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Aspects of the sensorial quality and nutraceuticals of *Plinia cauliflora* fruits

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ABSTRACT. Nationally known in Brazil, the jabuticabeira or jabuticaba tree produces fruits of wide commercial acceptance. However, little use of jabuticaba in commercial orchards and large genetic erosion of jabuticaba caused by human activities in its habitats have been historically observed. Thus, the goal of this study was to characterize fruits of the jabuticaba tree (*Plinia cauliflora*) in a forest fragment maintained in southwestern Paraná State in an attempt to identify trees with superior fruits for future selection as cultivars or male genitors. To this end, 15 variables linked to sensory and biochemical characteristics of harvested fruits were analysed during two years of production. Twenty percent of the genotypes that showed the highest frequency of superiority in the evaluated characteristics were preselected for analysis. The quality of the analysed fruits indicated their potential for use. Thus, this work resulted in the preselection of jabuticaba genotypes 7, 42, 43, 47, 54, 91, 97, 104, 105, 118, 134, 153, 154, 157, 163, 169, 177, 186, 212, J7-01, and J7-02, with 16 and 194 the only genotypes that had already been selected for superior characteristics during both growing cycles.

Keywords: Myrtaceae, phenotypic variability, biochemical characteristics.

Aspectos de qualidade sensorial e nutracêutica de frutos de *Plinia cauliflora*

RESUMO. Nacionalmente conhecida, a jabuticabeira possui frutos de ampla aceitação comercial. Todavia, o que se viu historicamente foi a pouca utilização da mesma em pomares comerciais e a ampla erosão genética ocorrida pela ação antrópica em seus habitats. Dessa forma, o objetivo deste trabalho foi caracterizar frutos de jabuticabeiras (*P. cauliflora*) de fragmento florestal mantido no sudoeste do Estado do Paraná, buscando-se identificar aquelas denominadas superiores para seleção como futuro cultivar ou genitor masculino. Para tal, foram analisadas 15 variáveis ligadas as características sensoriais e bioquímicas que os frutos colhidos apresentaram durante dois anos de produção. Como critério de pré-seleção foi adotada a escolha de 20% dos genótipos que apresentaram a maior frequência de superioridade nas características avaliadas. A qualidade das frutas analisadas demonstrou potencialidade para uso. Dessa forma, o presente trabalho permitiu pré-selecionar as jabuticabeiras 7, 42, 43, 47, 54, 91, 97, 104, 105, 118, 134, 153, 154, 157, 163, 169, 177, 186, 212, J7-01 e J7-02, sendo a 16 e 194 as únicas que já podem ser selecionadas pelas características de superioridade entre ambos ciclos.

Palavras-chave: Myrtaceae, variabilidade fenotípica, características bioquímicas.

Introduction

The jabuticaba tree (*Plinia* sp., synonym *Myrciaria* sp.) belonging to the Myrtaceae family (subfamily Myrtoideae, tribe Myrteae, subtribe Eugeniinae) is endemic to Brazil. This tree occurs in the Atlantic Forest biome, with Paraguay and Argentina as secondary centres. Nine species are known; some species have already been classified as endangered, of which only three are natural and cultivated in Brazil: *Plinia trunciflora* (O. Berg) Kausel, *P. cauliflora* (Mart.) Kausel, and *P. jaboticaba* (Vell.) Kausel (Citadin, Danner, & Sasso, 2010).

These three native species of jabuticaba (*P. cauliflora*, *P. Trunciflora,* and *P. jaboticaba*) present some distinctive phenotypic characteristics that are easy to recognize as described by Danner, Citadin, Sasso, Scariot, and Benin (2011a).

The acceptance of jabuticaba in the consumer market is almost unanimous because of its pleasant taste and its many functional properties, such as the presence of vitamins (Giacometti & Lleras, 1994), flavonoids (Danner et al., 2011a) and anthocyanins (Santos, Veggi, & Meireles, 2010; Danner et al., 2011a), as well as its antioxidant effects against free radicals (Sá et al., 2014).

The lack of knowledge concerning the production and feeding potential of jabuticaba still results in its low use. Low use of jabuticaba contributes to its genetic erosion, especially in places where the fruit is harvested for extraction. To prevent overgrowth, the usual option is to dispose of the plants. Thus, it is imperative to conduct basic studies to find existing genotypes in their natural habitat, analyse the sensory and functional characteristics of their fruits for later selection and make recommendations for cultivation in orchards, especially give their advantage of already being adapted to local conditions, if any selection is desired.

Given the above points, the objective of this study was to characterize jabuticaba (*P. cauliflora*) fruits in a forest fragment maintained in Clevelândia (Paraná State, Brazil), for the presence of phenotypic variability, seeking to identify superior traits for selection as future cultivars or male genitors.

Material and methods

Area Characterization

The study was conducted using a population of jabuticaba trees (*Plinia cauliflora* (Mart.) Kausel) in a fragment of mixed rainforest and Araucaria moist forest (26°26'17" S; 52°19'20" W; 963 m above sea level) located in the municipality of Clevelândia in the southwestern Paraná region, with an area of 12.3 hectares and 930 adult jaboticaba trees (Danner, Citadin, Sasso, & Tomazoni, 2010).

The climate classification (Köppen) of the chosen site is Cfb (humid subtropical without a dry season and with a mild summer), with severe winters (average temperatures below 18°C), frequent frosts and average summer temperatures below 22°C. The average annual rainfall is between 1,900 and 2,200 mm (Alvares, Stape, Sentelhas, Gonçalves, & Sparovek, 2013).

Due to the high number of individuals of the *P. cauliflora* species in the area, plots of one hectare (10,000 m^2) were defined in a grid system with an interval of 10 m and divided into 100 subplots of 100 m^2.

Fruit Harvesting

Sixty fruits of 70 genotypes were harvested in 2013, and 80 fruits of 56 genotypes in 2014 (Table 1). Some genotypes had their identifications removed, namely, those identified as 54, 106, 169, and 212 that were sampled in 2013. In a numerically equivalent way, genotypes J7-01, J7-02, 345, and 347, measured in 2014 (Table 1), lost their identification after being harvested in 2013 and were given new codes of identification during the harvest in 2014. As result, it is possible that these renamed genotypes were evaluated in 2013; however, there is no way to distinguish them.

Table 1. Genotypes of jabuticabeira trees with fruits collected in the years of 2013 (70 genotypes) and 2014 (56 genotypes). The genotypes sampled are divided in three groups, being the ones sampled only in 2013 in Group 1 (G1), the ones sampled in both years in Group 2 (G2) and the ones samples in the year of 2014 in Group 3 (G3).

Groups	Genotypes
Genotypes exclusive of 2013 (G1)	9, 20, 21, 30, 43, 46, 48, 52, 54, 58, 59, 72, 81, 87, 89, 90, 91, 95, 97, 103, 106, 113, 126, 134, 151, 154, 157, 161, 169, 174, 182, 186, 187, 192, 195, 212, 217
Genotypes analysed in 2013 and 2014 (G2)	10, 11, 16, 35, 41, 42, 47, 49, 57, 65, 79, 80, 88, 96, 98, 100, 101, 102, 104, 105, 107, 108, 117, 118, 119, 120, 148, 162, 163, 166, 177, 194, 204
Genotypes exclusive of 2014 (G3)	1, 2, 4, 5, 7, 14, 22, 26, 28, 68, 70, 93, 109, 112, 116, 136, 144, 153, 191, J7-01, J7-02, 345, 347

Shortly after harvest, the fruits were placed in plastic bags, which were labelled with the source tree, to the Plant Physiology Laboratory of UTFPR - Campus Dois Vizinhos. Shortly after the fruits arrived at the laboratory, the peel, pulp and seeds were separated, and physical tests were performed. The pulp was stored in a freezer (-18°C) for further analysis. For the tests, the harvested fruits were divided into four batches that constituted the repetitions, with batches of 15 fruits in 2013 and 20 fruits in 2014.

Physicochemical and Biochemical Tests

Physical tests were performed separately for each fruit. The equatorial and polar diameters (mm) were measured using a 6” digital calliper. The total fresh weight (g), fresh weight of the peel (g) and fresh weight of seeds (g) were obtained by determining the difference in the fresh weight of pulp (g) using a precision scale (*Beel Enginnering*). The percentage of pulp (%) was estimated by the equation (mass of pulp (g)) / (fruit mass (g)) × 100, and the total soluble solids (TSS; Brix) was determined using a digital refractometer (*Soloeste RTD-45*).

The pulp stored in the freezer at -18°C was used for chemical and biochemical tests that measured proteins, total sugars, anthocyanins, flavonoids, phenols and total titratable acidity (TTA). The TSS/TTA ratio was estimated by simple division of the means of repetitions of TSS by TTA. The TTA was determined using a digital burette and pH metre and titrating 0.1 N NaOH of standard solution into a solution composed of 10 mL of homogenized pulp sample in 90 mL of distilled water (pH 8.2). The results were expressed in grams of CAE (g CAE) (CAE: citric acid equivalent per 100 mL) (Zenebon, Pascuet, & Tiglea, 2008).

The content of soluble proteins was determined following the method described by Bradford (1976), with bovine serum albumin (BSA) as the standard protein. The results are expressed as micrograms (μg) of protein per gram of pulp (μg g^{-1}). The total sugar content was determined by the phenol sulfuric method described by Dubois, Gilles, Hamilton, Rebers, and Smith (1956), with glucose as the standard sugar. The results are expressed as milligrams of total sugars per gram of pulp (mg g^{-1}).

To determine the anthocyanin and flavonoid content, the methodology described by Lees and Francis (1972) was used. The results are expressed as milligrams of flavonoids and anthocyanins per 100 grams of pulp (mg 100 g^{-1}). The content of total phenol compounds was determined using the spectrophotometric Folin-Ciocalteu method described by Singleton, Orthofer, and Lamuela (1999), using gallic acid as a reference standard. The results of total phenols were expressed in milligrams of gallic acid equivalents (GAE) per 100 g of sample (mg GAE 100 g^{-1}).

Data analysis

Fifteen variables were analysed: equatorial diameter (ED; mm), polar diameter (PD; mm), fresh weight of the fruit (FW; g), fresh weight of the peel (FP; g), fresh weight of the seeds (FS; g), fresh weight of the pulp (FPe; g), percentage of the pulp (PULP; %), total soluble solids (TSS; Brix), total titratable acidity (TTA; g CAE), total soluble proteins (TSP; μg g^{-1}), total sugars (SUGARS; mg g^{-1}), flavonoids (FLAV; mg 100 g^{-1}), anthocyanins (ANT; mg 100 g^{-1}) and total phenols (FT; mg GAE 100 g^{-1}) as well as the TSS/TTA ratio.

The mass of the fresh seed material was used as a criterion for preselection and was replaced by the TSS/TTA in the average cluster analysis using the Skott-Knott test. The data of the variables that were not normally distributed according to the Lilliefors normality test at the 5% significance level were transformed by the equation $\sqrt{(x+1)}$ to perform the analysis of variance (ANOVA, F test). In 2013, these variables included the polar diameter, fresh weight of the fruit, fresh weight of the peel, fresh weight of seeds, fresh weight of pulp, total titratable acidity, total soluble proteins, total sugars, flavonoids, anthocyanins and total phenols; in 2014, the variables included the fresh weight of the peel, fresh weight of seeds, percentage of pulp, total titratable acidity, total sugars, flavonoids, anthocyanins, and total phenols.

Analysis of variance was performed using a completely randomized design with four replications and each experimental unit consisting of 15 or 20 fruits per year for 2013 and 2014, respectively. The means were compared by the original Scott-Knott test using the GENES software program (Cruz, 2013). The preselection criterion was 20% of the genotypes that showed the highest frequency of superiority in the evaluated characteristics.

To calculate the frequency, the genotypes were ranked in each of the 15 variables, from 1st to either 70th or 56th (for 2013 or 2014, respectively). The genotypes were classified by the means obtained from the variables in descending order, with the exception of the mass variables of the peel and total titratable acidity, which were sorted in ascending order, and the lowest values were sought. The position of the rank of each genotype for each variable was summed. The genotypes were then classified in ascending order based on the total sum. For each assessment year, the genotypes positioned among the top 20% were selected (up to 14th in 2013 and to 11th in 2014).

Results and discussion

According to the results obtained in 2013, all variables were significant in relation to the analysed genotypes. In 2014, significant results were repeated for all the variables, but when the protein means were submitted to the cluster test described by Scott & Knott, there was no significant difference between genotypes.

The equatorial diameter of the harvested fruits in 2013 led to the formation of four groups with the highest means among the 12 genotypes (72, 212, 162, 54, 16, 96, 91, 30, 41, 186, 97, and 89). The formation of the same four groups was also observed for polar diameter, but these four groups were composed of 14 superior genotypes, including 91, 16, 72, 30, 212, 54, 186, 162, 177, 96, 103 154, 41, and 97 (Table 2).

There was further similarity in the 2013 results, with genotypes 91, 16, 72, 30, 212, 54, 186, 162, 96, 41, and 97 being superior in both variables (Table 2).

However, these superiorities did not repeat in the next growing cycle, with 5 and 4 groups formed in 2014. In 2014, two jabuticaba trees (7 and 105) were selected for having superior equatorial diameter; eight (7, 105, J7-01, 88, 16, 118, 2, and 108), for polar diameter (Table 3). However, the two individuals classified as having a superior equatorial diameter also had a superior polar diameter.

Table 2. Grouped means of nine physicochemical variables of jabuticaba's fruit quality collected in 2013 from 70 genotypes in Clevelândia-PR: equatorial diameter (ED), polar diameter (PD), fresh weight of the fruit (FW), fresh weight of the peel (FP) and pulp (MPe), percentage of pulp (PULP), total soluble solids (TSS), total titratable acidity (TTA), and TSS/TTA ratio (TS /TTA).

Genotype	ED (mm)	PD (mm)	FW (g)	FP (g)	FPe (g)	PULP (%)	TSS (°Brix)	TTA (g EAC)	TSS/TTA
9	22.0 b[1]	21.4 b	6.62 a	3.67 a	2.58 b	39.0 b	9.24 b	1.22 a	7.8 d
10	21.8 b	20.7 c	6.01 b	2.82 d	3.00 b	50.0 a	8.72 c	0.77 b	11.4 c
11	21.0 d	20.4 c	6.27 b	2.98 d	3.07 a	48.9 a	7.50 d	1.11 a	7.7 d
16	22.9 a	22.4 a	7.61 a	3.32 b	4.01 a	52.8 a	9.47 b	0.47 b	20.3 a
20	21.7 b	21.0 c	6.45 b	3.41 b	2.84 b	44.1 b	8.56 c	1.15 a	7.7 d
21	20.8 d	20.2 d	5.84 b	3.24 c	2.42 b	41.4 b	9.12 b	1.32 a	6.9 d
30	22.8 a	22.3 a	7.73 a	3.88 a	3.57 a	46.2 a	8.81 c	1.28 a	7.9 d
35	20.8 d	19.8 d	5.95 b	2.92 d	2.67 b	44.8 b	9.29 b	1.33 a	7.1 d
41	22.7 a	21.7 a	7.09 a	3.23 c	3.63 a	51.2 a	8.79 c	0.44 b	20.2 a
42	21.1 c	20.3 d	6.18 b	3.03 c	2.91 b	47.0 a	8.19 d	0.62 b	14.0 b
43	22.1 b	21.2 b	6.75 a	3.48 b	2.99 b	44.3 b	8.99 c	0.76 b	12.2 c
46	20.9 d	20.2 d	5.92 b	2.97 d	2.69 b	45.4 a	8.67 c	1.12 a	7.9 d
47	21.7 c	20.7 c	6.28 b	2.97 d	3.08 a	49.1 a	9.25 b	0.80 b	11.6 c
48	20.7 d	20.0 d	5.78 b	2.77 d	2.76 b	47.7 a	8.65 c	0.88 b	9.9 c
49	21.5 c	20.8 c	6.48 b	3.42 b	2.83 b	43.7 b	9.83 b	0.77 b	13.2 b
52	21.5 c	21.1 b	6.60 b	3.14 c	3.10 a	47.0 a	7.80 d	1.31 a	6.8 d
54	23.1 a	22.1 a	7.55 a	3.67 a	3.61 a	47.9 a	9.28 b	0.51 b	18.9 a
57	22.2 b	21.7 b	6.88 a	3.83 a	2.83 b	41.2 b	10.09 a	0.93 b	11.9 c
58	20.2 d	20.0 d	5.75 b	2.85 d	2.66 b	46.1 a	7.98 d	1.39 a	6.9 d
59	21.9 b	20.9 c	6.24 b	3.17 c	2.74 b	43.8 b	9.55 b	0.81 b	12.4 c
65	20.3 d	19.6 d	5.66 b	2.97 d	2.47 b	43.6 b	8.40 d	1.04 a	8.2 d
72	23.4 a	22.4 a	7.91 a	4.12 a	3.45 a	43.6 b	10.54 a	0.64 b	16.5 b
79	21.8 b	21.0 c	6.32 b	3.40 b	2.58 b	40.8 b	9.27 b	0.98 a	9.7 c
80	22.1 b	21.5 b	7.11 a	3.15 c	3.59 a	50.5 a	8.56 c	0.58 b	15.6 b
81	21.8 b	21.0 c	6.77 a	3.25 c	3.19 a	47.0 a	8.65 c	0.93 b	9.5 c
87	21.3 c	20.6 c	6.26 b	3.05 c	2.84 b	45.4 a	8.43 d	0.92 b	10.1 c
88	21.6 c	21.0 c	6.37 b	3.45 b	2.64 b	41.5 b	8.18 d	1.30 a	6.5 d
89	22.5 a	21.6 b	6.99 a	3.43 b	3.33 a	47.6 a	9.17 b	0.91 b	10.2 c
90	20.4 d	19.6 d	5.32 b	2.73 d	2.33 b	43.8 b	8.98 c	1.03 a	8.8 d
91	22.8 a	22.6 a	7.72 a	3.75 a	3.74 a	48.5 a	10.02 a	0.79 b	14.3 b
95	21.0 d	20.3 d	6.70 a	2.78 d	3.58 a	52.8 a	8.98 c	1.06 a	9.1 c
96	22.8 a	21.9 a	7.48 a	3.74 a	3.54 a	47.3 a	8.95 c	0.93 b	10.3 c
97	22.6 a	21.7 a	7.30 a	3.55 b	3.51 a	48.1 a	9.26 b	0.66 b	15.2 b
98	20.6 d	20.1 d	5.82 b	2.95 d	2.56 b	44.0 b	8.70 c	0.96 b	9.1 c
100	21.0 d	20.4 d	5.93 b	2.92 d	2.73 b	46.0 a	9.02 c	0.76 b	12.0 c
101	20.6 d	19.9 d	5.81 b	3.13 c	2.44 b	42.1 b	8.54 c	0.91 b	9.4 c
102	21.9 b	20.8 c	6.31 b	3.48 b	2.56 b	40.6 b	9.07 c	1.09 a	8.4 d
103	22.4 b	21.9 a	7.00 a	3.44 b	3.34 a	47.5 a	8.50 c	1.38 a	7.1 d
104	22.1 b	21.4 b	7.06 a	3.53 b	3.28 a	46.4 a	7.99 d	0.94 b	8.6 d
105	22.0 b	21.2 b	6.74 a	3.42 b	3.02 b	44.9 b	9.03 c	1.16 a	7.8 d
106	21.6 c	20.7 c	6.40 b	3.17 c	2.92 b	45.6 a	9.07 c	0.81 b	11.5 c
107	20.8 d	20.5 c	5.99 b	3.01 d	2.76 b	46.1 a	8.31 d	1.09 a	8.3 d
108	22.1 b	21.2 b	6.37 b	3.46 b	2.63 b	41.4 b	9.20 b	0.86 b	10.8 c
113	21.4 c	20.9 c	6.27 b	2.94 d	2.97 b	47.9 a	8.13 d	1.26 a	7.5 d
117	21.8 b	21.2 b	6.59 b	3.16 c	3.20 a	48.5 a	8.90 c	1.13 a	9.7 c
118	21.6 c	21.0 c	6.10 b	3.22 c	2.65 b	43.5 b	7.96 d	1.13 a	7.0 d
119	21.8 b	21.0 c	6.06 b	3.10 c	2.94 b	46.2 a	8.20 d	1.23 a	8.2 d
120	21.4 c	20.3 d	6.26 b	3.35 b	2.64 b	42.3 b	9.24 b	0.86 b	10.8 c
126	20.5 d	20.2 d	5.69 b	2.73 d	2.71 b	47.6 a	10.95 a	0.68 b	16.3 b
134	22.1 b	21.3 b	6.56 b	3.13 c	3.20 a	48.6 a	8.27 d	0.86 b	9.8 c
148	20.3 d	19.6 d	5.06 b	2.92 d	1.93 b	38.1 b	9.15 b	1.31 a	7.3 d
151	22.3 b	21.5 b	6.73 a	3.15 c	3.31 a	49.1 a	8.64 c	0.70 b	12.5 c
154	22.1 b	21.8 a	7.21 a	3.56 b	3.34 a	46.4 a	9.56 b	0.90 b	11.3 c
157	21.8 b	20.9 c	6.48 b	3.22 c	3.06 a	47.1 a	9.54 b	0.56 b	17.1 b
161	21.3 c	20.3 d	6.92 a	3.24 c	3.28 a	46.2 a	8.19 d	1.17 a	7.1 d
162	23.2 a	22.0 a	7.22 a	3.43 b	3.51 a	48.5 a	8.65 c	0.90 b	10.5 c
163	22.4 b	21.3 b	6.82 a	3.22 c	3.33 a	48.7 a	8.80 c	0.82 b	10.9 c
166	22.0 b	21.1 b	6.29 b	3.56 b	2.49 b	39.6 b	9.00 c	1.38 a	6.6 d
169	22.4 b	21.0 c	6.84 a	3.49 b	3.19 a	46.5 a	10.36 a	0.52 b	20.7 a
174	21.8 b	20.5 c	5.93 b	2.94 d	2.88 b	48.5 a	10.26 a	0.62 b	17.0 b
177	22.3 b	21.9 a	7.17 a	3.58 b	3.36 a	46.9 a	9.82 b	0.73 b	13.9 b
182	20.9 d	19.7 d	5.95 b	3.03 c	2.63 b	44.2 b	8.99 c	1.29 a	7.0 d
186	22.6 a	22.0 a	7.19 a	3.63 b	3.36 a	46.6 a	9.11 b	0.80 b	11.6 c
187	21.3 c	20.7 c	6.47 b	3.33 b	2.88 b	44.5 b	8.49 c	0.90 b	9.6 c
192	22.3 b	21.4 b	6.82 a	3.96 a	2.73 b	39.9 b	8.78 c	0.96 b	9.4 c
194	22.2 b	21.0 c	6.68 a	3.16 c	3.30 a	49.3 a	9.38 b	0.82 b	12.0 c
195	21.4 c	21.0 c	6.46 b	2.77 d	3.42 a	53.0 a	9.61 b	0.66 b	14.6 b
204	21.4 c	20.7 c	6.27 b	3.43 b	2.62 b	41.9 b	8.57 c	1.07 a	8.5 d
212	23.2 a	22.2 a	7.70 a	3.57 b	3.86 a	50.1 a	10.58 a	0.50 b	21.6 a
217	21.5 c	20.8 c	6.30 b	3.13 c	2.84 b	45.0 b	8.17 d	1.39 a	6.0 d
Mean	21.7	21.0	6.53	3.27	3.01	45.9	8.97	0.94	10.9
Min.	20.2	19.6	5.06	2.73	1.93	38.1	7.50	0.44	6.0
Max.	23.4	22.6	7.91	4.12	4.01	53.0	10.95	1.39	21.6
CV (%)	3.1	1.5	4.0	3.0	5.7	8.0	6.1	8.2	13.6

[1]Means followed by the same letter in the column don't differ by the Skott & Knott test at 5%.

Table 3. Grouped means of nine physicochemical variables of jabuticaba's fruit quality collected in 2014 from 56 genotypes in Clevelândia-PR: equatorial diameter (ED), polar diameter (PD), fresh weight of the fruit (FW), fresh weight of the peel (FP) and pulp (MPe), percentage of pulp (PULP), total soluble solids (TSS), total titratable acidity (TTA), and TSS/TTA ratio (TSS /TTA).

Genotype	ED (mm)	PD (mm)	FW (g)	FP (g)	FPe (g)	PULP (%)	TSS (°Brix)	TTA (g EAC)	TSS/TTA
1	22.3 c[1]	21.4 c[1]	6.71 d[1]	2.09 b[1]	4.22 c[1]	62.8 b[1]	10.5 f[1]	0.575 e[1]	18.4 e[1]
2	23.4 b	22.8 a	7.78 b	2.75 a	4.58 c	58.9 c	11.4 e	0.617 d	18.6 e
4	22.5 c	22.2 b	7.73 b	2.23 a	5.09 b	65.8 a	11.3 e	0.501 f	22.6 c
5	22.0 d	21.7 b	7.67 b	2.45 a	4.87 b	63.5 b	12.1 d	0.604 d	20.0 d
7	24.7 a	24.0 a	9.15 a	2.57 a	6.19 a	67.6 a	13.2 c	0.526 f	25.2 c
10	23.0 c	22.0 b	7.25 c	2.50 a	4.40 c	60.5 c	12.4 d	0.859 b	14.7 f
11	22.6 c	21.9 b	6.90 c	1.92 b	4.63 c	67.2 a	12.5 d	0.752 c	16.6 e
14	20.9 e	20.5 d	6.45 d	1.81 b	4.27 c	66.2 a	12.9 c	0.471 f	27.6 b
16	23.5 b	23.0 a	7.97 b	2.60 a	5.08 b	63.7 b	14.2 a	0.479 f	29.7 b
22	22.9 c	22.1 b	7.24 c	2.39 a	4.54 c	62.6 b	12.6 c	0.613 d	20.7 d
26	21.3 d	21.0 c	6.58 d	2.11 b	4.17 d	63.2 b	11.9 d	0.766 c	15.7 f
28	22.8 c	22.0 b	7.08 c	2.43 a	4.24 c	59.7 c	13.6 b	0.566 e	24.2 c
35	23.1 c	22.6 b	7.44 b	2.53 a	4.34 c	58.3 c	13.0 c	0.540 e	24.1 c
41	21.6 d	21.1 c	7.10 c	2.28 a	4.44 c	62.2 b	12.6 c	0.653 d	19.4 d
42	21.8 d	21.3 c	7.04 c	2.15 b	4.61 c	65.3 a	14.8 a	0.497 f	29.9 b
47	20.4 e	20.0 d	6.90 c	2.15 b	4.42 c	64.0 b	12.4 d	0.497 f	25.2 c
49	20.1 e	19.7 d	6.63 d	1.86 b	4.40 c	66.4 a	13.8 b	0.469 f	29.4 b
57	20.3 e	20.2 d	6.32 d	2.05 b	4.04 d	63.8 b	12.8 c	0.784 c	16.4 f
65	22.7 c	22.1 b	6.89 c	2.32 a	4.25 c	61.6 b	13.2 c	0.551 e	24.0 c
68	20.7 e	20.4 d	6.33 d	1.95 b	4.02 d	63.5 b	13.4 b	0.872 b	15.3 f
70	22.5 c	22.2 b	7.79 b	2.51 a	4.94 b	63.5 b	12.8 c	0.725 c	17.7 e
79	21.5 d	21.4 c	7.02 c	2.05 b	4.59 c	65.4 a	12.6 c	0.366 g	34.5 a
80	21.9 d	21.4 c	7.42 b	1.87 b	5.19 b	69.8 a	12.7 c	0.708 c	18.0 e
88	23.9 b	23.1 a	8.32 a	2.26 a	5.54 a	66.6 a	12.5 d	0.845 b	14.8 f
93	23.3 c	22.6 b	7.62 b	1.70 b	5.54 a	72.8 a	12.3 d	0.761 c	16.1 f
96	22.1 d	21.4 c	6.42 d	2.29 a	3.77 d	58.5 c	12.3 d	0.577 e	21.7 c
98	23.3 c	22.4 b	7.26 c	2.27 a	4.59 c	63.1 b	12.4 d	0.525 f	23.7 c
100	22.5 c	21.8 b	6.91 c	2.26 a	4.27 c	61.7 b	12.9 c	0.822 b	15.7 f
101	23.1 c	22.5 b	7.98 b	2.22 a	5.33 b	66.8 a	13.5 b	0.612 d	22.0 c
102	22.1 d	21.4 c	6.43 d	2.23 a	3.91 d	60.7 c	11.5 e	0.859 b	13.5 g
104	22.7 c	22.3 b	8.57 a	2.47 a	5.65 a	65.9 a	12.6 c	0.617 d	20.5 d
105	24.4 a	23.5 a	8.64 a	2.74 a	5.47 a	63.2 b	13.4 b	0.501 f	27.0 b
107	21.9 d	21.1 c	6.23 d	2.20 b	3.59 d	57.3 c	11.9 d	0.699 c	17.1 e
108	23.7 b	22.7 a	7.75 b	1.91 b	5.32 b	68.5 a	12.9 c	0.585 e	22.2 c
109	19.9 e	19.4 d	6.64 d	2.15 b	4.11 d	62.0 b	11.5 e	0.662 d	17.4 e
112	21.3 d	21.0 c	6.65 d	1.99 b	4.26 c	64.0 b	11.9 d	0.897 b	13.3 g
116	22.9 c	22.5 b	7.97 b	2.22 a	5.48 a	68.7 a	12.3 d	0.732 c	16.8 e
117	21.7 d	20.9 c	6.19 d	2.00 b	3.80 d	60.6 c	10.9 f	0.745 c	15.1 f
118	23.9 b	22.9 a	7.88 b	1.93 b	5.55 a	70.3 a	12.9 c	0.839 b	15.5 f
119	21.4 d	20.9 c	6.61 d	2.38 a	3.89 d	58.9 c	13.5 b	1.190 a	11.4 g
120	22.9 c	22.2 b	7.29 c	2.31 a	4.49 c	61.5 b	11.8 d	0.750 c	15.7 f
136	23.0 c	22.4 b	7.38 b	2.39 a	4.71 c	63.9 b	13.6 b	0.558 e	24.6 c
144	22.1 d	21.7 b	7.55 b	2.06 b	5.15 b	68.1 a	11.8 d	0.469 f	25.5 c
148	22.9 c	22.3 b	7.23 c	2.31 a	4.46 c	61.6 b	12.7 c	0.577 e	22.1 c
153	22.7 c	22.2 b	7.81 b	2.17 b	5.25 b	67.3 a	12.6 c	0.737 c	17.1 e
162	21.9 d	21.4 c	7.82 b	2.26 a	5.13 b	65.6 a	11.6 e	0.562 e	20.7 d
163	22.0 d	21.5 c	7.19 c	2.30 a	4.62 c	64.1 b	12.1 d	0.553 e	21.9 c
166	22.7 c	22.0 b	7.44 b	2.62 a	4.40 c	59.1 c	13.2 c	0.484 f	27.4 b
177	21.5 d	21.3 c	6.87 c	2.30 a	4.12 d	60.0 c	12.8 c	0.577 e	22.2 c
191	22.6 c	22.1 b	7.85 b	2.09 b	5.35 b	68.1 a	12.2 d	0.654 d	18.7 e
194	22.9 c	21.9 b	7.76 b	2.39 a	5.10 b	65.7 a	12.9 c	0.488 f	26.5 b
204	20.6 e	20.2 d	7.42 b	2.19 b	4.88 b	65.8 a	12.9 c	0.468 f	27.9 b
345	21.7 d	21.0 c	6.08 d	1.94 b	3.85 d	63.4 b	11.6 e	0.659 d	17.6 e
347	22.3 c	21.5 c	6.59 d	2.11 b	4.02 d	61.3 b	12.2 d	0.693 c	17.9 e
J7-01	23.8 b	23.1 a	8.06 b	2.69 a	5.04 b	62.4 b	14.2 a	0.480 f	29.7 b
J7-02	22.9 c	22.6 b	8.31 a	2.40 a	5.61 a	67.5 a	13.8 b	0.396 g	34.9 a
Mean	22.3	21.8	7.29	2.24	4.67	63.9	12.6	0.635	21.1
Min.	19.9	19.4	6.08	1.70	3.59	57.3	10.9	0.366	11.4
Max.	24.7	24.0	9.15	2.75	6.19	72.8	14.8	1.190	34.9
CV (%)	2.9	2.9	7.5	4.1	9.3	2.5	3.8	1.9	5.1

[1]Means followed by the same letter in the column don't differ by the Skott & Knott test at 5%.

The observed values for the polar and equatorial diameters are indicators of the fruit geometry, which may be round, oval or oblong. Superior results for passion fruit were found by Gonçalves et al. (2007) and Santos, Bruckner, Cruz, Siqueira, and Rosado (2011), who showed mean values of 86.25 and 89.54 mm, respectively, for polar diameter and 75.37 and 77.92 mm, respectively, for equatorial diameter, with more oval-shaped fruit compared to the results of the present study (rounded shape). A study conducted by Danner et al. (2011a), who evaluated jabuticaba fruits from the same population as in the present study, found an equatorial diameter of 22.6 mm. This characteristic is important for analysis because although the fruits are commercialized by fresh weight and diameter (mainly equatorial), the equatorial diameter has been used for other fruit trees in terms of selection and fruit classification by size, with the largest being valued, adding more value.

Fresh weight is an important parameter for the selection of genotypes despite its direct influence on the amount produced. Thus, regarding this variable, the means of the genotypes in 2013 remained uniform, forming only two groups: the first group consisting of those whose weight was between 7.91 and 6.62 g (72, 30, 91, 212, 16, 54, 96, 97, 162, 154, 186, 177, 80, 41, 104, 103, 89, 161, 57, 169, 192, 163, 81, 43, 105, 151, 95, 194, and 9) and the second group consisting of those (the other genotypes) whose weight was between 6.60 and 5.06 g (Table 2). In 2014, with respect to the fresh weight of the fruits, more groups were formed (4) compared to 2013. This observation may be related to the greater weight gain obtained during the last year, as the jabuticaba genotypes of the first group (7, 105, 104, 88, and J7-02) ranged from 9.15 to 8.31 g; the second group (J7-01, 101, 16, 116, 118, 191, 162, 153, 70, 2, 194, 108, 4, 5, 93, 144, 166, 35, 80, and 204), 8.06 to 7.38 g; the third group (120, 98, 10, 22, 148, 163, 41, 28, 42, 79, 100, 47, 11, 65, and 177), 7.29 to 6.87 g; and the last group (the remaining jabuticaba genotypes), 6.08 to 6.71 g (Table 3).

The genotypes with the highest values of fresh weight also have the same such superiority in their polar and equatorial diameters (Tables 2 and 3, respectively), with the jabuticaba genotypes of 2013 (91, 16, 72, 30, 212, 54, 186, 162, 96, 41, and 97) and 2014 (7 and 105) grouped in terms of superiority. Danner et al. (2011a), who evaluated jabuticaba fruits of this same population, observed a mean weight of 7.3 g. These results were similar to those obtained in the present study: in 2013 and 2014, the average fresh weights of the fruit were 6.53 and 7.29 g, respectively, and the average equatorial diameters were 21.7 and 22.3 mm, respectively. In a study conducted with eight jabuticaba clones in Viçosa (Minas Gerais State), Pereira, Salomão, Mota, and Vieira (2000) observed variation ranging from 7-15 g for the fresh weight of fruit, which could possibly be explained by the local climatic conditions and the presence of long days, high temperatures and rainfall levels that were suitable for the development of the species.

Although the first characteristics observed in fruits are size, shape and colour, satisfaction depends on qualities that affect taste, such as texture, flavour and aroma (Topp & Sherman, 2000). The main factors that determine the flavour of the fruit are the soluble solids and acidity (Rhodes, 1980; Souza, Byrne, & Taylor, 2000). Thus, the ratio of soluble solids and total titratable acidity is one of the best parameters for evaluating this feature (Chitarra & Chitarra, 1990).

Regarding the jabuticaba genotypes evaluated in the present study, the highest values of soluble solids in relation to fruits from 2013 were observed in the genotypes 126, 212, 72, 169, 174, 57, and 91. In 2014, the number of superior genotypes decreased to three: 42, J7-01 and 16. The data in Tables 3 and 4 show that that fruits with a higher degree of °Brix content were produced in 2014 compared to 2013; in 2013, the range was from 10.95 to 7.5 °Brix, and in 2014, it was 14.8 to 7.50 Brix. Danner, Citadin, Sasso, Sachet, and Mazaro (2011b), who assessed the quality of fruits of three genotypes of *P. cauliflora* in the city of Itapejara d'Oeste (Paraná State), noticed that the fruits had a range of values between 15.4 and 16.4 °Brix in 2007 and 11.5 and 14.4 Brix in 2008. Such differences may be related to the differences in gene expression and the influence of local conditions.

The acidity of fruits in 2013 resulted in the formation of two groups, with the majority of genotypes (48) bearing less acidic fruits. This characteristic is important: by relating fruit acidity to TSS, better flavour could be presented (Table 3). In part, such a response can be shown in 2013 because despite the existence of 48 genotypes with lower acidity, the last five (212, 169, 16, 41, and 54) with lower means for this variable were those with the highest TSS/, which is considered superior (Table 3). Acidity values in 2014 were higher than those obtained in 2013 (21.6 compared with 6.0, respectively), allowing the formation of seven groups, with two genotypes (J7-02 and 79) standing out as having the lowest average. These same two genotypes were grouped among those with the highest TSS/TTA, with values of 34.9 and 34.5 for genotypes J7-02 and 79, respectively (Table 4).

The higher acidity observed in 2014 may be related to the lack of management of the plants, particularly fruit thinning, because without conducting this technique conducted, plant production tends to stagger, with years of higher production featuring fruits with lower fresh weight and sensorial quality. A similar difference between the variables each year was observed by Citadin, Vicari, Silva, and Danner (2005), who studied the fruit quality of *P. cauliflora* under the influence of full sun or forest conditions.

The average TSS/TTA values with the lowest range of variation were 10.9 in 2013 and 21.1 and 2014, which may be related to the analysed genotypes. Superior results were found by Danner et al. (2011a), who assessed the quality of 36 genotypes of *P. cauliflora* fruit from five locations in southwestern Paraná, whose TSS/TTA average was 28.5, ranging from 10.3 to 63.2, showing in part that jabuticaba trees can present higher values and reinforcing the potential of these trees.

Table 4. Grouped means of five biochemical variables for quality fruit pulp of jabuticabas collected in 2013 from 70 genotypes in Clevelândia-PR: total soluble protein (TSP), total sugars (TS), flavonoids (FLAV), anthocyanins (ANT), and total phenols (TF).

Genotypes	TSP	TS	FLAV	ANT	TF
9	53.8 a[1]	60.5 a[1]	2.74 a[1]	0.291 b[1]	76.7 a[1]
10	46.8 b	41.7 b	1.46 b	0.139 c	45.8 b
11	69.6 a	44.3 b	2.15 b	0.157 c	53.5 a
16	29.9 b	68.2 a	1.87 b	0.144 c	38.5 b
20	60.7 a	85.5 a	1.70 b	0.189 c	46.4 b
21	37.7 b	57.8 a	1.74 b	0.159 c	66.4 a
30	65.2 a	41.8 b	1.65 b	0.219 c	60.4 a
35	64.6 a	92.4 a	2.54 b	0.339 b	76.0 a
41	49.6 b	39.4 b	2.06 b	0.095 c	33.4 b
42	59.6 a	46.8 b	1.74 b	0.152 c	34.0 b
43	57.1 a	74.8 a	3.10 a	0.298 b	72.5 a
46	66.6 a	56.2 a	2.46 b	0.237 c	38.7 b
47	56.9 a	61.8 a	1.84 b	0.153 c	34.6 b
48	37.8 b	26.0 b	2.44 b	0.167 c	34.0 b
49	32.0 b	41.5 b	2.15 b	0.071 c	48.3 a
52	62.9 a	90.9 a	4.02 a	0.431 a	79.6 a
54	46.6 b	54.3 a	2.80 a	0.243 c	36.2 b
57	50.1 b	60.0 a	1.71 b	0.357 b	24.3 b
58	32.1 b	94.3 a	3.32 a	0.209 c	33.2 b
59	47.6 b	68.9 a	2.84 a	0.150 c	34.4 b
65	36.0 b	40.6 b	2.81 a	0.213 c	36.0 b
72	42.8 b	63.2 a	1.95 b	0.139 c	22.4 b
79	45.0 b	43.6 b	1.55 b	0.163 c	36.9 b
80	32.0 b	55.3 a	3.44 a	0.223 c	39.7 b
81	58.1 a	61.5 a	2.91 a	0.315 b	52.0 a
87	45.1 b	74.9 a	3.33 a	0.287 b	49.4 a
88	25.6 b	58.5 a	1.26 b	0.128 c	31.3 b
89	31.6 b	40.3 b	1.80 b	0.183 c	43.4 b
90	56.6 a	82.8 a	2.03 b	0.243 c	56.5 a
91	52.0 a	29.0 b	3.30 a	0.232 c	56.8 a
95	40.0 b	34.8 b	2.15 b	0.184 c	38.9 b
96	60.4 a	29.0 b	1.33 b	0.184 c	40.7 b
97	52.5 a	59.3 a	3.08 a	0.564 a	62.9 a
98	91.7 a	55.0 a	2.55 b	0.172 c	52.9 a
100	58.0 a	78.3 a	1.80 b	0.309 b	52.9 a
101	89.1 a	79.8 a	2.27 b	0.323 b	39.1 b
102	68.4 a	27.2 b	3.83 a	0.456 a	66.6 a
103	60.6 a	67.1 a	2.69 b	0.316 b	52.0 a
104	72.6 a	81.2 a	4.18 a	0.172 c	78.7 a
105	66.5 a	42.7 b	2.29 b	0.174 c	47.5 a
106	60.1 a	105.3 a	3.21 a	0.258 c	51.3 a
107	45.4 b	35.2 b	1.91 b	0.312 b	45.6 b
108	37.2 b	62.7 a	1.58 b	0.155 c	50.0 a
113	41.9 b	52.6 b	4.38 a	0.297 b	64.0 a
117	42.8 b	78.4 a	2.68 b	0.215 c	36.2 b
118	43.3 b	66.1 a	3.18 a	0.219 c	58.2 a
119	54.0 a	34.1 b	2.55 b	0.097 c	45.2 b
120	49.4 b	33.4 b	2.66 b	0.285 b	53.9 a
126	49.0 b	43.2 b	3.68 a	0.408 a	40.5 b
134	44.6 b	67.7 a	5.42 a	0.456 a	61.6 a
148	56.1 a	84.4 a	4.71 a	0.179 c	69.7 a
151	43.2 b	25.6 b	2.35 b	0.199 c	51.7 a
154	63.8 a	34.2 b	2.54 b	0.242 c	48.5 a
157	42.9 b	84.6 a	3.22 a	0.246 c	37.9 b
161	52.3 a	82.7 a	3.78 a	0.268 b	45.5 b
162	40.6 b	66.6 a	1.89 b	0.216 c	36.3 b
163	35.8 b	49.1 b	2.53 b	0.160 c	49.0 a
166	63.8 a	86.9 a	3.34 a	0.512 a	56.1 a
169	48.2 b	60.6 a	2.15 b	0.201 c	44.1 b
174	48.6 b	66.6 a	3.16 a	0.252 c	46.7 b
177	55.4 a	43.3 b	2.39 b	0.272 b	47.6 a
182	49.7 b	72.7 a	2.13 b	0.236 c	51.3 a
186	37.2 b	74.4 a	1.46 b	0.270 b	37.2 b
187	66.7 a	51.0 b	2.35 b	0.242 c	48.7 a
192	49.5 b	58.3 a	1.47 b	0.386 a	57.7 a
194	57.6 a	74.4 a	1.82 b	0.302 b	46.7 b
195	29.8 b	69.0 a	2.23 b	0.192 c	38.3 b
204	67.7 a	69.2 a	3.58 a	0.185 c	60.8 a
212	63.0 a	63.4 a	2.85 a	0.183 c	31.9 b
217	80.0 a	89.2 a	4.47 a	0.326 b	49.4 a
Mean	51.9	59.9	2.61	0.242	48.36
Min.	25.6	25.6	1.26	0.071	22.4
Max.	91.7	105.3	5.42	0.564	79.6
CV (%)	19.7	22.2	13.2	3.9	17.2

[1]Means followed by the same letter in the column don't differ by the Skott & Knott test at 5%.

However, fruits with lower TSS/TTA values may be promising for industrialization since this characteristic is desirable in fruits of other species, such as fig and peach. For industry, the fresh weight of the peel, despite being discarded during consumption *in natura*, has many functional properties, such as the effects of anthocyanins and flavonoids in combating free radicals and in reducing cholesterol and diabetes (Leite-Legatti et al., 2012; Lenquiste, Batista, Marineli, Dragano, & Maróstica Júnior, 2012). Since the identification of these effects, many companies in the food, pharmaceutical and cosmetics sector have shown special interest in the jabuticaba.

Thus, the fresh weight of the peel of the analysed fruits was used to group the fruits into four and two groups in 2013 and 2014, respectively. In 2013, the superior genotypes were 72, 192, 30, 57, 91, 96, 54, and 9. The following year, more genotypes were selected, including 2, 105, J7-01, 166, 16, 7, 35, 70, 10, 104, 5, 28, J7-02, 22, 136, 194, 119, 65, 120, 148, 177, 163, 96, 41, 98, 100, 162, 88, 4, 102, 116, and 101 (Tables 2 and 3). This characteristic, which is also related to the size of the fruit and peel thickness (Donadio, Môro, & Servidone, 2002), ranged from 4.12 to 2.73 g in 2013 and from 2.75 to 1.70 g in 2014. In 2013, although the fruits had less mass, they had a higher peel weight, although the opposite response occurred in 2014. Such behaviour may be related to the fresh weight of the pulp obtained in those years. In 2013, two groups were formed, with the first values ranging from 4.01 to 3.06 g and the second in the range from 3.02 to 1.93 g (Table 2). In 2014, four groups were formed, with classifications between 6.19 and 5.47 g, 5.35 and 4.87 g, 4.71 and 4.22 g and 4.17 and 3.59 g (Table 3).

The genotypes of the jabuticaba fruit gathered in 2013 that displayed superior values for the fresh weight of the pulp were 16, 212, 91, 41, 54, 80, 95, 30, 96, 97, 162, 72, 195, 186, 177, 154, 103, 89, 163, 151, 194, 161, 104, 117, 134, 81, 169, 52, 47, 11, and 157. Fewer jabuticaba fruits in the superior group were produced in 2014; this group included the genotypes 7, 104, J7 -02, 118, 93, 88, 116, and 105. The same number of groups (2) was submitted for the fresh weight of the pulp as for the percentage of pulp in 2013; therefore, in 2014, only three groups were formed (Tables 2 and 3). Another similarity occurred with respect to the selection of jabuticaba fruit superior for their fresh weight of the pulp, (genotype 72 was the only exception). Furthermore, this group of superior fruit included other genotypes (10, 174, 113, 54, 48, 126, 42, 58, 107, 100, 106, 87, and 46) that did not have the same rating for the fresh weight of the pulp (Table 2).

As in the previous year, almost all genotypes (7, 104, J7-02, 118, 93, 88, and 116) in 2014 selected for their superior values for the fresh weight of the pulp were also selected for the percentage of pulp, excluding only genotype 105. In this same group of genotypes with a superior percentage of pulp, genotypes 80, 108, 144, 191, 153, 11, 101, 49, 14, 204, 4, 194, 162, 79, and 42 were also included (Table 3). In this context, it can be partially inferred that pulp with a higher fresh weight or percentage can interfere with a number of functional compounds associated with these characteristics of the pulp. Thus, analysis of the functional characteristics present in the pulp becomes important when pulp is designated for *in natura* consumption since this portion is enjoyed along with the seed when the fruit is ingested, and if such properties are identified, the industry could make use of the pulp.

As such, the analysis of flavonoids in the pulp in 2013 resulted in the formation of two groups, with 27 individuals constituting the highest means. Of these individuals (134, 148, 217, 113, 104, 52, 102, 161, 126, 204, 80, 166, 87, 58, 91, 157, 106, 118, 174, 43, 97, 81, 212, 59, 65, 54, and 9) (Table 4), only 11 (212, 91, 54, 80, 97, 161, 104, 134, 81, 52 and 157) and 17 (80, 212, 134, 91, 174, 97, 113, 54, 126, 157, 81, 52, 104, 161, 58, 106, and 87) were among those with the highest fresh weight of the pulp and pulp percentage, respectively (Table 2).

In 2014, of the four genotypes (112, 162, 109 and 153) superior for flavonoids in the pulp (Table 5), none presented the highest values for the fresh weight of the pulp (Table 3), which may be due to the greater number of groups (4) formed in that year. The same situation did not occur for the pulp percentage, with two genotypes (153 and 162) in the highest means group (Table 3).

The flavonoid content in the pulp ranged from 5.42 to 1.26 mg 100 g^{-1} in 2013 and from 4.41 to 1.47 mg 100 g^{-1} in 2014, indicating that although fruits from 2013 had a lower TSS/TTA ratio, these fruits may prove interesting for industry. The variation in flavonoid concentrations in the assessments of each year may be related to differences in temperature, ultraviolet radiation intensity, water and nutrient availability as well as to pathogenic attacks (Gobbo-Netto & Lopes, 2007).

In studies of jabuticaba fruit carried out by Danner et al. (2011a and b), the amount of flavonoids in the peel in comparison to the pulp tended to be higher, with values ranging from 344.9 to 342.9 mg 100 g peel^{-1}. The same finding was observed for anthocyanins in the peel, whose averages ranged from 755.1 to 361.3 mg 100 g peel^{-1}. A contradictory result was observed in the present study regarding the anthocyanins in the pulp in relation to the flavonoids, whose average ranged from 0.564 to 0.071 mg 100 g^{-1} in 2013 (Table 4) and from 2.024 to 0.204 mg 100 g^{-1} in 2014 (Table 5). Therefore, by increasing the production of flavonoids in the first year, anthocyanin levels decreased in the pulp, and the opposite trend occurred in the following year.

Table 5. Grouped means of five biochemical variables for quality fruit pulp of jabuticabas collected in 2014 from 56 genotypes in Clevelândia-PR: total soluble proteins (TSP), total sugars (TS), flavonoids (FLAV), anthocyanins (ANT), and total phenols (TF).

Gen.	TTSP (μg g^{-1})	TS (mg g^{-1})	FFLAV (mg 100g^{-1})	AANT (mg 100g^{-1})	TF (mg GAE 100g^{-1})
1	68.9 a[1]	55.7 b[1]	3.25 b[1]	0.807 d[1]	42.0 a[1]
2	70.5 a	62.1 b	1.47 d	0.583 d	34.8 b
4	64.1 a	70.1 b	2.67 b	1.038 c	44.7 a
5	77.3 a	63.6 b	2.14 c	0.604 d	38.5 a
7	53.4 a	78.4 a	1.89 d	0.814 d	40.3 a
10	67.5 a	49.4 b	1.74 d	0.226 e	35.2 b
11	76.1 a	43.6 b	2.41 c	1.113 c	26.7 c
14	92.9 a	60.6 b	2.95 b	1.378 b	29.4 c
16	61.1 a	87.8 a	2.58 c	0.673 d	19.1 c
22	70.0 a	60.4 b	2.06 c	0.810 d	23.3 c
26	60.7 a	72.2 a	2.98 b	0.912 d	24.4 c
28	73.0 a	92.0 a	2.10 c	0.204 e	23.6 c
35	64.7 a	95.2 a	1.97 d	0.613 d	21.3 c
41	98.7 a	80.8 a	2.09 c	0.544 e	20.9 c
42	94.8 a	127.2 a	3.29 b	0.668 d	43.7 a
47	78.4 a	115.4 a	3.42 b	1.183 c	39.0 a
49	64.8 a	83.6 a	2.14 c	1.185 c	36.7 b
57	76.1 a	47.2 b	3.35 b	0.746 d	40.3 a
65	62.8 a	87.5 a	2.12 c	0.651 d	32.8 b
68	59.6 a	78.6 a	3.16 b	0.379 e	35.5 b
70	65.8 a	57.6 b	1.51 d	0.601 d	14.0 c
79	77.1 a	87.7 a	1.64 d	0.740 d	22.7 c
80	76.3 a	76.9 a	2.20 c	0.729 d	32.9 b
88	65.7 a	74.9 a	1.74 d	0.715 d	30.4 b
93	86.0 a	59.5 b	2.16 c	1.039 c	20.8 c
96	67.2 a	81.4 a	2.01 d	1.284 c	26.2 c
98	66.4 a	96.1 a	2.14 c	1.109 c	19.8 c
100	98.9 a	76.9 a	2.90 b	1.503 b	34.0 b
101	79.3 a	52.2 b	2.98 b	0.688 d	33.7 b
102	84.5 a	45.8 b	3.19 b	0.668 d	46.1 a
104	62.8 a	67.9 b	1.85 d	0.432 e	31.4 b
105	67.6 a	53.3 b	1.87 d	0.913 d	26.7 c
107	63.2 a	95.5 a	2.58 c	0.440 e	34.4 b
108	50.4 a	84.6 a	2.76 b	0.431 e	41.5 a
109	84.7 a	43.1 b	3.83 a	0.717 d	49.0 a
112	71.8 a	77.4 a	4.41 a	1.502 b	38.9 a
116	94.9 a	46.8 b	2.36 c	0.559 d	31.6 b
117	74.6 a	65.5 b	3.31 b	0.734 d	30.9 b
118	82.0 a	88.1 a	2.36 c	1.309 c	31.4 b
119	75.9 a	70.1 b	3.37 b	2.024 a	30.2 b
120	75.7 a	69.1 b	2.25 c	1.036 c	31.6 b
136	48.7 a	64.2 b	1.76 d	0.398 e	23.2 c
144	54.2 a	67.1 b	2.61 c	0.694 d	27.9 c
148	68.2 a	60.3 b	3.41 b	0.443 e	26.1 c
153	72.1 a	99.1 a	3.62 a	1.421 b	36.7 b
162	72.7 a	76.6 a	3.95 a	1.125 c	39.7 a
163	77.2 a	70.0 b	2.19 c	1.109 c	35.0 b
166	52.2 a	81.0 a	2.02 d	0.806 d	30.6 b
177	55.5 a	53.6 b	2.47 c	0.830 d	22.3 c
191	64.1 a	48.4 b	2.36 c	0.657 d	26.6 c
194	50.4 a	115.0 a	3.16 b	1.044 c	35.6 b
204	56.2 a	90.5 a	2.42 c	0.919 d	34.8 b
345	67.9 a	81.0 a	3.05 b	1.589 b	33.5 b
347	46.9 a	73.5 a	3.29 b	1.119 c	35.1 b
J7-01	52.8 a	75.2 a	1.88 d	0.809 d	35.6 b
J7-02	70.5 a	95.1 a	3.02 b	0.360 e	53.2 a
Mean	69.9	73.8	2.58	0.850	32.3
Min.	46.9	43.1	1.47	0.204	14.0
Max.	98.9	127.2	4.41	2.024	53.2
C.V. (%)	28.7	17.8	7.0	6.9	12.2

[1]Means followed by the same letter in the column don't differ by the Skott & Knott test at 5%.

In general, seven jabuticaba tree genotypes (97, 166, 134, 102, 52, 126, and 192) were highlighted as those with higher anthocyanin means in the pulp in 2013 (Table 4), and one (genotype 119) had higher anthocyanin means in 2014 (Table 5), which resulted in the formation of groups of three and five, respectively. Of these genotypes, four (134, 97, 126, and 52) and three (97, 134, and 52) were among those with a higher percentage of pulp and fresh weight of pulp, respectively, in 2013 (Table 2). In 2014, genotype 119, described as having the highest content of anthocyanins in the pulp, was in the lowest means groups for percentage and fresh weight of pulp (Table 3).

In the present study, small and almost insignificant amounts of anthocyanins in the pulp were reported. However, it has been noted that anthocyanin production is higher in the peel to increase attractiveness to dispersing animals. Still, the behaviour observed for anthocyanins and flavonoids may have occurred because of the different climatic conditions between the two years of evaluation. In general, the genotypes responded differently between the two growing cycles evaluated, prioritizing certain metabolic compounds over others. This difference in behaviour may be because both anthocyanins and flavonoids are synthesized by the same pathway of phenolic compounds, resulting in competition for the same enzymes (Taiz & Zeiger, 2010).

In 2013, total phenols clustered into two classes. The genotypes with the highest average were 52, 104, 9, 35, 43, 148, 102, 21, 113, 97, 134, 204, 30, 118, 192, 91, 90, 166, 120, 11, 98, 100, 81, 103, 151, 182, 106, 108, 217, 87, 163, 187, 154, 49, 177, and 105, whose values ranged from 79.6 mg 100 g^{-1} to 47.5 mg 100 g^{-1}. The remaining genotypes, with lowest average, presented values ranging from 46.7 to 22.4 mg 100 g^{-1} (Table 4).

In 2014, the number of total phenol groups formed was three. The highest means, with values ranging from 53.2 to 38.5 mg 100 g^{-1}, occurred with genotypes J7-02, 109, 102, 4, 42, 1, 108, 7, 57, 162, 47, 112, and 5 (Table 5). Higher contents of phenolic compounds have been found in fruits of guava (*Psidium guajava*) (83.0 mg 100 g^{-1}) (Kuskoski, Asuero, Morales, & Fett, 2006) and gabiroba (259-285 mg 100 g^{-1}) (Rocha et al., 2011) when compared to those found in the present study, despite fruits of jabuticaba trees belonging to the same botanical family. Such averages of total phenols obtained in this study in both years reinforces what has been described for flavonoids: despite the lower values of the sensorial quality of fruits harvested in 2013, these fruits tended to have higher biochemical means, with the exception of anthocyanins.

Regarding proteins and total sugars of the pulp, the responses seemed to become more similar. The former variable formed two groups in 2013 (Table 4) and one group in 2014 (Table 5); the latter variable, two groups during both years (Tables 3 and 4).

With respect to proteins present in the pulp, values in 2013 ranged from 91.7 to 25.6 μg g^{-1}, with the highest reaching 52 μg g^{-1}. The group with the higher means included genotypes 98, 101, 217, 104, 11, 102, 204, 187, 46, 105, 30, 35, 154, 166, 212, 52, 20, 103, 96, 106, 42, 81, 100, 194, 43, 47, 90, 148, 177, 119, 9, 97, 161, and 91. In 2014, this range was between 98.9 and 46.9 μg g^{-1}, with no significant differences among the means.

Results considered superior to those in the present study for proteins, albeit still considered low, were observed in gabiroba (*Campomanesia xanthocarpa*) (1.08 g 100 g^{-1}) (Santos, Carneiro, Wosiascki, Petkowicz, & Carneiro, 2009), jabuticaba (*P. trunciflora*) (0.22 g 100 g^{-1}), guava (*Psidium guajava*) (0.76 g 100 g^{-1}), Surinam cherry (*Eugenia uniflora*) (0.76 g 100 g^{-1}) and uvaia (*Eugenia pyriformis*) (1.56 g 100 g^{-1}) (Lajolo, 2002; Franco, 1992), which are common fruits of plants in the Myrtaceae family (Santos, Petkowicz, Wosiacki, Nogueira, & Beleski Carneiro, 2007).

Regarding total sugars, the values obtained in 2013 ranged from 105.3 to 25.6 mg 100 g^{-1}. In 2014, this range was extended slightly: the highest value obtained was 127.2 and the lowest 43.1 mg 100 g^{-1}, but these values were higher than that found by Sato and Cunha (2007) for fresh pulp of the Sabará variety of jabuticaba (11.80 g 100 g^{-1}). Still, it was noted that in both growing cycles two groups were formed (Tables 3 and 4). Of the 70 jabuticaba genotypes analysed in 2013, only 25 (113, 187, 163, 42, 11, 79, 177, 126, 105, 30, 10, 49, 65, 89, 41, 107, 95, 154, 119, 120, 96, 91, 102, 48, and 151) were classified as having among the lowest mean total sugar in the pulp (Table 4). In 2014, genotypes 56 and 26 were similar to those of the lower means (4, 119, 163, 120, 104, 144, 117, 136, 5, 2, 14, 22, 148, 93, 70, 1, 177, 105, 101, 10, 191, 57, 116, 102, 11, and 109) (Table 5).

It is important to highlight the superiority obtained during both growing cycles (2013 and 2014) after quantification of the protein content in the pulp for genotypes 4, 119, 104, 144, 117, 136, 5, 2, 14, 22, 148, 93, 70, 1, 101, 191, 57, 116, and 109 and for the other group (163, 120, 177, 105, and 10), which constituted the first year of the lowest production and the second lowest, respectively.

In general, during these two growing cycles of analysis, the responses in most of the variables were different. There were no similarities regarding superiority, except the cases mentioned above, and regarding the mean values obtained. It is assumed that such behaviour is related to the lack of plant management since management can interfere completely with the productive capacity from one year to another, affecting sensorial quality and nutraceutical content. Another point may be related to climatic conditions that occurred during each cycle, despite harvest occurring during the same period.

Based on the adopted criterion, genotypes 97, 91, 212, 54, 177, 169, 16, 43, 186, 194, 104, 157, 134, and 154 in 2013 and J7-02, 194, 7, J7-01, 118, 16, 42, 47, 153, 163, and 105 in 2014 were preselected. The presence of genotypes 16 and 194 in both selection years is noteworthy; these genotypes can already serve as selected material for future use as cultivars and/or genitors, in general, to improve both sensorial quality and nutraceuticals of the fruit. What is also interesting about the preselections made concerns the presence of three groups of genotypes: 101, 103, 104, and 105; J7-01 and J7-02; and 153 and 154. These three groups share a commonality among them regarding the close physical distance between the genotypes within a plot, unless it is assumed that they are clones that have originated from apomixis.

Conclusion

The quality of fruits analysed showed potential with dual purpose, serving both *in natura* or processing consumption.

The genotypes 7, 42, 43, 47, 54, 91, 97, 104, 105, 118, 134, 153, 154, 157, 163, 169, 177, 186, 212, J7-01, and J7 -02, being 16 and 194 the only ones that can already be selected by the superior characteristics shown in both cycles.

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