tubers are round-oval, weighing 102–154 g, with yellow skin. The flesh is light yellow (sometimes yellow). The eyes are small. Main advantages: good yield, large tubers, long storage life; the variety is resistant to various diseases.

- potato tubers of the economic-botanical variety “Umid” looked whole, dry, uncontaminated, healthy, not sprouted, not wilted, not cracked, free from damage by agricultural pests and without excess external moisture. The tubers are uniform, large, oval, yellow, weighing 110–180 g. The eyes are few and small. The skin is smooth.

The physicochemical indicators of the vegetable raw materials were determined in accordance with the regulatory documents presented in Table 1.

Table 1

Methods of research of fruit and vegetable products

Objects of research	Indicators	Methods of determination
1	2	3
Carrot roots	organoleptic indicators	GOST 32284-2013 Fresh table carrots sold in retail trade. Specifications

	moisture content (or dry matter content)	GOST 28561-90 Fruit and vegetable products. Methods for determination of dry matter or moisture, standard thermogravimetric method
	sugar content	GOST 8756.13-87 Fruit and vegetable products. Methods for determination of sugars, standard photocolorimetric method
	ß-carotene content	GOST ISO 6558-2-2019 Fruits, vegetables and derived products. Determination of carotene content by the spectrophotometric method
	content of pectin substances	GOST 29059-91 Fruit and vegetable products. Titrimetric method for determination of pectin substances
	content of organic acids	GOST ISO 750-2013 Fruit and vegetable products. Determination of titratable acidity by the potentiometric method
	ascorbic acid (vitamin C) content	GOST 24556-89 Fruit and vegetable products. Methods for determination of vitamin C
Beetroots	organoleptic indicators	GOST 32285-2013 Fresh table beet sold in retail trade. Specifications
	moisture (dry matter) content	GOST 28561-90 Fruit and vegetable products. Methods for determination of dry matter or moisture
	sugar content	GOST 8756.13-87 Fruit and vegetable products. Methods for determination of sugars
	content of organic acids	GOST ISO 750-2013 Fruit and vegetable products. Determination of titratable acidity by the potentiometric method
	ascorbic acid (vitamin C) content	GOST 24556-89 Fruit and vegetable products. Methods for determination of vitamin C
Potatoes	organoleptic indicators	GOST 7176-2017 Ware potatoes. Specifications
	moisture (dry matter) content	GOST 28561-90 Fruit and vegetable products. Methods for determination of dry matter or moisture
	sugar content	GOST 8756.13-87 Fruit and vegetable products. Methods for determination of sugars
	starch	GOST 7194-81. Fresh potatoes. Acceptance rules and methods for quality determination

On the basis of the developed system of indicators given in Table 1, the quality indicators of the base raw materials were studied after 0, 7, 14 and 21 days of storage. The results of the studies are shown in Fig. 1.

Fig. 1 shows that the values of active acidity of the base raw materials changed only slightly throughout the entire period of refrigerated storage – by 0.1–0.3 pH units.

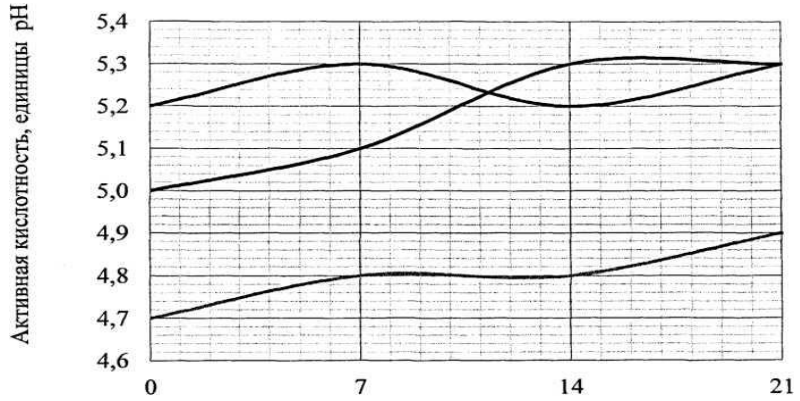


Figure 1 – Change in active acidity during storage of vegetables 1 – carrots; 2 – beetroots; 3 – potatoes.

The values of active acidity did not exceed pH = 5.3, which corresponds to the maximum value of the quality indicators. The results of the study of active acidity are consistent with the results of the microbiological study given in Table 2.

During storage of the base raw materials for 21 days, a significant increase in titratable acidity was found, amounting to 30.6% (Fig. 2).

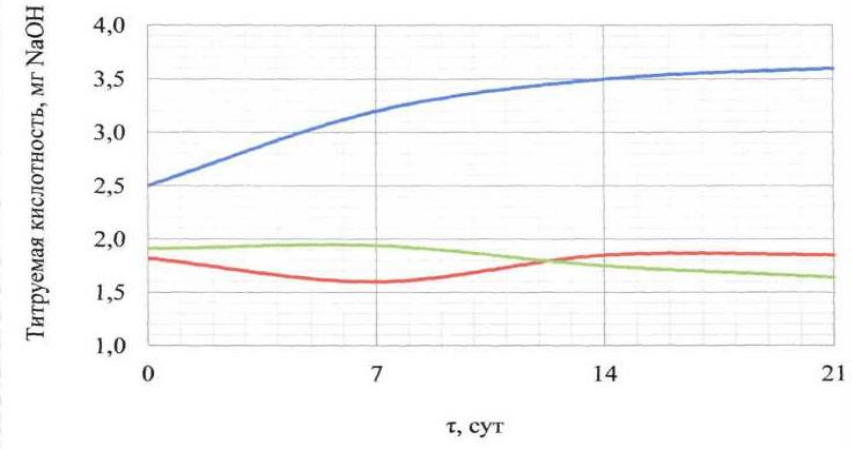


Figure 2 – Change in titratable acidity during storage of vegetables 1 – carrots; 2 – beetroots; 3 – potatoes.

In the base raw materials and their universal sets, titratable acidity changed only slightly.

The sucrose content during storage of the base raw materials increased by 4.7% in the period from day 14 to day 21 (Fig. 3).

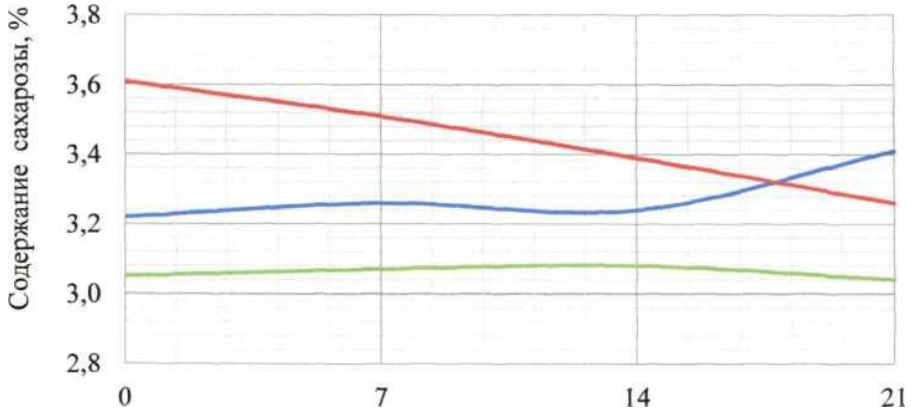


Figure 3 – Change in sucrose content during storage of vegetables 1 – carrots; 2 – beetroots; 3 – potatoes.

The sucrose content in the base raw materials stored for 21 days decreased by 8.3%. In the raw materials from the universal set, the sucrose content remained practically unchanged over this storage period.

The colour index during three-week storage decreased to a greater extent in the base raw materials (Fig. 4). Its decrease amounted to 18.4%, which is explained by the destruction of beet betanin during storage of the multicomponent system of the base raw materials, in which the beet is heated twice (Fig. 5), compared with the raw materials from the universal sets of semi-finished products, which were stored separately in hermetically sealed packaging without access to atmospheric oxygen.

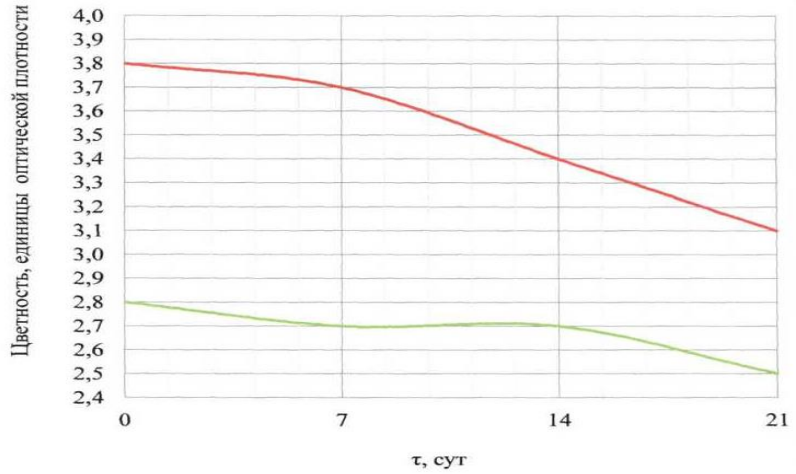


Figure 4 – Change in the colour index during storage of vegetables 1 – carrots; 2 – beetroots; 3 – potatoes

During storage of the base raw materials for 21 days, the dry matter content decreased by 8%, which may be associated with the formation of volatile substances (Fig. 5).

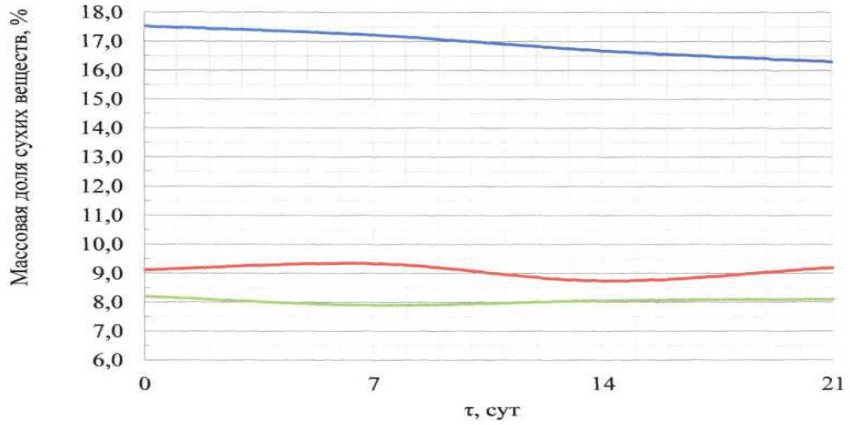


Figure 5 – Change in the mass fraction of dry matter during storage of vegetables 1 – carrots; 2 – beetroots; 3 – potatoes.

In the samples from the base raw materials and from the universal sets, there is practically no loss of dry matter during processing.

The value of the sugar–acid ratio in the sample from the raw materials increased from 2.0 to 2.2 conventional units during the first 7 days of storage due to the accumulation of hydrolysis products – reducing monosaccharides (Fig. 6).

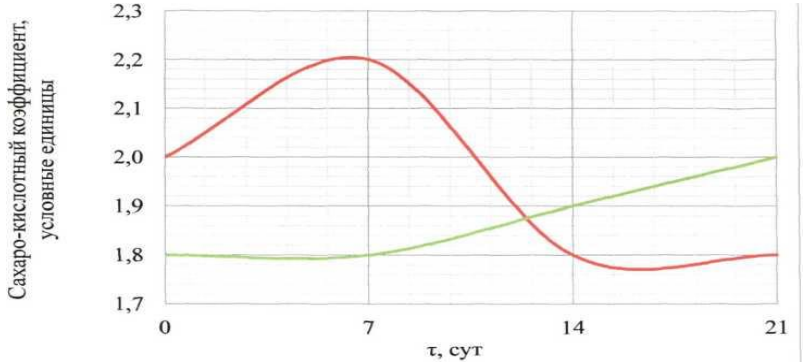


Figure 6 – Change in the sugar–acid ratio during storage 1 – carrots; 2 – beetroots; 3 – potatoes

In the sample from the universal sets, the fluctuations of the sugar–acid ratio are explained by sensory adjustment of the product's taste during its preparation.

After 14 days of storage of the base raw materials, a decrease in the sugar–acid ratio from 2.2 to 1.8 conventional units was observed in the finished product made from them, which is associated with an increase in titratable acidity and a decrease in reducing sugars. Despite the decrease in the sugar–acid ratio in the sample from the base semi-finished product, the scores of its organoleptic evaluation were quite high.

Thus, during three-week storage, the following changes in the physicochemical indicators of the base raw materials were established:

- the values of active acidity did not exceed pH = 5.3, which corresponds to the maximum value of the developed

safety indicator given in Table 2;

- a significant increase in titratable acidity, amounting to 30.6%;
- an increase in sucrose content by 4.7% in the period from day 14 to day 21;
- the decrease in the colour index amounted to 18.4%;
- the dry matter content decreased by 8%;

In general, the quality and safety indicators of the products prepared from the base raw materials were within the limits of the reference standard.

Table 2

Quality indicators of the sample from the base raw materials during storage at a temperature of 4±2°C for 21 days

Indicator	Standard value	Storage duration, days			
		0	7	14	21
Safety indicator, pH units	4.6 <...>5.3	5.0±0.1	5.1±0.1	5.3±0.1	5.3±0.1
Colour, optical density units	Not <2.2/ R-red component – not <160	3.8±0.2	3.7±0.2	3.4±0.1	3.1±0.2
Sugar–acid ratio, conventional units	1.8<...>2.5	2.0	2.2	1.8	1.8
Mass fraction of dry matter, %	8.0<...>10.5	9.12±0.02	9.34±0.03	8.74±0.02	8.70±0.02
Score	According to GOST	5.0	5.0	5.0	5.0

In the finished sample from the universal sets, the quality and safety indicators corresponded to the developed indicators for finished products and are given in Table 3.

Table 3

Quality indicators of the sample from the universal sets during storage at a temperature of 4±2°C for 21 days

Indicator	Standard value	Storage duration, days			
		0	7	14	21
Safety indicator, pH units	4.6 <...> 5.3	4.7±0.1	4.8±0.1	4.8±0.1	4.9±0.1
Colour, optical density units	Not <2.2/R- red component – not <160	2.8±0.2	2.7±0.2	2.7±0.1	2.5±0.2
Sugar–acid ratio, conventional units	1.8<.. >2.5	1.8	1.8	1.9	2.0
Mass fraction of dry matter, %	8.0<...>10.5	8.11 ±0.02	8.15±0.03	8.00±0.02	8.07±0.02
Score	According to GOST	5.0	5.0	5.0	5.0

As can be seen from Table 3, the quality and safety indicators of the finished sample from the universal sets were within acceptable limits and indicated the high quality of the finished products.

CONCLUSION

The quality indicators of the base raw materials were studied after 0, 7, 14 and 21 days of storage. The values of active acidity of the base raw materials changed only slightly throughout the entire period of refrigerated storage – by 0.1–0.3 pH units.

The values of active acidity did not exceed pH = 5.3, which corresponds to the maximum value of the developed quality indicators.

During storage of the base raw materials for 21 days, a significant increase in titratable acidity was found, amounting to 30.6%.

The sucrose content during storage of the base raw materials increased by 4.7% in the period from day 14 to day 21.

The colour index during three-week storage decreased to a greater extent in the base raw materials; its decrease amounted to 18.4%.

The value of the sugar–acid ratio in the sample from the raw materials increased from 2.0 to 2.2 conventional units during the first 7 days of storage due to the accumulation of hydrolysis products. The above changes in the physicochemical indicators were established in the base raw materials during three-week storage.

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