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Qualitative attributes of some mango cultivars fruits

Joyce Helena Modesto*, Sarita Leonel, Daniela Mota Segantini, Jackson Mirellys Azêvedo Souza, Rafael Augusto Ferraz

Department of Horticulture, Universidade Estadual Paulista (UNESP), Botucatu, Brazil

***Corresponding author: joyce_helena_modesto@hotmail.com**

Abstract

The aim of this study was to physically and chemically characterize the fruit quality of some mango cultivars grown in a subtropical climate region of São Paulo, in the municipality of São Manuel. The experiment design was totally randomized, consisting of 4 treatments (Palmer, Parwin, Tommy Atkins and Haden cultivars) and 4 repetitions for the physical analyses and 6 repetitions for the chemical analyses. Each repetition composed of 5 fruit from each cultivar. Fruits from two production years: 2011/2012 and 2012/2013 were used for the study. According to the results we concluded that all of the cultivars are suitable for industrialization. Fruit from the Palmer and Parwin cultivars are interesting, in terms of harvesting and transporting as they showed the best values for firmness. The fruits of the Palmer cultivar presented higher physical and chemical quality.

Keywords: Analyses; *Mangifera indica* L.; polyphenols; pulp yield; vitamin C.

Introduction

In many regions of the world, the mango stands out for its high commercial and nutritional values, especially in the tropical regions. It is one of the main fresh fruits that can be exported, generating foreign exchange, creating jobs and increasing income for both small and large producers. Brazil is the fourth largest exporter of this fruit (FAO, 2013).

There are many discrepancies concerning the physical and chemical characteristics of mangoes produced in Brazil. This may be explained by the differences between varieties and methodologies of analysis, the ripeness of the fruit when harvested and climatic differences between the regions they were produced (Benevides et al., 2008). According to Chitarra and Chitarra (2005), the proportion between pulp, skin and endocarp is strongly influenced by the variety and the SS/TA ratio (soluble solids/titratable acidity) in mangoes. These characteristics are commonly used for of evaluating flavor and are more representative than measuring sugars or acidity in isolation.

Study of physical and chemical characteristics of mango trees can help to identify the best varieties for consumption and industrialization. In general, industry prefers mangoes with a higher yield of pulp, high soluble solid content and lack of fiber. For fresh consumption, consumers prefer fruit with low acidity, high soluble solid content and lack of fibers (Silva et al., 2012). The fruit contains various substances such as antioxidants, carotenoids, vitamin C and phenol compounds that can potentially help human health (Kaur and Kapoor, 2001). Phenol compounds are the most abundant antioxidants in food. Its intake on average is ten times that of vitamin C and 100 times that of vitamin E or carotenoids (Curin and Andriantsitohaima, 2005).

Brazil's tropical climate favors the occurrence of a wide variety of carotenogenic fruits (Azevedo-Meleiro and Rodriguez-Amaya, 2004). Mango is the most of interest, for its flavor, aroma and characteristic and attractive coloration. The vitamin value of the diverse varieties of mango depends on carotenoid, vitamin C and small vitamin B complex content (Cardello; Cardello, 1998). The fruit quality is attributed to its physical characteristics, namely external appearance, especially the color of skin and fruit's shape and size. These characteristics are factors that mostly influence the fruit's acceptability to consumers. Beside these attributes, fruit composition is also highly relevant, conferring various physicochemical and chemical constituents in the pulp. It influences quality of fruit and its by-products as well as the organoleptic and nutritional quality responsible for final acceptance in the market (Lima et al., 2002).

Therefore, the aim of this study was to physically and chemically characterize the fruit quality of four renowned mango cultivars, Haden, Parwin, Tommy Atkins and Palmer, produced in two production years in a subtropical region of São Paulo state, in the municipality of São Manuel.

Results and Discussion

Physical characteristics

There was significant interaction between the cultivars and the production year for the characteristics such as longitudinal diameter, the longitudinal/equatorial diameter ratio and fresh mass of fruit. Also, no interaction was found for firmness, equatorial diameter or pulp yield. The Palmer and Parwin cultivars had the fruit with the most firm pulp (486.80 and 337.08 N), making these cultivars interesting, especially in terms of harvesting and transporting (Table 1). Less firm fruit are preferred by customers because the texture is softer, although this also indicates less resistance to damage from falling or during transport, affecting the final

Table 1. Mean results for firmness, equatorial diameter and fruit pulp yield of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Firmness (N)	Equatorial diameter(cm)	Pulp yield (%)
Haden	201.62 B ± 18.6	9.41 A ± 3.6	71.41 A ± 10.5
Palmer	486.80 A ± 65.6	9.10 AB ± 3.3	71.97 A ± 6.0
Parwin	337.08 AB ± 124.4	8.89 B ± 3.8	73.98 A ± 3.4
Tommy Atkins	176.62 B ± 35.4	9.14 AB ± 5.9	71.80 A ± 5.3
VC (%)	38.60	2.75	8.53
Agricultural years			
2011/2012	299.31 B ± 145.9	9.41 A ± 3.6	74.21 A ± 7.7
2012/2013	301.75 A ± 146.0	8.86 B ± 3.5	70.38 A ± 4.7
VC (%)	0.29	2.92	8.96

Means followed by different letters are significantly different using Tukey's test (p≤0.05).

Table 2. Mean results for longitudinal diameter (cm), fresh mass (g) and longitudinal diameter (LD)/equatorial diameter (ED) ratio of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Longitudinal diameter (cm)		Fresh mass (g)		Ratio LD/ED	
	Agricultural year		Agricultural year		Agricultural year	
	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013
Haden	105.12 Ca ± 4.7	103.22 Ba ± 3.1	540.93 Ca ± 7.7	446.85 Bb ± 35.4	1.09 Ca ± 0.05	1.12 Ca ± 0.03
Palmer	140.57 Aa ± 4.2	133.12 Ab ± 5.0	745.48 Aa ± 8.0	557.33 Ab ± 38.7	1.52 Aa ± 0.03	1.48 Aa ± 0.05
Parwin	125.59 Ba ± 4.6	107.07 Bb ± 6.6	656.06 Ba ± 14.5	455.09 Bb ± 67.4	1.37 Ba ±0.05	1.24 Bb ± 0.03
Tommy Atkins	129.68 Ba ± 5.6	105.57 Bb ± 5.8	587.09 Ca ± 7.3	325.77 Cb ± 30.3	1.34 Ba ± 0.06	1.22 Bb ± 0.06
VC (%)	3.11	5.12	4.64	6.47	3.54	3.58

Identical upper case letter in the columns (cultivars) and identical lower case letter in rows (agricultural year) do not differ using Tukey's test (p≤0.05).

Table 3. Mean results for titratable acidity (g of citr. acid.100g^{-1}) and technological index (%) of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Titratable acidity (g of citr. acid.100g^{-1})	Technological index (%)
Haden	0.36 AB ± 0.07	12.12 A ± 2.5
Palmer	0.34 AB ± 0.13	11.74 AB ± 0.7
Parwin	0.41 A ± 0.09	10.83 AB ± 0.9
Tommy Atkins	0.24 B ± 0.10	9.27 B ± 2.2
VC (%)	30.74	14.59
Agricultural years		
2011/2012	0.37 A ± 0.13	11.74 A ± 2.7
2012/2013	0.31 A ± 0.07	10.25 B ± 1.9
VC (%)	28.74	12.55

Means followed by different letters are significantly different using Tukey's test (p≤0.05).

Table 4. Mean results for soluble solids (ºBrix), pH and "ratio" in the fruit pulp of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Soluble solids (ºBrix)		pH		"Ratio"	
	Agricultural year		Agricultural year		Agricultural year	
	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013
Haden	17.22 Aa ± 1.3	16.52 Aa ± 0.5	3.97 Aa ± 0.1	4.05 Aba ± 0.2	46.73 Aba ± 15.0	49.61 Aa ± 6.7
Palmer	17.32 Aa ± 0.6	15.42 Ab ± 0.5	4.48 Aa ± 0.5	4.17 Aa ± 0.1	48.44 Aba ± 21.0	57.54 Aa ± 6.9
Parwin	14.22 Ba ± 0.9	15.05 Aa ± 0.8	4.13 Aa ± 0.1	3.89 Aba ± 0.1	33.85 Ba ± 10.2	40.69 Aa ± 3.7
Tommy Atkins	14.55 Ba ± 0.9	11.05 Bb ± 1.5	4.44 Aa ± 0.5	3.62 Bb ± 0.2	76.81 Aa ± 34.8	45.42 Ab ± 13.0
VC (%)	6.91	5.42	7.26	5.90	42.20	27.60

Identical upper case letter in the columns (cultivars) and identical lower case letter in rows (agricultural year) do not differ in the Tukey's test (p≤0.05).

Table 5. Mean results for flavonoids in the fruit pulp of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Flavonoids (mg.100g^{-1})
Haden	0.275 B ± 0.15
Palmer	0.379 A ± 0.10
Parwin	0.262 B ± 0.08
Tommy Atkins	0.265 B ± 0.06
VC (%)	26.04
Ciclos agrícolas	
2011/2012	0.362 A ± 0.11
2012/2013	0.228 B ± 0.06
VC (%)	24.38

Means followed by different letters are significantly different using Tukey's test (p≤0.05).

Table 6. Mean results for antioxidant capacity (mg.100g^{-1}) and polyphenols (mg of gallic acid.100g^{-1}) in the fruit pulp of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Capacity antioxidant (mg.100g^{-1})		Polyphenols (mg of gallic acid.100g^{-1})	
	Agricultural year		Agricultural year	
	2011/2012	2012/2013	2011/2012	2012/2013
Haden	0.77 Bb ± 0.25	6.51 Ba ± 1.34	135.93 Ba ± 6.51	106.72 Bb ± 8.05
Palmer	2.26 ABb ± 0.22	13.06 Aa ± 3.34	157.14 Aa ± 3.58	153.85 Aa ± 19.82
Parwin	1.63 Aba ± 0.26	2.93 Ca ± 0.42	101.38 Ca ± 5.30	76.66 Cb ± 3.93
Tommy Atkins	3.50 Aa ± 0.64	3.58 Ca ± 1.22	69.27 Db ± 2.89	82.53 Ca ± 13.36
VC (%)	33.36	30.49	7.87	8.63

Identical upper case letter in the columns (cultivars) and identical lower case letter in rows (agricultural year) do not differ in the Tukey's test (p≤0.05).

Table 7. Mean results for carotenoids and vitamin C, ascorbic acid, in the fruit pulp of the four mango cultivars harvested in São Manuel-SP in the 2011/2012 and 2012/2013 agricultural years.

Cultivars	Carotenoids (ug.100g^{-1})		Ascorbic acid (mg.100g^{-1})	
	Agricultural year		Agricultural year	
	2011/2012	2012/2013	2011/2012	2012/2013
Haden	496.05 Aba ± 50.22	645.48 Aa ± 256.51	27.78 Ba ± 0.71	24.13 Bb ± 1.26
Palmer	221.82 Bb ± 25.09	593.00 Aa ± 8.23	64.81 Aa ± 1.71	41.73 Ab ± 4.80
Parwin	542.50 Aa ± 22.82	637.84 Aa ± 85.64	9.26 Ca ± 0.82	11.09 Ca ± 1.90
Tommy Atkins	569.21 Aa ± 95.47	391.01 Aa ± 76.72	8.73 Ca ± 0.87	7.46 Da ± 1.59
VC (%)	32.32	38.41	10.01	7.25

Means followed by different letters are significantly different using Tukey's test (p≤0.05).

physical appearance. Silva et al. (2012) evaluated some cultivars and reported that Palmer, Parwin, Haden and Tommy Atkins cultivars had values for firmness varying from 67.91 N to 103.19 N. In this study, the values ranged from 176.62 to 486.80N, which may be attributable to the ripeness of the fruit, because of the harvest.

The Haden, Palmer and Tommy Atkins cultivars had the highest values for the equatorial diameter of the fruit. The fruits from the first year (2011/2012) showed higher values for equatorial diameter.

There was no statistical difference among the cultivars or the two years regarding pulp yield (Table 1). Such high values for pulp yield mean the fruit has great potential for the food industry, especially for producing juices and fruit pulp, being the main factor when acquiring raw material. Significant values for pulp yield were also reported by Silva et al. (2012), for the Palmer, Parwin and Tommy Atkins cultivars. Lira Junior et al. (2005), stated that pulp yield is considered an attribute of quality, especially for fruit destined for making sub-products, considering that the minimum value for processing industries is 40%. Irrespective of the agricultural year evaluated, the ‘Palmer’ mango had the highest values for longitudinal diameter and fresh mass of fruit. In the first year, the Haden cultivar had the lowest longitudinal diameter and in the second year there were no significant differences between Haden, Parwin and Tommy Atkins cultivars (Table 2). Silva et al. (2012) found higher values for longitudinal diameter in fruit from the Palmer cultivar (13.67 cm), In this study, the values varied from 13.31 to 14.05 cm. For the longitudinal/equatorial diameter ratio, we observed that fruit from the ‘Palmer’ cultivar had the highest values (1.52 and 1.48) and fruit from the ‘Haden’ cultivar the lowest (1.09 and 1.12), in the first (2011/2012) and 2nd year (2012/2013), respectively (Table 2). However, fruit from the Palmer cultivar had longer length. When the value of this ratio is equal to 1.0, the fruit is round, when ratios higher than 1.0, look longer and when lower than 1.0, the fruit is flattened (Silva et al., 2012).

We obtained the highest fresh mass of fruit (745.48 and 557.33 g) for the Palmer cultivar, in the first (2011/2012) and 2nd year (2012/2013), respectively, is in line with the data reported by Silva et al. (2009), (678.6 g), and, (562.40 g) for the same cultivar. Silva et al. (2012) stated that fruit from the mango tree should have mass exceeding 200 g for producing fruit in syrup. In this study, all the cultivars produced fruit mass above the minimum standard for industrialization. Neves et al. (2008), found mean mass values for the Haden and Tommy Atkins cultivars of 675 and 583 g, respectively. We found similar results of 540.93 and 446.85 g for Haden and 587.09 and 325.77g for Tommy Atkins cultivars. The variable data concerning the physical characteristics of mangoes in Brazil may be explained by genotype differences between the studied varieties, differences in the methodology and analysis, the ripeness of the fruit at harvest and edaphoclimatic differences between the regions, in which they were produced (Bernardes-Silva et al., 2003; Bastos et al., 2005; Benevides et al., 2008; Silva et al., 2009).

For the technological index, which ranged from 9.27 to 12.12%, fruit from Haden, Palmer and Parwin cultivars had the highest values (Table 3). There are no data available for comparing the technological index of fruit from the mango tree. The values found in this study are high, compared with those obtained for orange trees, the fruit of which was destined for industrial processing to make juice. Di Giorgi et al. (1990) reported that for the 'Valencia' cultivar, the technological index ranged from 2.49 to 2.86 kg of SS carton-1. For the authors, this is the best index for purchasing fruit for industry, reflecting a combination of physical and chemical characteristics. For the best performance, in term of concentration of soluble solids, the most desirable fruit are those with the highest technological index (index of industrial yield). The association between soluble solids and industrial yield as a quality index has already been used for differentiating payment for citrus fruit and passion fruit, becoming a trend used in the agricultural industry (Sacramento et al. 2007).

Chemical characteristics

There was significant interaction between the cultivars and the production years for the characteristics of soluble solids, pH and “ratio”, although there was no significant interaction for titratable acidity (Tables 3 and 4). Gonçalves et al. (1998), reported that total acidity in the mango, usually expressed as citric or malic acid, had values ranging from 0.17% to 3.66% and between 0.11 and 0.56% for ripe and unripe fruit. The titratable acidity content varied from 0.24 to 0.41 grams of citric acid per 100 grams of pulp, being higher in pulp from the Parwin, Haden and Palmer cultivars, with no difference according to year (Table 3). These data show values below those found by Silva et al. (2012), which ranged from 0.8422 to 0.9026% for citric acid. Lower acidity in the 'Tommy Atkins' cultivar in the first production year led to a better “ratio” for this agricultural year, making the fruit appropriate for consumption, based on the principle that sweet mangoes suit the consumer plate (Table 4). The pH ranged from 3.62 to 4.48, soluble solids from 11.05 to 17.32 ºBrix and the “ratio” oscillated between 33.85 and 76.81. The lowest pH values were found for the Tommy Atkins cultivar, 3.62 and 4.44, in line with Silva et al. (2012) who found the lowest pH, 3.0, for this cultivar.

Cruz et al. (2010) found pH of 4.06, soluble solids of 7.12 ºBrix and titratable acidity of 3.13 g of citric acid per 100 ml^{-1} for fruit from the ‘Tommy Atkins’ cultivar, originating from the CEASA-Maringá/PR, at stage 4 of ripeness scale, given the coloration of the skin and pulp, with a predominantly orange coloration in the region close to the stone. The pH values for the Tommy Atkins cultivar in the second harvest were below the values reported by Carvalho et al. (2004), who found value of 4.37, corroborating the onset of the ripening process. Mango is a climacteric fruit, in which the organic acid is consumed by the respiration process when fruit ripens and; therefore, acidity decreases and pH rises. Chitarra and Chitarra (2005) reported that the increase in soluble solid content is also due to the synthesis of secondary compounds such as simple phenols.

Ripen fruits from the ‘Haden’ and ‘Tommy Atkins’ cultivars were harvested in Boa Vista-RR, with a reddish-green and purplish-green color; mean soluble solids of 8.9 and 9.1º Brix; mean titratable acidity of 1.09 and 1.13% citric acid, respectively (Neves et al., 2008). Ramos et al. (2011) stated that, for the same cultivar, the variations in chemical characteristics are due to the different degree of ripeness at harvesting (especially using visual criteria), handling, soil and climate, as well as to place and origin of the fruit evaluated. Fruit produced in regions with a subtropical climate are often more acidic compared with those harvested in warmer regions. Fruit from the 'Palmer' cultivar, minimally processed and stored at different temperatures showed a pH of 4.0 and a loss of firmness from 0.489 N to 0.268 N, when stored for 10 days (Alves et al., 2010). Hojo et al. (2009), in Bahia, worked with the same cultivar, and found 6.2 ºBrix; 0.8 of citric acid 100 g^{-1} of the pulp for titratable acidity; pH

3.3; SS/TA ration of 9.0 and ascorbic acid content of 60 mg per 100 g^{-1} of pulp.

Bioactive compounds

There was significant interaction between the cultivars and the production years for concentrations of antioxidant capacity, polyphenols, carotenoids and vitamin C, expressed as ascorbic acid, except for flavonoids. From the point of view of functional properties, the fruit is highly recommended for being rich in vitamin C, carotenoids and phenol compounds among others, as well as for its antioxidant action, cleaning up free radicals and sequestering carcinogens and their metabolites, protecting against the degenerative processes that lead to disease and ageing (Sgarbieri and Pacheco, 1999).

Values for flavonoids varied from 0.262 to 0.379 mg $100g^{-1}$. The fruit pulp from the Palmer cultivar had the highest flavonoids content, especially in the first year (Table 5). There was a lower level of antioxidant capacity in the pulp of the fruit from the Haden and Palmer cultivars in the second year (2012/2013), and the Palmer cultivar stood out as having the highest value (Table 6). As for polyphenol content, the Palmer cultivar had the highest content in both agricultural years. The value for the antioxidant capacity of the mango pulp varied from 0.77 to 13.06 mg $100g^{-1}$ and that of polyphenols from 69.27 to 157.14 mg of gallic acid $100g^{-1}$. Antioxidants are compounds that inhibit or delay oxidation of other molecules by inhibiting the start of oxidative chain reactions (Taiz and Zeiger, 2009). Due to chemical variety, phenol compounds have a diverse range of functions in vegetables, many act as defense against herbivores and pathogens, others attract pollinators or even act as support and protection mechanisms against solar radiation (Taiz and Zeiger, 2009).

Many studies have shown that phenol compounds are responsible for the antioxidant activity of fruit. The final quantity of total phenols can be affected by factors such as: ripeness, species, cultivation techniques, geographic origin, stage of growth and harvesting and storage conditions (Soares et al., 2008; Sousa et al., 2012). Moreover, the quantity phenols present in vegetables may vary according to factors that are not intrinsic to the food, such as solar radiation, time of year, rainfall and U, among others which can affect metabolism and phenol production in foods (Machado et al., 2008).

The value for carotenoids in the pulp of the mango cultivars varied from 2.21 to 6.45 mg $100g^{-1}$ and for vitamin C, ascorbic acid, they varied from 7.46 to 64.81 mg per 100 grams of pulp (Table 7). Ascorbic acid content in vegetables is an important indicator of the preservation of other nutrients due to its thermolabile characteristics, in addition to its essential role in human nutrition. When ascorbic acid breaks down it can lead a non-enzymatic browning and cause the appearance of disagreeable tastes (Alves et al., 2010).

The highest vitamin C content (ascorbic acid) was found in fruit pulp from Palmer cultivar (64.81 mg $100g^{-1}$) in both of the years evaluated. The lowest amount was observed for Tommy Atkins cultivar (7.46 mg $100g^{-1}$), in line with the data by Silva et al (2012), who reported the highest values for the Palmer, 34.27 mg $100g^{-1}$, and the lowest for the Tommy Atkins, 7.47 mg 100 g^{-1}. Alves et al. (2010), determined mean values of 45.27 mg 100 g^{-1} of vitamin C in pulp from Palmer mangoes acquired for the local market at Lavras-MG. The explanation for the differences found in the two studies for this cultivar may lie in ripeness stage at time of harvest. Silva et al. (2009), evaluated the Haden cultivar in Viçosa-MG and found the following values: fruit of a mean 321.3 g weight, with pulp of 132.3 N firmness, titratable acidity of 0.35 % (citric acid), 12.1 ºBrix for soluble solids, 36.3 SS/TA ratio, 17.7 mg vitamin C in 100 g^{-1} pulp and 25.2 μg g^{-1} of carotenoids. According to Oliveira et al. (2013), the carotenoids found in the fruit of 46 Ubá mangoes varied between 0.61 and 2.12 mg $100g^{-1}$ pulp.

Materials and Methods

Experimental location and harvest

The fruit produced in the São Manuel laboratory farm orchard, Faculty of Agricultural Sciences, UNESP (Botucatu-SP). The fruits were harvested, separated according to cultivar and transported to the Fruticulture Laboratory of faculty, where the physical and chemical analyses to characterize the fruit took place. The fruits from the harvests of the 2011/2012 and 2012/2013 agricultural years were evaluated. The fruits were collected when ripened. The criteria for deciding the harvest time were the color of the skin, the shape of the fruit and the plumpness of the area near to the stem. When harvested, 60% of the fruit skin had a reddish-purplish coloration, as with the fruit evaluated by Silva et al. (2014).

Experiment design

The experiment design was totally randomized, consisting of 4 treatments and 4 repetitions for the physical analyses and 4 treatments and 6 repetitions for the chemical analyses, with treatments represented by the cultivars and the repetitions composed of 5 fruit from each cultivar.

Physical analyses

The physical analyses were: fresh mass of fruit (g), pulp yield (%), equatorial diameter (ED) (cm), longitudinal diameter (LD) (cm), LD/ED ratio and firmness of fruit (N).

Chemical analyses

The following chemical analyses were performed: pH, titratable acidity (g citric acid 100g $pulp^{-1}$), soluble solids (º Brix), ripeness ratio (“Ratio”), technological index (obtained in % using the equation: soluble solids x pulp yield/100 as in Chitarra and Chitarra (2005), vitamin C (mg 100 g^{-1} ascorbic acid), flavonoids (mg 100 g^{-1}), polyphenols (mg 100 g^{-1} gallic acid), antioxidant capacity (mg 100 g^{-1}) and carotenoids (mg 100 g^{-1}) (Hassimoto et al., 2008).

Statistical analysis

All data were subjected to analysis of variance (ANOVA) and when there was significant variance, the means were compared by Tukey test at $p \leq 0.05$.

Conclusions

The cultivars evaluated are suitable for industrialization, because high pulp yield was found for all the cultivars (>70%). Fruit from the Palmer and Parwin cultivars are favourable, in terms of harvesting and transporting. These showed the best values for firmness. Among the four cultivars, the fruits of the Palmer present higher physical and chemical quality, since they stand out with high mean mass, longitudinal/equatorial diameter ratio, vitamin C content, expressed as ascorbic acid, flavonoid, polyphenol content and antioxidant capacity in the agricultural year 2012/2013.

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