The content of polyphenolic compounds in feijoa fruits in the humid subtropics of Russia

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Abstract. Experimental data on the content of total polyphenols and rutin in promising feijoa varieties selected by the Subtropical Scientific Center (Sochi, Russia) are presented. The performed analysis did not reveal a correlation between the content of rutin and polyphenols (r = 0.40), as well as a relationship between the time of fruit ripening and the amount of phenolic compounds in them. The compared varieties differ significantly in the content of polyphenols (LSD=5.67) and rutin (LSD=1.5). The results obtained revealed promising varieties with a high content of polyphenols that can be used for breeding work as sources of valuable traits and as functional food products with antioxidant activity. The highest polyphenolic content was found in fruits of cv. Dachnaja (41.16 mg/100 g of raw weight). The highest content of rutin was found in fruits of cv. Dagomysskaja (42.1 mg/100 g of raw weight), cv. Dachnaja (38.4 mg/100 g) and control cv. Superba (36.8 mg/100 g). The minimum level of synthesis of flavonoid compounds was found in the ShV-07 form. Since the factor of genotypic features of varieties is essential in the accumulation of phenolic compounds, it became possible to select an assortment characterized by an optimal content of phenolic compounds.

1 Introduction

The consumption of products that have the ability to neutralize the effects of all kinds of stress in today's environmental conditions is essential. In this regard, of particular interest are crops whose products have anti-stress, tonic, stimulating and radioprotective properties. All subtropical plants, including feijoa, fall into this category.

The major advantage of subtropical fruits is their high content of various biologically active substances of an antioxidant nature, for example, polyphenols. According to numerous studies, the most common representatives of plant polyphenols are flavonoids [1-6]. This group is quite diverse, but all compounds related to flavonoids possess similar properties: anti-inflammatory effect, P-vitamin activity, stabilizing effect relative to ascorbic acid, etc. [7-9]

The concentration of polyphenols in fruits depends primarily on genetic and environmental factors. In addition, their accumulation is affected by the degree of fruit maturity, storage, food processing, etc.

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Plants containing various types of polyphenols are the only source of raw materials for obtaining natural P-vitamin preparations with antioxidant properties.

Considering the fact that polyphenols are one of the most important groups of functional food components necessary to improve the nutritional structure and prevent a number of diseases, it is important to study the content of this group of biologically active substances in the fruits of subtropical crops.

The collection of subtropical, southern fruit and flower-ornamental crops at the Federal Research Centre the Subtropical Scientific Centre of the Russian Academy of Sciences (FRC SSC RAS) includes 2,650 variety types. Breeding work is carried out to obtain varieties with an increased content of biologically active substances of antioxidant action. One of the popular cultures among residents and guests of the resort city of Sochi is feijoa (pineapple guava). Feijoa (*Acca sellowiana* (O. Berg) Burret, syn. *Feijoa sellowiana*) is native to Paraguay, Brazil, Chile, Urguvai. The main producers of fruits are Brazil, New Zealand and Italy [10, 11]. The area of distribution of feijoa is expanding due to its ability to tolerate a decrease in temperature to -12 °C. The fruit is a berry with a thin skin and jelly-like pulp. Many experts compare the taste of fruits with pineapple and strawberries, while a unique resinous aroma is noted [11, 12]. Feijoa fruits are mainly used fresh together with the peel, which is rich in bioflavonoids. At the same time, the fruits have a number of physiological features, belong to climacteric fruits, i.e., they are harvested physiologically ripe. Fruits contribute to better digestion of food, and the content of many antioxidant substances in them makes the products of this culture valuable in nutritional value.

This work aims to assess the content of common polyphenols and rutin in feijoa fruits and identify promising varieties with a high content of polyphenols.

2 Materials and Methods

The research was conducted on varieties growing at the Feijoa plantation in the experimental and technological department of the fruit crops sector, Federal Research Centre the Subtropical Scientific Centre of the Russian Academy of Sciences (FRC SSC RAS).

Laboratory studies were carried out at the Laboratory of Plant Physiology and Biochemistry of the center.

2.1 Materials

The objects of the study were 3 promising varieties and one form of feijoa breeding center:

- cv. Dagomysskaja was bred at a private plot in the Dagomys village by M.D. Omarov in 1993. This variety has medium maturity. Fruits are sweet and sour, large, 6.9 × 5.3 cm. The average weight of one fruit is 102 g, the maximum weight is 173 g. The ratio of the weight of the pulp and peel is 78:22 %. The average fruit yield from a tree is about 33.3 kg.
- cv. Sentjabr'skaja was bred in experimental and collection plantings of the Subtropical Scientific Center by M.D. Omarov and Z.M. Omarova. Fruit ripening occurs at the very beginning of September. The fruits are sweet and sour, medium-sized, 4.8 × 3.5 cm. The average weight of one fruit is 32 g. The average yield from a tree is 9.5 kg.
- cv. Dachnaja was bred at the private sector plantings by M.D. Omarov and Z.M. Omarova in 2001. This is an arly ripening variety. The fruits are sweet and sour. Average weight of one fruit is 45.8 g. The average yield from a tree is 10.5 kg.
- Form ShV-07 was bred at the private sector plantings in the village of Razdolnoye (Sochi) by M.D. Omarov in 2007. This is the form of the average ripening period. The

fruits are sweet and sour, with a slight presence of stony inclusions. The average weight of one fruit is 41.2 g. The average yield from a tree is 10.8 kg.

The control variety is cv. Superba. It was bred in California (USA) in 1912. It was introduced to Russia in 1935. It is cultivated in the humid subtropics of Russia, Abkhazia, Georgia, Azerbaijan, being the most common, and in some cases. the only cultured variety of feijoa. The variety is self-fertile, bears fruit well without pollination, has the average ripening period (II decade of October - II decade of November). The fruits are large (6.0 × 4.3 cm), the color is emerald green, yellow-green at full maturity. The pulp is whitish, very tender, juicy, with a strong aroma. The taste is sweet and sour. Fruiting comes in the 3rd year. The average yield is 26.0 kg from a full-aged tree.

2.2 Methods

The total phenolic content was determined by the spectrophotometric method using the Folin-Ciocalteu (FC) reagent as a group reagent. The method is based on the formation of tungsten blue, which has an absorption band with a maximum of 765 nm [13].

The experimental technique was as follows: 5.0 ml of diluted FC reagent was added to the diluted and filtered juice of fresh feijoa fruits. After 5 minutes, 4.0 ml of 20% solution of Na_2CO_3 was added, stirred and kept for 30 minutes at room temperature. Although the Folin-Ciocalteu reagent interacts differently with different polyphenols, the use of gallic acid as a standard makes it possible to reliably determine the total content of polyphenols.

Flavonoid compounds with P-vitamin activity (rutin) were determined by titration by the method of vitamin analysis [14]. The quantitative determination of rutin is based on its ability to be oxidized by permanganate. Indigocarmine is used as an indicator, which reacts with permanganate after the entire rutin is oxidized.

The obtained data were processed statistically and presented in Figure in the form of arithmetic averages and their standard errors. The reliability of the differences between the variants was determined using Student's t-criteria ($p \leq 0.05$).

3 Results and discussion

The analysis of hydrothermal conditions was carried out using the data from www.pogodaklimat.ru. The analysis of weather conditions in the studied area showed that the climate is moderately warm, and the area usually has a significant (about 1514 mm per year) amount of precipitation during the year. The Köppen-Geiger climate classification represents Cfa. The lowest amount of precipitation falls in the summertime (80 mm on average), the highest amount is registered from November to January (194 mm on average), usually in the form of rain. The difference between a dry and rainy month is about 110 mm. The average air temperature is 14.5 °C, the highest temperatures are in July - August (up to 30-36 °C), the coldest months are January and February (the temperature can drop to 0 °C). In some years, short-term frosts up to -7.0 °C (1985) and -5.0 °C (2004) were observed. This affects the content of biochemical components in fruits.

Figure shows the contents of total phenols and rutin in the fruits of the studied varieties/forms of feijoa. The presented data shows that cv. Dachnaja has the highest total phenolic content (41.16 mg/100 g of raw weight). At the same time, the content of rutin shows another trend, the highest content was found in fruits of cv. Dagomysskaja (42.1 mg/100 g of raw weight). Varieties cv. Dachnaja and the control Superba have almost the same rutin content, 38.4 mg/100 g and 36.8 mg/100 g, respectively. Form ShV-07 contains the smallest amount of both polyphenols (25.48 mg/100 g of raw weight), and rutin (22.9 mg/100 g of raw weight).

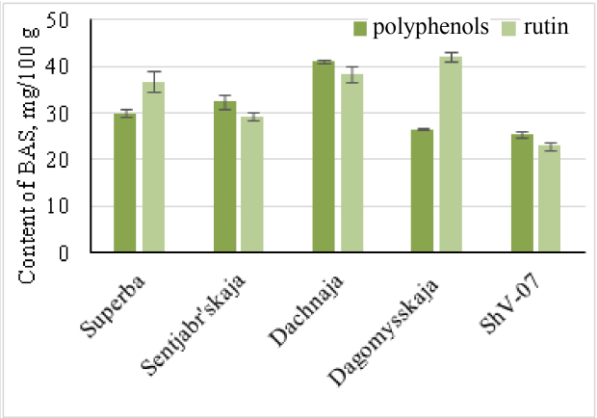

Fig. 1. The content of biologically active substances (BAS) in feijoa fruits

The feijoa fruits grown in the subtropical conditions of Russia have lower content of total polyphenols that that grown in other conditions. For example, Ebrahimzadeh et al. [15] showed that the content of polyphenols in fruits from Iran ranges from 44.17 to 89.07 mg/100 g, which is twice as high as in our samples. The works of Van Acker et al. [16] established that high antioxidant activity of extracts from feijoa fruits was due to the high content of total polyphenols (220.2 - 460.5 mg/100 g on average). This difference is explained by climatic conditions, since the subtropical zone of Russia is located on the northern border of the spread of this crop.

The synthesis of phenolic compounds in feijoa fruits is completed by the time of harvest and their quantitative content depends primarily on varietal characteristics. The conducted dispersion analysis showed that the studied varieties differ significantly in the content of polyphenols (LSD=5.67) and rutin (LSD=1.53). Significantly higher accumulation of polyphenols is observed in the Dachnaja variety, as for the rutin content, varieties Dachnaja and Dagomysskaja prevail. Since the factor of genotypic features of varieties is essential in the accumulation of phenolic compounds, we had the opportunity to select an assortment characterized by an optimal content of phenolic compounds.

Many scientists associate the level of antioxidant activity with the chemical composition of fruits [17, 18]. Their quality is assessed by the content of the main compounds that determine the nutritional and technological qualities of the product. Earlier, the qualitative indicators included the content of solids, sugars and organic acids, but now due to the increasing role of phenolic compounds in the prevention of oxidative stress, indicators of antioxidant activity are necessarily taken into account the content of phenolic compounds [18, 19]. Analysis of the obtained data on the content of various phenolic compounds did not reveal a correlation between the content of rutin and polyphenols ($r = 0.40$) in feijoa fruits. Also, we did not noted a relationship between the ripening dates of fruits and the amount of phenolic compounds in them.

4 Conclusion

The performed analysis of the accumulation of phenolic compounds revealed samples with the maximum level of biosynthesis of total polyphenols and compounds with P-vitamin activity. The maximum content of both groups of substances is typical of the early ripening variety Dachnaja, the minimum level of synthesis was found in the ShV-07 form.

The obtained data allow us to evaluate the antioxidant properties of the studied fruits. The varieties with a high content of these biologically active substances are recommended as sources of economically valuable traits and foods with a high antioxidant effect. At the next stage, the task is to find out the change in the amount of phenolic compounds during fruit storage in order to select the most stable feijoa varieties in terms of antioxidant content.

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