Biochemical composition of feijoa fruits under various storage

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Abstract. The article discusses the issues of changes in the main biochemical components (mono- and disaccharides, organic acids) in feijoa fruits under different fruit storage conditions (temperature and humidity were regulated). Biochemical analyses were performed by capillary electrophoresis. As a result, an increase in soluble solids was revealed against the background of a decrease in fruit weight. An active decrease in the amount of all mono- and disaccharides was recorded after two weeks of storage. At the end of the experiment, the previously discovered oxalic and tartaric acids were not present in the fruits, and the amount of citric and malic acid was significantly reduced. It was determined that the most optimal storage conditions for feijoa fruits are a temperature of +8 °C and air humidity within 36 %.

1 Introduction

Currently, the issues of providing the population with vitamin products are of particular relevance [1-2]. The use of subtropical crop production products can solve this problem. Fresh fruits of subtropical crops are the most important components of dietary nutrition, so their consumption should be uniform throughout the year. It is also important that subtropical plants are a valuable source of biologically active substances. However, the time of consumption of fresh fruits is quite limited, while the Russian consumer (both local residents and a large number of visitors, including families with children, to a year-round resort) has a need for multifunctional, nutritionally significant plant products of subtropical origin.

It is known that the reason for the loss and decrease in the quality of fruits is a complex of factors: the genotype of the variety, ecological and agrotechnical conditions of cultivation, the physiological status of the plant and the fruits themselves, shelf life, processing conditions.

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In addition, the quality of fruits is significantly lost during their storage, and losses can range from 30 % to 100 % [2-4]. And if a large number of works have been carried out with regard to the storage of fruits of the temperate zone [5-12], then the issues of storing products of subtropical crop production, which reduce losses, extend shelf life, preserve the quality and nutritional value of fruits, are not scientifically justified. Solving this problem requires an integrated approach involving fundamental research in the field of biochemistry of both raw materials and conditions for its transformation.

Feijoa (*Feijoa sellowiana* (O.Berg) O.Berg) belongs to the myrtle family (Myrtacea Juss.). As Omarov et al. point out in their monograph: "For a long time, botanists and taxonomists attributed Feijoa to the genus Feijoa. Nevertheless, to date, taxonomists tend to attribute feijoa to the species *Acca sellowiana* (O. Berg) Burret…" [13]. Feijoa fruits are rich in polyphenols, sugars, organic acids, trace elements, etc. [14-15]. Fruits are harvested in the phase of removable maturity and in the process of storage (transportation), their ripening occurs, in which a sweet and sour taste is manifested. In the humid subtropics of Russia, the collection of feijoa fruits is stretched and, depending on the variety, the collection takes place in September – November. According to the shelf life of feijoa, they belong to the fruits of the average term, at a temperature of + 5 °C they can be stored for 1-2 months.

2 Materials and methods

The objects of biochemical research were feijoa fruits of several varieties: 'Superba', 'Dachnaja', 'Sentjabr'skaja', 'Dagomysskaja' и ShV-07, grown at the experimental site of the breeding laboratory of the Department of Plant Genetic Resources FRC SSC RAS (Federal Research Centre the Subtropical Scientific Centre of the Russian Academy of Sciences, Sochi, Krasnodar Region).

Loading for storage was carried out immediately after harvesting on November 25 at the stage of removable maturity, the fruits were stored for a month in a normal atmosphere in three versions of the experiment: at a temperature of +8 °C and humidity of 36 %, + 13 °C and humidity of 81 %; temperature +22 °C and humidity 46 %. The analysis of biochemical and weight parameters was carried out weekly. At the same time, every 12 hours, the temperature regime was recorded using a recorder (logger) TR-2L (Engineering Technologies LLC, Russia).

The quantitative content of sugars and organic acids in fruits was carried out using capillary electrophoresis "Kapel – 105M" [16-17] in the Laboratory of Biosynthetic Processes of Plant Raw Materials Transformation of the Department of Plant Physiology and Biochemistry FRC SSC RAS.

Statistical processing of the results of the study was carried out by the method of variance analysis [18] using a software program Statgraphics Centurion.

3 Results

Within dynamic procedures, we have analysed feijoa fruits (an average sample of five varieties) deposited for storage. There was a slight decrease in fruit weight, weight loss averaged 5.85 %. At the same time, the content of soluble solids increased by 1.3 times. It

was noted that the most significant increase in soluble solids occurs two weeks after fruit storage (table 1).

Table 1. Changing the characteristics of feijoa fruits during storage.

Indicator		Before the laying for storage	After three weeks of storage	One month after storage
Fruit weight, g		13.83±1.82	13.26±1.08	13.02±1.23
Soluble solids, %		12.30±1.28	12.80±1.27	15.40±1.67
Mono- and disaccharide, g/l	fructose	21.12±3.28	17.49±1.28	9.66±0.71
	glucose	16.12±2.64	8.47±0.72	5.05±0.11
	sucrose	58.36±6.84	42.12±6.27	28.06±1.24
Organic acids, g/l	citric	15.12±5.32	11.23±1.05	14.66±0.51
	malic	2.63±0.06	1.51±0.03	1.51±0.03
	oxalic	0.76±0.05	0.26±0.0	0.0
	tartaric	0.21±0.03	0.0	0.0

A decrease in the amount of all mono- and disaccharides was recorded, and after two weeks of storage, the process of their hydrolysis increases.

We have identified 4 organic acids in the stored fruits; the most represented is citric acid. In addition, malic, oxalic and tartaric acids were identified. We noted that after three weeks of storage, tartaric acid is not identified in the fruit, and by the end of storage, oxalic acid is not fixed in the fruit (table 1).

With the general processes going on in fruits, different temperature conditions have different effects on the dynamics of biochemical parameters (figures 1-3).

At the same time, the lack of data on soluble solids, sugars and organic acids after four weeks of storage (since December 23) is due to the lack of marketable fruits when stored in higher temperature conditions (+13 and +22 °C).

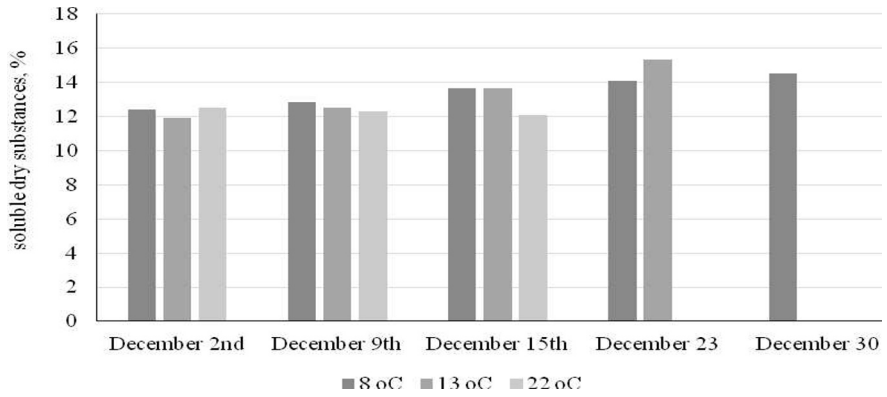

Fig. 1. Changes in the content of soluble solids at different storage temperatures of feijoa fruits.

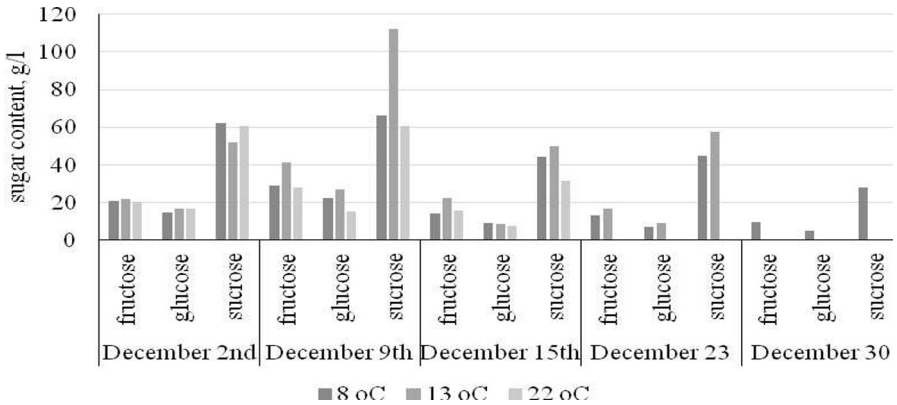

Fig. 2. Changes in the content of mono- and disaccharides at different storage temperatures of feijoa fruits.

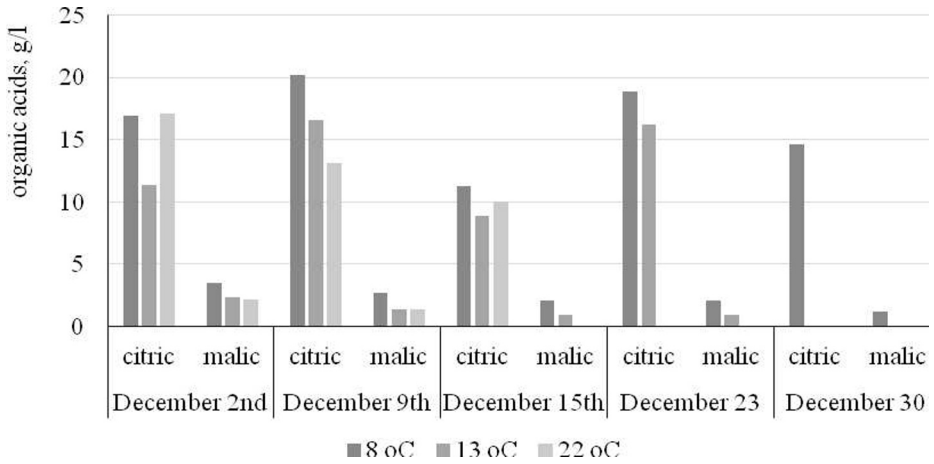

Fig. 3. Changes in the content of basic organic acids at different storage temperatures of feijoa fruits.

4 Discussion

Laboratory of Biosynthetic Processes of Plant Raw Materials Transformation of the Department of Plant Physiology and Biochemistry has been opened in the Department of Plant Physiology and Biochemistry on the basis of the FRC SSC RAS. The task facing the youth team of the laboratory is to study the fundamental processes occurring in subtropical plant raw materials during storage and processing.

Recently, on the shelves of stores, you can increasingly see such a fruit as feijoa. At the moment, the main exporter of feijoa is Thailand, and importers are China (20.65 % of the share of world imports) and the United States (20.33 %). Among residents and guests of the resort city of Sochi, feijoa is the most popular in the autumn, especially since the fruits are not export products on the shelves of the city, the culture grows well in the humid subtropics of Russia. However, there is a question of extending the time of consumption of this vitamin product as long as possible.

As you know, most subtropical fruits belong to the climacteric group, as they have a very high coefficient of respiration and heat release. This affects the ripening rate of fruits, as they ripen faster, are poorly stored and can deteriorate during prolonged transportation [19-20]. All this is fully characteristic of the fruits of feijoa. This led to a study on the storage of feijoa fruits under different temperature conditions in a normal atmosphere.

After removal from the mother plants, the processes of respiration, transpiration, etc. take place in the fruits, all that I call either "maturation" or "aging" [20]. As is known, during storage, it is at this moment that the loss of fruit weight begins to occur, which is associated with the loss of water [20-21]. At the same time, the nature of metabolic reactions changes and the content of soluble solids increases, the quantity of which determines the quality of both plant raw materials and products of its processing (juices, jams, jams, etc.). We have shown that in general, the content of soluble solids really increased, which indicates the ongoing processes of fruit ripening (figure 1). At the same time, this was most noticeable when stored at a temperature of +8 and +13 °C. At a temperature of +22 °C, there were no significantly significant changes in soluble solids, moreover, four weeks after storage, the rejection of fruits of low commercial quality began, which is associated with the formation of damage, drying, and the appearance of fruit rot. The process of fruit rejection after a month of storage also occurred at a temperature of +13 °C, as a result, from November 25 to December 30, the fruits were stored only at a temperature of +8 °C. However, at a temperature of +13 °C by the four weeks of storage, the content of soluble solids increased from 11.9 to 15.3 % (1.3 times), while at a temperature of +8 °C, the decrease in fruit weight was minimal, which also affected the growth of soluble solids, under these conditions, an increase of 1.2 times was observed only after a month of storage (figure 1).

It is known that at the beginning of fruit storage, as a rule, there is an increase in the amount of sugars, because in the first moments the synthesis processes are still continuing. Further, hydrolysis processes are included in the fruits separated from the tree, which leads to a decrease in the amount of sugars [4;9;12;20]. We have shown that at the beginning of storage (after a week), the process of increasing the amount of sugars was observed (figure 2). This was especially true with the amount of sucrose, its content in all variants of the experiment increased by 1.06-2.15 times. The largest amount of sucrose after the first week of storage was observed at a temperature of +13 °C. However, in the future, there is a containment of maturation processes, which leads to the activation of carbohydrate hydrolysis and the amount of sugars begins to fall (figure 2). A month after storage, the fructose content decreased to 9.66 g/l (a decrease of 2.2 times), glucose – to 5.05 g/l (4.3 times) in the fruits remaining only on the variant with a temperature of +8 °C. And only the amount of sucrose in this variant increased to 28.06 g/l (1.4 times the initial value).

An equally important characteristic, along with the sugar content, are organic acids. They not only determine the taste of fruits, their nutritional value, but also affect the technological qualities of raw materials (the possibility of producing jams, compotes, etc.). According to the analysis of a number of sources, during storage, the content of acids in fruits decreases, mainly malic [5;12;20]. Studies of fruits of the temperate zone (apples, pears, etc.) have shown that during storage, acids decompose faster than sugars due to their active consumption for respiration [4;20]. Moreover, experiments on the storage of apples have revealed that during prolonged storage they lose almost all the acids contained in them. And especially a significant decrease in the acid content is observed in the last storage period [5].

We have established that the leading acid in feijoa fruits is citric, its amount ranges from 11.32 to 17.09 g/l. In addition, malic acid is present in the fruit in an amount of 2.13-3.44 g/l; oxalic (on average 0.76 g/l) and tartaric (about 0.21 g/l) acids have been identified (table 1). During the first storage period (during a week), an increase in the amount of citric

acid is observed, and at a temperature of +8 °C this process is more pronounced, at the same time, the process of decomposition of malic acid is 1.3 (at a temperature of +8 °C) and 1.5-1.7 times at a temperature of +22 and +13 °C, accordingly (figure 3). After two weeks of storage in fruits laid at a temperature of +22 °C, we have not identified malic acid, and the amount of citric acid decreased in all variants by 1.3-1.8 times, depending on temperature conditions. As a result, at the end of the experiment, the content of citric acid in fruits stored at a temperature of + 8 °C decreased by an average of 1.4 times, and apple acid by 2.2 times (figure 3).

5 Conclusion

Thus, it was found that the maximum storage period of feijoa fruits taken at the stage of removable maturity is one month at a temperature of +8 °C and air humidity 36 %. During this period, there are active biochemical processes associated with the breakdown of sugars and acids. These processes are most active when fruits are stored in a normal atmosphere at a temperature of + 22 °C (humidity is an 81 %). Starting from the third week of storage on variants with a temperature of +13 and +22 °C, fruit rejection begins due to the formation of damage, the appearance of fruit rot and desiccation.

In the future, it is planned to conduct experiments to fix the dynamics of biochemical parameters and marketable quality when loading fruits for storage with pretreatment with specialized preparations.

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