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Quality of the Pulp of Passion Fruit Produced in the Brazilian Savanna

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Abstract

Because it is a species of tropical climate, the passion fruit is distributed widely in South America, mainly in Brazil. Its cultivation represents approximately 95% of the commercial orchards of the country, nevertheless, it presents productivity below its productive potential, being necessary to obtain cultivars adapted to the climate of the regions of culture. The objective of this work was to evaluate the quality of the fruit pulp of yellow passion fruit produced in Jataí-GO as well as the correlations between some physical and chemical characteristics. The fruits were collected in an experimental orchard and sectioned transversely to obtain the pulp. The characteristics of acidity, vitamin C content, soluble solids content, soluble solids/acidity ratio (Ratio), and pulp color parameters were evaluated through the coordinates L*, a*, b*, C* and h* of yellow passion fruit and of the cultivar FB 200. Data were analyzed by means of analysis of variance and Pearson's correlation at 5% of significance with the aid of the statistical program Rbio. It is concluded that the characteristics of the fruits of the cultivar FB200 differed from the fruits of yellow passion fruit and that these characteristics correlated significantly and positively.

Keywords: antioxidants, cultivar FB 200 "Yellow Master", chemical characteristics, *Passiflora edulis* Sims

1. Introduction

The yellow passion fruit (*Passiflora edulis* Sims) is the main species of the genus *Passiflora* commercially exploited in Brazil (Casagrande, Machado, Silva, & Canteri, 2017). It is a native species of South America, in which Brazil leads the ranking of the world's largest producer, followed by countries like Colombia, Peru and Ecuador (Coelho, Oliveira, Resende, & Thiébaut, 2011). It presents a socioeconomic appeal for the widespread use of family labor, being much cultivated by small producers (Jesus, Carvalho, Girardi, Rosa, & Jesus, 2018).

Corresponding to approximately 95% of the country's commercial orchards, the fruits of this species are preferably destined for the juice processing industry and for the fresh fruit market (Aguiar, Zaccheo, Stenzel, Sera, & Neves, 2015). For this, the fruits must meet the standards required by each consumer market, and for the juice industry the soluble solids content, pulp acidity and flavor expressed by the ratio of soluble solids and acidity are very important characteristics (Medeiros et al., 2014).

The fruits of this species are widely marketed in the fresh fruit market for in natura consumption, however, there is a growing demand for the use of these fruits in the form of processed products such as ice cream, jellies, cosmetics and beverages, with juice being the main by-product (Melletti, 2011; Venâncio et al., 2013). In order to meet the needs of the consumer markets, the pulp quality must meet the required standards (Medeiros, 2014).

By default, the juice processing industry requires a minimum soluble solids content of 13 °Brix, and the higher this value, the less sugar will be added to the pulp at the time of processing, and the less fruit will be required for the ideal juice concentration, in addition to using smaller amount of pulp to juice concentrate preparation (Aguiar et al., 2015). It is known that these levels fluctuate depending on the stage of ripening of fruit and the place of cultivation (Flores, Silva, Bruckner, Oliveira, & Salomão, 2011).

High acidity gives a longer post-harvest shelf life and vitamin C plays an antioxidant role participating in several reactions in the human body (Araújo, Castro, Rodrigues, Rêgo, & Uchôa, 2017). For the juice processing market the high acidity is a desired characteristic, however, when these fruits are intended for the fresh fruit market, low acidity levels are preferred. The ideal levels demanded by the consumer market are between 2.9 and 5.0% (Silva, Ataíde, Santos, & Souza, 2016a).

Currently, Brazil produces 14 tons ha^{-1} $year^{-1}$ of fruits, much lower than the productive potential of this species, which is around 40 tons ha^{-1}, due to the lack of cultivars adapted to the climatic conditions of the region (Jesus et al., 2018). It is necessary to obtain commercial cultivars adapted to fruit producing regions to improve fruit quality and increase yield (Aguiar et al., 2015).

The cultivar FB 200 Yellow Master® (*Passiflora edulis* Sims. *f. flavicarpa* Deg.) is intended for processing and the fresh market, presenting about 36% yield of juice and 14 °Brix, has high productive potential and presents fruits with uniform size, shape and color (Boechat, Teixeira, Costa, & Souza, 2010).

Brazil has been emphasizing production in passion fruit production, with Bahia and Ceará being the main producing states (Almeida, Silva, Cabral, Matos, & Meneguci, 2015). Despite the low yield of this species in the state of Goiás (6.099 tons), the region of Southwest of Goiás presents the climatic conditions necessary for the development of the crop (Pereira et al., 2018). This work aimed to evaluate the quality of the pulp of yellow passion fruit produced in Jataí, Brazil, as well as the correlations between some physical and chemical characteristics.

2. Materials and Method

In order to determine the physical and chemical quality of the pulp of yellow passion fruit (*Passiflora edulis* Sims) and of the cultivar FB 200 “Yellow Master” (commercial cultivar) (*Passiflora edulis* Sims *f. flavicarpa* Deg.) of the Flora Brazil nursery (Araguari-MG), all fruits of each plant were collected in the experimental orchard at 17º53′ of Latitude South, 51º43′ Longitude West and 670 meters high. The orchard is composed of 60 plants with 20 blocks for each genotype.

After the harvest, the fruits were brought to the laboratory where they were washed, separated and each fruit was numbered for the fruit draw with the aid of a smartphone application called “random number”. Afterwards, the fruits were cut in half, the mucilage and the seeds were removed and transferred to a blender, where the pulp was extracted using the pulse function.

The samples were mixed and homogenized, and the following fruit pulp characteristics were evaluated: titratable acidity, vitamin C, soluble solids content and instrumental color parameters L*, a*, b*, C* and h*.

To determine the titratable acidity were placed 5 mL of pulp measured with a pipette in erlenmeyer with capacity for 250 mL, plus 100 mL of distilled water. Three drops of phenolphthalein were used as the indicator and the titration was done with NaOH 0.1 N, standardized with potassium biftalate, according to the methodology proposed by the Adolfo Lutz Institute (2008). The results were expressed as percent citric acid (%).

Soluble solids contents were obtained through refractometry using an Atago® portable refractometer, where a few drops of the pulp were placed in the apparatus and read. Values were expressed as °Brix.

The ratio between the soluble solids content and the titratable acidity was obtained between the two variables.

To determine the vitamin C content of the samples, the methodology described by AOAC (1997) was used, titrating with Tillman [2,6-dichlorophenolindofenol (0.1% sodium salt)] reagent. For this, 2 mL of pulp was placed in Erlenmeyer and 50 mL of 1% oxalic acid solution and titrated with dichlorophenolindofenol solution (DCPIP) until persistent pink color was obtained. Results were expressed as mg/100 mL.

To determine the color parameters of the pulp was used a Konica Minolta® colorimeter model CR-10, where reading was performed to obtain the characters L*, a*, b*, C* and h*. The coordinate L* represents the brightness of the sample, which ranges from 0 (black) to 100 (white), the character a* indicates the predominance of green and red, ranging from +60 to -60, where a* positive (red) and a* negative (green), the character b* represents the predominance of blue and yellow, ranging from +60 to -60, where b* positive (yellow) and b* negative (blue). The angle Hue (°h*) is a measure derived from a* and b* and assumes zero value for red, 90° for yellow, 180° for green and 270° for blue.

The experimental design was a randomized block with three replicates, in 20 blocks, totaling 60 samples for each genotype. The data were submitted to analysis of variance, tested by the F test with 5% significance and tested by Pearson’s Correlation at 1 and 5%. The calculations for the statistical analyzes were performed using the Rbio program (Bhering, 2017).

3. Results and Discussion

It was observed that the acidity, vitamin C and soluble solids of the pulp from the cultivar differed significantly from the fruits of yellow passion fruit at 5% significance and that the ratio of the fruits did not differ from each other (Table 1).

Table 1. Acidity (% citric acid), Vitamin C (mg/100 ml), Soluble Solids Content (°Brix) and Soluble Solids/Acidity (Ratio) of pulp of yellow passion fruit and of cultivar FB200. Jataí-GO, 2018

	Acidity	Vitamin C	Soluble solids	SS/AT (ratio)
FB200	5.34±0.6	63.59±17.41	11.32±1.66	2.119
Yellow	4.56±0.63	43.94±7.50	9.64±1.64	2.114
F	72.94*	114.53*	36.87*	0.06 ns
CV (%)	10.11	18.70	14.48	16.08

Note. *: Significant at 5%, ns: Not significant at 5%.

Note to the characteristic titratable acidity that the fruits of the cultivar FB 200 presented 5.34% of citric acid and the fruits of yellow passion fruit 4.56%. This characteristic is very important for fruits destined to the industry, allowing the reduction of acidifiers in the processing (Aguiar et al., 2015). Jesus et al. (2018), evaluating fruits of the cultivar FB 200 in the state of São Paulo obtained 4.92% of citric acid, and the high acidity of the pulp guarantees a longer life at the time of processing. Lower acidity levels were observed in yellow passion fruit fruits produced in the São Francisco Valley by Silva et al. (2016a), where 3.7% of citric acid was obtained. The citric acid content decreases as the fruit maturity increases (Araújo et al., 2017), and can be influenced by environmental factors and fertilizer dosages (Aguiar et al., 2015). These results demonstrate that the fruits analyzed in this work have the potential to be absorbed by the industry due to the high acid content present in the fruit pulp.

For the characteristic vitamin C content, it was observed that the contents of cultivar FB 200 differed statistically from yellow passion fruit, demonstrating that the pulp of the FB 200 has a greater amount of vitamin C. According to Morais, Xavier, Silva, Oliveira, and Bruckner (2017), the content of vitamin C in fruits differs between cultivars and crops. Medeiros et al. (2014), evaluating the vitamin C content in yellow passion fruit fruits under different doses of biofertilizers obtained 15.65 mg/100 mL, much lower than those obtained in the present study, and the respective authors point out that the production of vitamin C is related to the sugar content present in the fruits.

Regarding the soluble solids content, the fruits of the cultivar FB 200 presented 11.32 °Brix, whereas the fruits of yellow passion fruit had 9.64 °Brix. The soluble solids content is a very important characteristic because it determines the amount of sugars present in the fruits (Morais et al., 2017). According to Jesus et al. (2018), fruits destined for the processing must have soluble solids content around 13 °Brix, and the authors obtained 15 °Brix for fruits of the cultivar FB 200. Silva et al. (2016a), found values of 12.9 °Brix for fruits of yellow passion fruit. It is known that the environment where the fruits are produced influence some characteristics of fruit quality, such as the soluble solids content (Botelho et al., 2016).

The Ratio for fruits of cultivar FB 200 and of yellow passion fruit was 2.11, Jesus et al. (2018) found a 3.03 ratio for fruits of cultivar FB 200 in the State of São Paulo. Silva et al. (2016a) evaluating yellow passion fruit fruits produced in the Bahia state obtained a ratio between SS and TA of 3.7. The ratio between solid solubles and titratable acidity is a way of evaluating fruit flavor, these contents can be influenced by sunlight, temperature and management practices (Aguiar et al., 2015). The ratio indicates the flavor of the pulp, and the higher its value, the sweeter the pulp (Silva et al., 2016a).

According to Table 2, the L* coordinate of the pulp of the fruits of cultivar FB 200 does not differ statistically from the fruits of yellow passion fruit, however, the coordinates a, b, C and h of the fruit pulp differ significantly from each other at 5% of probability, indicating that the brightness of the samples are the same and that the colors of the samples are different.

For the L* coordinate, the fruits of the cultivar FB 200 and yellow passion fruit presented lower values than the average brightness, indicating that both samples had dark colors.

For the a* coordinate, the fruit pulp of the FB 200 obtained an average value of 1.97 and the fruits of yellow passion fruit 1.40, indicating that the predominance of red was greater in the fruits of the cultivar, being the pulp of these fruits has a stronger coloration.

Table 2. Color parameters for the fruit pulp of yellow passion fruit and cultivar FB 200. Jataí-GO, 2018

	CL*	Ca*	Cb*	CC*	Ch*
FB200	36.95±5.33	1.97±1.59	3.57±5.03	4.02±2.22	92.33±41.90
Yellow	37±1.61	1.40±0.58	1.81±1.20	2.53±1.20	132.72±27.87
F	0.005^{ns}	8.78*	8.12*	29.35*	63.29*
CV (%)	10.19	62.29	125.53	46	24.71

Note. *: Significant to 5%, ns: Not significant at 5%. CL: Coordinate L, Ca: Coordinate a, Cb: Coordinate b, CC: coordinate C, Ch: coordinate h.

The b* coordinate of the fruits pulp of the cultivar FB 200 presented an average value of 3.57, whereas the fruits of yellow passion fruit had values of 1.81. These values demonstrate that the predominance of yellow is higher in the fruit pulp of the cultivar FB 200.

The Hue angle of the fruits pulp indicates that the fruits of the cultivar FB 200 presented 92.33 °h* and the fruits of yellow passion fruit 132.72 °h*, these values represent the intensity of predominant coloration of the pulp, indicating that the fruits of the cultivar have pulp in yellow tone closer to red and the fruits of yellow passion fruit have pulp in shades of yellow closer to the green.

For the industry these are characteristics of extreme importance, since the pulp of passion fruit must have orange coloration (Medeiros et al., 2009). This coloring allows that at the time of juice processing, less dyes are used. According to Meletti (2011), the strong yellow-colored pulp indicates higher levels of vitamin C and because this is a characteristic desired by the juice processing industry, new cultivars are obtained in order to meet the demands of the consumer market, which is why the fruits of the cultivar FB 200 present a more intense pulp coloration.

It was observed that there was a positive and significant correlation between vitamin C and acidity (0.017*), indicating that the two characteristics are related to each other, which means, as the fruit acidity increases, vitamin C content also increases (Table 3).

Likewise, a positive and significant correlation was observed between acidity and soluble solids content (0.048*), indicating that one characteristic may can be influenced by the other.

Table 3. Pearson's correlation coefficients obtained among the physical and chemical characteristics of yellow passion fruit pulp and cultivar FB 200. Jataí-GO, 2018

	Acidity	Vitamin C	SS	CL*	Ca*	Cb*	CC*
Vitamin C	0.017*						
SS	0.048*	0.167*					
CL*	0.117*	-0.201*	-0.053*				
Ca*	0.223*	-0.053*	0.096*	0.148*			
Cb*	-0.047*	-0.145*	-0.045*	-0.090*	-0.185*		
CC*	-0.020*	0.015*	0.032*	0.170*	0.348^{ns}	0.410^{ns}	
Ch*	0.372^{ns}	0.002*	-0.420^{ns}	-0.090*	-0.481^{ns}	-0.139*	-0.418^{ns}

Note. *: Significant to 5%, ns: Not significant at 5%. SS: Soluble Solids content, CL: coordinate L, Ca: coordinate a, Cb: Coordinate b, CC: coordinate C, Ch: coordinate h.

The levels of vitamin C and soluble solids correlated positively and significantly between each other (*0.167), indicating that as the vitamin C content increases, so does the soluble solids content.

The Hue angle showed a positive and non-significant correlation with the acidity (0.372^{ns}) and the soluble solids content showed a negative and non-significant correlation with the Hue angle (-0.420^{ns}), indicating that these characteristics are not correlated with each other.

Through the study of correlations it is possible to predict the effects of a characteristic when the characteristic correlated to it is manipulated for selection purposes (Giles et al., 2016), however, when a characteristic has positive correlation with some characteristics and negative with others, the selection must be careful, since can generate changes in other characteristics (Silva et al., 2016b).

4. Conclusions

The characteristics acidity, vitamin C content and soluble solids content of fruits of cultivar FB200 differed from yellow passion fruit, presenting higher values. These characteristics also correlated positively and significantly. In this study it was observed that some characteristics such as soluble solids contents are below the values demanded by the consumer market, indicating the need to obtain cultivars adapted to the climatic conditions of the region.

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