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Quality and bioactive compounds in fruit of foreign accessions of mango conserved in an Active Germplasm Bank[1]

Qualidade e compostos bioativos de frutos de acessos estrangeiros de mangueira conservados em Banco Ativo de Germoplasma

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ABSTRACT - The aim of this study was to characterise the quality and levels of bioactive compounds in the fruit of 22 foreign accessions of the mango belonging to the Active Germplasm Bank of *Embrapa Semiárido*. Sixty fruits from each of the accessions: Florigon, Haden, 65, Irwin, M 13269, Momi-K, Scuper Many, Simmonds, Tommy Atkins, Van Dyke, Winter, Zill, Amrapali, Olour, Aplle DCG 406, Mon Amon DCG 407, Black Java, Kensington, Chené, Manila, Manzanillo and Maya, were harvested upon reaching physiological maturity, one half being analysed when harvested and the other half stored at ambient temperature (25.4 ± 2.9 ºC and 41 ± 9% RH) until ripe. The experimental design was completely randomised in a 22 x 2 factorial (accession x maturity stage), with three replications of ten fruits. The accessions Chene, Momi-K and Van Dyke stood out for their physical attributes: weight, length, diameter and firmness of pulp, and for their good post-harvest conservation. The accession Amrapali was different because of its high levels of soluble solids, total soluble sugars, starch, ascorbic acid and carotenoids, suggesting a high potential for insertion into a breeding program aimed at the quality of the mango.

Key words: Mango. Postharvest. Genetic resources. Vitamin C. Carotenoids.

RESUMO - O objetivo deste estudo foi caracterizar a qualidade e o teor de compostos bioativos dos frutos de 22 acessos estrangeiros de mangueira, pertencentes ao Banco Ativo de Germoplasma da Embrapa Semiárido. Sessenta frutos de cada um dos acessos Florigon, Haden, 65, Irwin, M 13269, Momi-K, Scuper Many, Simmonds, Tommy Atkins, Van Dyke, Winter, Zill, Amrapali, Olour, Aplle DCG 406, Mon Amon DCG 407, Black Java, Kensington, Chené, Manila, Manzanillo e Maya foram colhidos quando atingiram a maturidade fisiológica, sendo a metade analisada no dia da colheita e a outra metade armazenada, sob temperatura ambiente (25,4 ± 2,9 ºC e 41 ± 9% UR), para completar o amadurecimento. O delineamento experimental foi inteiramente casualizado, em fatorial 22 x 2 (acesso x estádio de maturação), com três repetições de dez frutos. Os acessos Chené, Momi-K e Van Dyke destacaram-se quanto aos atributos físicos peso, comprimento, diâmetro e firmeza da polpa e pela boa conservação pós-colheita. O acesso Amrapali diferenciou-se pelos elevados teores de sólidos solúveis, açúcares solúveis totais, amido, ácido ascórbico e carotenoides, sugerindo alto potencial para inserção em programa de melhoramento genético orientado para a qualidade da manga.

Palavras-chave: Manga. Pós-Colheita. Recursos genéticos. Vitamina C. Carotenoides.

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INTRODUCTION

Brazilian mango production in 2010 was 1,197,694 tonnes, of which about 124,694 tonnes were exported, producing US$ 119,929,762 in revenue. The main destinations were the Netherlands, the United States, Spain, the UK and Portugal, which received respectively 49, 20, 10, 7 and 5% of the Brazilian exports (INSTITUTO BRASILEIRO DE FRUTAS, 2011; VALEXPORT, 2011).

Among cultivars, the most widely produced and exported by Brazil is still Tommy Atkins, which despite excellent fruit colouration, relative resistance to disease and acceptable post-harvest conservation, has a high susceptibility to floral malformation and internal breakdown, as well as fibres and only a slightly pronounced flavour, characteristics which have reduced its acceptance among foreign consumers (PINTO *et al*., 2002). Moreover, the predominance of any one cultivar over large areas increases the risk of phytosanitary problems or of oversupply, reducing business competitiveness, or even compromising its continuation (PINTO *et al*., 2005).

To prevent such serious consequences, it is important to introduce, evaluate and select species which offer innovative features to the market, as well as cultivars with characteristics that may strengthen the list of choices of parental groups, leading to the achievement of new genetic material (PINTO; PINHEIRO NETO; GUIMARÃES, 2011). Currently, action does not just focus on productivity, adaptation to environmental conditions or agricultural practices, but mainly on fruit quality, which has become a differentiating and determining element in breeding programs. Among the requirements related to quality are included sensory attributes connected to appearance (colour, size, shape, absence of defects), flavour (levels of soluble solids, titratable acidity) and aroma, as well as nutritional value (vitamin C content, carotenoids) and the health and physical integrity of the consumer (BRECHT; YAHIA, 2009).

Aiming to provide technical and scientific support to these initiatives, studies are being conducted in various regions to characterise mango cultivars (BERNARDES-SILVA; LAJOLO; CORDENUNSI, 2003; GALLI *et al*., 2008; RUFINI *et al*., 2011). Many of these studies consider the physicochemical and chemical characteristics of the fruit. Under the conditions of the state of Minas Gerais, Ribeiro *et al*. (2007) emphasised that the Tommy Atkins, Palmer and Ubá cultivars displayed high levels of carotenoids, however the Ubá cultivar was also distinguished by its high levels of phenolic compounds and ascorbic acid.

Using this approach, the aim of this study was to characterise the quality and levels of bioactive compounds in the fruit of 22 foreign accessions of the mango, which are stored in the Active Germplasm Bank (AGB) of *Embrapa Semiárido*.

MATERIAL AND METHODS

The mango fruit originated at the AGB of *Embrapa Semiárido*, located in the Mandacaru Experimental Area in Juazeiro, in the state of Bahia (09º24 ‘S, 40º26’ W). Twenty-two accessions were evaluated, twelve from North America (Florigon, Haden, 65, Irwin, M 13269, Momi-K, Scuper Many, Simmonds, Tommy Atkins, Van Dyke, Winter and Zill), two from India (Amrapali and Olour) two from Thailand (Aplle DCG 406 and Mon Amon DCG 407), two from Australia (Black Java and Kensington), one from Africa (Chené), one from the Philipines (Manila), one from Mexico (Manzanillo) and one from Israel (Maya). The Tommy Atkins cultivar was taken as the reference for the evaluations due to its economic importance.

The plants from the ABG were planted in 1994, and are grown on a Vertisol, at a spacing of 10 m x 10 m, and irrigated by micro-sprinkler. Agricultural treatments followed the recommendations for crops in the Vale do São Francisco.

During the 2008/2009 harvest, 60 fruits were uniformly collected for each accession when reaching physiological maturity, which is characterised by a change in skin colour to light green and by the beginning of softening. After collection, the fruits were transported to the Laboratory for Post-harvest Physiology of *Embrapa Semiárido* in Petrolina, in the state of Pernambuco. In the laboratory, half of the fruit from each accession was analysed at their current maturity stage, and the other half was stored at room temperature (25.4 ± 2.9 °C and 41 ± 9% RH) until they ripened, when they were then analysed. It should be noted that storage at room temperature to complete ripening was not possible for the fruits of the Manila accession. Plants from that accession had low fruit yield and the advancement of maturation in some of the fruits meant that standardised harvesting at physiological maturity was not possible. Consequently for that case, only fruits that ripened on the plant were evaluated.

The variables analysed were: a) weight (g): obtained with a semi-analytic balance; b) longitudinal and transverse diameters (mm): obtained with calipers; c) pulp firmness (N): measured using an FT 327 manual penetrometer with a tip of 8 mm in diameter; d) presence of fibres: by subjective assessment (visual and tactile), considering absent, low and fibrous; e) colour of the skin and pulp: determined by digital colorimeter, using the attributes of luminosity (L), chroma (C) and hue (H) (RIBEIRO *et al*., 2009); f) titratable acidity (TA, % citric acid): by titration with a solution of 0.1 N NaOH (ASSOCIATION OF OFFICIAL ANALYTICAL

CHEMISTS, 1998); g) soluble solid content (SS, °Brix): determined by direct reading with a digital refractometer with automatic temperature compensation (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 1998); h) total soluble sugar content (TSS, g 100 g^{-1}), extracted in 80% ethanol and quantified using the anthrone reagent (YEMN; WILLIS, 1954); i) reducing sugars content (RS, g 100g^{-1}): extracted in water and determined with the method proposed by Miller (1959); j) starch content (100g^{-1}): determined by acid hydrolysis (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 1998) and quantified from the released RS (Miller, 1959); k) vitamin C content (mg ascorbic acid 100 ml^{-1}): following a recommendation of the Association of Official Analytical Chemists (1998); l) total carotenoids content (mg 100 g^{-1}): determined according to the method described by the Association of Official Analytical Chemists (1998). The number of days from harvest to the ripe stage were also evaluated, as indication of the perishability of the fruits of each accession under the storage conditions mentioned above.

The experimental design was completely randomised, in a 22 x 2 factorial (accession x maturity stage), with three replications consisting of ten fruits. The data were submitted to variance analysis and the means were compared by Scott-Knott test ($p \leq 0.05$). When interaction between factors was statistically significant, a breakdown of the accessions for each maturity stage was carried out (BANZATTO; KRONKA, 2006).

RESULTS AND DISCUSSION

As there was significant interaction between factors for all variables, this study demonstrated the existence of high genetic variability between accessions, influenced in a decisive way by their maturity stage.

Although not currently a criterion for mandatory disposal, since smaller fruits can be used for the domestic market, there are requirements as to the weight of mangoes for export, with priority being given to fruits of approximately 450 g (PINTO *et al*., 2002). Fruits from the accessions Tommy Atkins, Aplle DCG 406, Black Java, Chené, Kensington, Mon Amon, 65, Haden, Irwin, Momi-K and Zill (Table 1) all met this requirement. Galli *et al*. (2008) had already highlighted this attribute in the latter.

The relationship between length and diameter with fruit weight was confirmed in the Tommy Atkins accession, which showed an average of 103.69 and 97.81 mm for length and 90.07 and 78.76 mm for diameter at the two maturity stage respectively (Table 1). The accessions that were similar were the Chené, Manzanillo and Momi-K.

As to firmness, eight distinct groups were formed for fruit at physiological maturity, whose averages ranged from 57.22 to 123.58 N (Table 1). The Winter and Van Dyke accessions stood out as having more firmness when harvested. A second group was formed by the Momi-K, M-13269, Tommy Atkins and Aplle DCG 406 accessions, with a pulp firmness of more than 110 N, giving them greater resistance to handling and transport. Pinto, Pinheiro Neto and Guimarães (2011) noted that distributors want cultivars with this feature. Firmness did not differ in the mature fruit, although the Van Dyke, Momi-K and Aplle DCG 406 had values of approximately 7 N (Table 1), which is characteristic of good firmness, according Montalvo *et al*. (2009).

Knowledge of the shelf life of fruits is essential to assess the need for the use of specific techniques of post-harvest conservation. The accessions under test varied as to the number of days of storage needed to ripen at room temperature, two groups being determined: 6-9 days and 10-13 days (Table 1). Fruits from accessions M-13269, Chené and Van Dyke were similar to the Tommy Atkins, displaying slower ripening.

The accessions Amrapali, Manila and Scuper Many, were characterised by the absence of fibre, while the Olour, Aplle DCG 406, Black Java, Chené, Manzanillo, Mon Amon, 65, Florigon, Irwin, Momi-K Maya and Winter had low fibre (Table 1). The fruits of the remaining accessions were characterised as fibrous. Pinto *et al*. (2005) stressed the importance of cultivars without fibres, which appeal to consumers.

Colour is a very important component of quality for the consumer, and should display uniformity and intensity. The Manila accession showed the greatest skin brightness for the two maturity stage (Table 2). According to Ribeiro *et al*. (2007), ripe fruit from the Haden, Tommy Atkins and Palmer accessions had a skin luminosity of 61.3, 58.3 and 54.9 respectively. For values of C in the skin, representing purity of colour, there were statistically significant differences between accessions, forming two groups for the physiologically mature fruit, which ranged from 18.05 in the Manzanillo to 31.08 in the Black Java (Table 2). The ripe fruit of the Momi-K accession had a markedly higher colour intensity (Table 2). For H, the skin colour of the accessions at physiological maturity was characterised by variations from a yellowish green to yellow (Table 2). In the Tommy Atkins and Van Dyke accessions, skin colour, which was already yellow when harvested, turned orange when the fruits were ripe (Table 2). For the ripe mangoes, the predominant skin colour was yellow.

In the pulp, the Manila accession also had the highest average values for L, both in fruits at physiological maturity (66.48) and when ripe (49,06) (Table 2). The Zill and Mon Amon accessions showed more intense colour at physiological maturity (Table 2). However, the mature fruit of the Amrapali, Winter, Simmonds and Momi-K accessions had the highest averages (Table 2). The accessions already had a yellow-coloured pulp when harvested, but after maturing turned orange, with the strongest colour at both maturity stage being observed in the Haden, Simmonds, Winter Manila, Amrapali, Scuper Many, Maya, 65, Momi-K and Van Dyke (Table 2). According to Silva *et al*. (2011), at harvest time, the cultivar Ubá showed a greenish pulp in the region near the seeds. On the sixth day of storage however, the value for H was 93.90, and by the end of the 42 days, these values went down to around 60.00, characteristic of the orange colour of the pulp and similar to values found for most of the accessions tested in this study.

Table 1 - Average weight (AW), longitudinal diameter (LD), transverse diameter (TD), pulp firmness (PF), number of days for the completion of ripening (NR) and the presence of fibres, in fruits of mango accessions from the Active Germplasm Bank of *Embrapa Semiárido*, evaluated at two maturity stages (MS): physiological maturity (PM) and mature*

Acession	MS	AW (g)	LD (mm)	TD (mm)	PF (N)	NR (days)	Fibre
Olour	PM	245.10 D	96.69 D	74.09 D	63.06 A	6 A	Low
	Mature	217.74 b	94.41 c	61.22 d	3.80 a		
Amrapali	PM	144.35 A	82.80 A	59.01 B	92.51 D	8 A	Absent
	Mature	136.49 a	81.92 a	49.38 a	3.38 a		
Aplle DCG 406	PM	328.26 F	98.26 D	84.32 E	117.94 G	6 A	Low
	Mature	287.83 d	92.68 c	65.98 e	7.66 a		
Black Java	PM	388.94 G	89.86 B	81.44 E	97.37 E	9 A	Low
	Mature	281.36 d	80.0 a	74.83 g	6.95 a		
Chené	PM	372.06 G	104.17 F	75.58 D	106.16 F	11 B	Low
	Mature	353.13 e	100.85 d	71.89 f	1.43 a		
Kensington	PM	299.25 E	87.20 A	71.34 C	72.03 B	7 A	Fibrous
	Mature	295.40 e	89.77 b	69.08 f	2.79 a		
Manila	PM	227.41 C	118.45 G	55.34 A	72.06 B	-	Absent
	Mature	205.05 b	112.57 f	57.32 c	0.15 a		
Manzanillo	PM	536.96 I	107.50 F	98.79 G	89.58 D	8 A	Low
	Mature	528.13 g	108.47 e	83.72 i	6.67 a		
Maya	PM	187.71 B	93.73 C	56.27 A	104.84 F	7 A	Low
	Mature	172.67 a	92.82 c	53.64 b	6.30 a		
Mon Amon DCG 407	PM	327.15 F	92.89 C	76.49 D	57.22 A	7 A	Low
	Mature	297.48 d	92.21 c	70.39 f	1.03 a		
Tommy Atkins	PM	429.81 H	103.69 F	90.07 F	114.99 G	13 B	Fibrous
	Mature	365.18 e	97.81 d	78.76 h	4.25 a		
65	PM	381.51 G	91.03 B	80.20 E	78.44 C	6 A	Low
	Mature	354.85 e	90.02 b	75.18 g	6.82 a		
Florigon	PM	293.68 E	100.01 E	69.01 C	86.56 D	8 A	Low
	Mature	265.65 c	98.65 d	64.99 e	6.00 a		
Haden	PM	325.01 F	90.47 B	76.41 D	85.12 D	6 A	Fibrous
	Mature	399.83 f	100.52 d	77.85 h	5.91 a		

Continuation of Table 1

Irwin	PM	285.90 E	92.49 C	71.38 C	75.22 B	7 A	Low
	Mature	297.42 e	89.11 b	69.96 f	4.21 a		
M 13269	PM	207.66 C	101.01 E	60.62 B	113.33 G	10 B	Fibrous
	Mature	193.91 b	101.29 d	57.54 c	5.02 a		
Momi-K	PM	399.31 G	116.86 G	74.63 D	111.19 G	6 A	Low
	Mature	380.45 f	113.96 f	70.59 f	7.49 a		
Scuper Many	PM	206.08 C	91.60 B	60.64 B	103.91 F	7 A	Absent
	Mature	209.54 b	91.89 c	58.26 c	6.71 a		
Simmonds	PM	260.20 D	88.84 B	68.32 C	82.21 C	9 A	Fibrous
	Mature	306.71 d	95.33 c	69.94 f	5.02 a		
Zill	PM	307.52 E	96.42 D	70.44 C	79.75 C	8 A	Fibrous
	Mature	315.58 d	99.02 d	67.23 e	5.32 a		
Van Dyke	PM	235.38 D	90.42 B	63.59 B	123.58 H	12 B	Fibrous
	Mature	222.97 b	88.55 b	61.63 d	6.97 a		
Winter	PM	184.45 B	86.19 A	59.30 B	122.49 H	7 A	Low
	Mature	158.95 a	80.12 a	54.71 b	4.92 a		

*Averages followed by the same uppercase or lowercase letter in a column do not differ by Scott-Knott test ($p \leq 0.05$)

Table 2 - Luminosity (L) of the skin, chroma (C) of the skin, hue (H) of the skin, L of the pulp, C of the pulp, H of the pulp in fruits of mango accessions from the Active Germplasm Bank of *Embrapa Semiárido*, evaluated at two maturity stages (MS): physiological maturity (PM) and mature*

Acession	MS	Skin L	Skin C	Skin H	Pulp L	Pulp C	Pulp H
Olour	PM	45.18 D	30.01 B	115.84 C	49.08 B	17 A	180.80 D
	Mature	48.51 c	29.04 b	99.97 e	33.37 a	18.69 a	95.84 c
Amrapali	PM	39.14 C	28.22 B	107.76 B	53.99 C	31.79 D	91.53 A
	Mature	38.24 a	22.96 a	101.03 e	40.27 b	36.76 d	77.94 a
Aplle DCG 406	PM	40.69 C	24.16 A	119.57 C	54.68 C	20.52 A	104.46 C
	Mature	42.53 b	26.35 a	103.16 e	39.14 b	24.83 b	83.28 b
Black Java	PM	49.27 E	31.08 B	109.40 B	51.64 B	24.36 C	102.13 C
	Mature	49.92 c	30.08 b	86.59 c	39.08 b	26.03 b	89.83 c
Chené	PM	40.21 C	21.87 A	123.49 C	54.89 C	21.67 B	102.69 C
	Mature	47.03 c	34.85 b	80.56 c	39.83 b	27.51 b	84.03 b
Kensington	PM	35.82 A	29.91 B	108.29 B	42.64 A	27.13 C	93.38 B
	Mature	44.79 b	31.34 b	92.46 d	35.07 a	35.27 c	82.13 a
Manila	PM	60.50 F	22.65 A	104.94 A	66.48 D	25.14 B	88.94 A
	Mature	58.35 d	26.25 a	80.45 c	49.06 d	23.71 b	77.45 a

Continuation of Table 2

Manzanillo	PM	34.45 A	18.05 A	119.02 C	50.62 B	22.63 B	97.20 B
	Mature	39.75 a	24.97 a	76.26 b	37.12 a	25.56 b	84.08 a
Maya	PM	43.77 D	23.46 A	120.14 C	47.65 B	28.08 C	88.10 A
	Mature	50.13 c	30.04 b	84.86 c	35.88 a	25.27 b	80.40 a
Mon Amon DCG 407	PM	45.42 D	25.17 A	118.52 C	51.43 B	38.76 E	95.18 B
	Mature	49.49 c	32.13 b	95.36 d	45.38 c	35.25 c	84.92 b
Tommy Atkins	PM	38.26 B	20.36 A	99.31 A	46.35 A	24.18 B	94.34 B
	Mature	39.98 a	24.96 a	70.37 a	37.82 b	25.76 b	86.55 b
65	PM	45.79 D	28.58 B	110.77 B	50.83 B	26.46 C	87.99 A
	Mature	44.61 b	29.74 a	93.65 d	37.11 a	28.77 b	80.47 a
Florigon	PM	41.16 C	25.47 A	117.18 C	54.04 C	27.96 C	96.97 B
	Mature	48.11 c	26.97 a	84.77 c	40.52 b	28.84 b	86.19 b
Haden	PM	40.83 C	22.74 A	116.77 C	52.46 C	26.18 C	90.34 A
	Mature	46.98 c	30.72 a	82.76 c	35.40 a	29.12 b	74.94 a
Irwin	PM	40.35 C	24.34 A	115.37 C	49.53 B	32.17 D	90.34 a
	Mature	44.25 b	26.04 a	85.14 c	39.72 b	32.77 c	83.04 b
M 13269	PM	44.96 D	28.36 B	112.53 C	55.27 C	13.84 A	111.65 D
	Mature	48.85 c	31.03 a	87.40 c	36.08 a	26.43 b	85.29 b
Momi-K	PM	39.90 C	25.05 A	116.83 C	55.53 C	30.68 D	86.03 A
	Mature	41.66 a	49.46 c	66.19 a	38.72 b	39.93 d	81.13 a
Scuper Many	PM	42.66 D	25.71 A	116.39 C	42.89 A	27.51 C	87.47 A
	Mature	48.98 c	30.27 a	85.54 c	32.97 a	31.99 c	78.16 a
Simmonds	PM	34.01 A	24.46 A	111.32 B	48.37 B	30.03 D	86.10 a
	Mature	41.89 a	32.73 a	75.03 b	36.70 a	39.83 d	75.85 a
Zill	PM	34.11 A	27.58 B	113.45 C	44.89 A	35.94 E	90.79 A
	Mature	43.47 b	27.63 a	92.89 d	35.61 a	31.51 c	82.75 b
Van Dyke	PM	43.38 D	23.85 A	105.48 A	51.12 B	24.30 B	91.49 A
	Mature	44.64 b	33.02 a	74.84 b	35.08 a	28.31 b	81.39 a
Winter	PM	42.34 C	25.99 A	112.96 C	55.39 C	30.98 D	91.07 A
	Mature	50.04 c	31.05 a	79.17 c	36.85 a	37.58 d	77.16 a

*Averages followed by the same uppercase or lowercase letter in a column do not differ by Scott-Knott test ($p \leq 0.05$)

Titratable acidity is very important to the taste of mangoes due to the ratio of sugar to acidity. The fruits generally display a decrease in TA during ripening, however with the increase in carbon availability there is an increase in the sugar concentration (JOAS; CARO; LECHAUDEL, 2009). The TA of the fruit at physiological maturity ranged from 0.13 to 1.71% citric acid (Table 3), seen in the Oluor and M-13269 accessions respectively. Given that fruits with a better flavour are those with intermediate acidity, around 0.40% citric acid when ripe, the accessions Irwin, Florigon, Amon Mon, Momi-K, Black Java, Winter, Zill, M 13269 and Aplle DCG 406 would all meet this supposition. Faraoni, Ramos and Stringheta (2009) reported that the Ubá cultivar when mature has a TA of 0.40% citric acid and is well accepted in the market.

The levels of SS in the fruits at physiological maturity ranged from 8.2 to 12.2 °Brix, seen in the M 13269 and Olour accessions respectively (Table 3). When ripe, the fruits of the Amrapali accession showed the highest levels of SS at 24.7 °Brix. It should be noted that after ripening, with the exception of the Chené, the other accessions showed an SS greater than that of the Tommy Atkins. As TSS are the main constituents of SS, accessions that showed the highest levels were also the Olour (10.5 g 100 g^{-1}) and the Amrapali (23.0 g 100 g^{-1}), when harvested and when mature respectively (Table 3). In a study with the Ataulfo cultivar, Montalvo *et al*. (2009) found an increase of 17.47% in SS levels during storage. When characterising 39 mango cultivars from the *Polo Apta Centro-Norte* collection in Sao Paulo, SS levels ranged from 24.9 to 12.5 °Brix for the Smith and Brazil cultivars respectively (GALLI *et al*., 2008).

The increase in SS content in the fruit during ripening is due mainly to the hydrolysis of reserve carbohydrates. In this study, the starch content at physiological maturity ranged from 3.42 g 100 g^{-1} for the Chené accession, to 14.22 g 100 g^{-1} for the Manila, which was no different from the Amrapali (Table 3). In the mature fruit, there was no statistical difference for starch content (Table 3). According to Bernardes-Silva, Lajolo and Cordenunsi (2003), the pattern of starch degradation varies with the cultivar. Those authors stated that the levels of starch found are sources of carbon for the post-harvest synthesis of sucrose, despite there being a time lag in some cases between this degradation and accumulation of the sucrose.

Table 3 - Titratable acidity (TA), soluble solids (SS), total soluble sugars (TSS), reducing sugars (RS), starch, vitamin C (Vit. C) and total carotenoids (TC) in fruits of mango accessions from the Active Germplasm Bank of *Embrapa Semiárido*, evaluated at two maturity stages (MS): physiological maturity (PM) and mature*

Accession	MS	TA	SS	TSS	RS	Starch	Vit. C	TC
		(% citric acid)	(°Brix)	(g.100 g^{-1})		(mg.100 mL^{-1})		(mg.100 g^{-1})
Olour	PM	0.13 A	12.20 C	10.54 C	6.65 H	3.69 A	53.86 B	0.80 B
	Mature	0.19 a	20.73 e	17.43 b	7.06 f	0.25 a	49.00 b	0.38 a
Amrapali	PM	1.53 E	11.40 C	7.43 A	3.38 B	13.26 E	96.33 F	0.80 B
	Mature	0.21 a	24.67 g	23.03 e	4.47 c	0.14 a	50.58 b	2.30 d
Aplle DCG 406	PM	0.53 B	9.07 A	7.07 A	4.85 E	4.36 A	75.13 D	0.80 B
	Mature	0.48 b	19.53 d	14.76 a	5.57 d	0.22 a	53.85 b	0.53 a
Black Java	PM	1.25 D	9.20 A	6.10 A	3.60 B	7.36 C	44.08 A	0.80 B
	Mature	0.40 b	18.37 c	14.25 a	5.56 d	0.25 a	53.87 b	0.38 a
Chené	PM	0.87 C	8.80 A	5.90 A	3.86 C	3.42 A	78.35 D	0.80 B
	Mature	0.17 a	15.47 a	13.12 a	3.39 a	0.12 a	55.53 b	0.83 a
Kensington	PM	1.21 D	11.23 C	7.97 B	4.74 E	5.01 A	53.89 B	0.27 A
	Mature	0.28 a	19.07 d	16.51 b	4.74 c	0.12 a	40.82 a	0.63 a
Manila	PM	1.55 E	10.07 A	8.07 B	6.23 G	14.22 E	63.67 C	0.70 B
	Mature	0.16 a	21.87 e	20.49 d	4.02 b	0.13 a	50.62 b	0.55 a
Manzanillo	PM	0.99 D	9.60 A	6.70 A	4.08 C	4.29 A	52.25 B	0.23 A
	Mature	0.77 c	17.57 c	15.92 b	5.58 d	0.13 a	53.86 b	0.78 a
Maya	PM	0.40 B	11.20 C	8.87 B	7.13 I	6.66 B	58.75 B	0.18 A
	Mature	0.31 a	19.93 d	17.24 b	4.24 b	0.73 a	52.22 b	1.17 b

Continuation of Table 3

Mon Amon DCG 407	PM	1.43 E	9.47 A	6.82 A	2.48 A	9.03 D	75.09 D	0.44A
	Mature	0.39 b	22.67 f	18.50 c	4.92 c	0.38 a	73.43 c	1.66 c
Tommy Atkins	PM	0.60 B	8.63 A	6.46 A	4.30 D	4.94 A	40.82 A	0.58 B
	Mature	0.17 a	16.97 b	15.22 a	3.55 a	0.12 a	50.60 b	1.28 b
65	PM	1.12 D	10.33 B	7.46 A	3.46 B	5.89 B	58.79 B	0.48 B
	Mature	0.62 c	18.50 c	14.27 a	4.82 c	0.26 a	37.54 a	0.65 a
Florigon	PM	0.56 B	10.30 B	8.40 B	4.32 D	4.27 A	52.24 B	0.39 A
	Mature	0.37 b	17.60 c	14.99 a	5.89 e	0.25 a	65.32 c	0.49 a
Haden	PM	0.95 D	9.17 A	6.87 A	3.29 B	5.42 A	47.94 A	0.52 B
	Mature	0.29 a	19.97 d	18.56 c	4.08 b	0.24 a	42.44 a	1.25 b
Irwin	PM	0.96 C	10.33 B	7.47 A	4.26 D	7.62 C	35.91 A	0.21 A
	Mature	0.37 b	21.87 e	19.87 d	4.99 c	0.25 a	34.28 a	1.02 b
M 13269	PM	1.71 E	8.23 A	5.44 A	2.79 A	9.19 D	76.75 D	-
	Mature	0.45 b	18.27 c	14.67 a	3.85 b	1.02 a	63.65 c	0.73 a
Momi-K	PM	1.47 E	8.83 A	5.58 A	3.59 B	5.05 A	44.07 A	0.42 A
	Mature	0.40 b	20.23 d	16.77 b	5.27 d	0.48 a	47.36 b	1.06 b
Scuper Many	PM	0.40 B	9.33 A	7.60 A	6.05 G	8.50 D	65.30 C	0.16 A
	Mature	0.29 a	21.27 e	18.11 c	7.36 f	0.27 a	48.98 b	1.03 b
Simmonds	PM	1.19 D	11.60 C	8.47 B	5.65 F	4.75 A	45.71 A	0.22 A
	Mature	0.17 a	20.13 d	15.87 b	3.78 b	0.37 a	37.57 a	1.39 c
Zill	PM	1.13 D	10.40 B	7.27 A	3.71 B	4.63 A	45.70 A	0.50 B
	Mature	0.42 b	19.83 d	15.94 b	4.89 c	0.76 a	37.56 a	1.06 b
Van Dyke	PM	1.27 D	8.63 A	6.53 A	4.39 D	6.11 B	48.96 A	0.51 B
	Mature	0.32 a	18.60 c	15.11 a	4.05 b	0.29 a	47.34 b	1.42 c
Winter	PM	1.70 E	9.96 B	6.62 A	3.92 C	7.37 C	83.23 E	0.59 B
	Mature	0.42 b	23.10 f	16.98 b	3.98 b	0.15 a	47.36 b	1.51 c

*Averages followed by the same uppercase or lowercase letter in a column do not differ by Scott-Knott test ($p \leq 0.05$)

The accessions that showed the highest levels of reducing sugars at the two different maturity stages (MS) were the Olour and Scuper Many (Table 3). After ripening, the accessions Chené, Manila, Manzanillo, Tommy Atkins, Simmonds and Van Dyke displayed little change in the levels of reducing sugars. Whereas the Maya accession suffered a sharp decline, going from 7.1 to 4.2 g 100 g^{-1}. According to Hulme (1971), this is possibly due to most of the sugars being reducing sugars (fructose and glucose) at the start of maturation, however by the end of the process, non-reducing sugars predominate. As such, there is a change in the quality of the sugars but not in the quantity.

Vitamin C is degraded at ripening, so values tend to decrease in the mature fruit. In fruits of the Chené, 65, Winter and Amrapali accessions, this reduction was more pronounced (Table 3). The latter accession showed the highest ascorbic acid content at harvest. In the mature fruit, the highest levels of vitamin C were 73.43, 65.32 and 63.65 mg 100 mL^{-1}, seen in the Mon Amon, Florigon and M-13269 accessions respectively (Table 3). Such levels are relatively good when compared to cultivars that excel due to their high levels of vitamin C, such as the Ubá (100.40 mg 100 mL^{-1}) (FARAONI; RAMOS; STRINGHETA, 2009). In this study, the vitamin C content of the ripe fruit of the Tommy Atkins accession was 50.60 mg 100 mL^{-1}, more than that observed in fruits of the same cultivar produced in the state of São Paulo, which had levels of 39.00 mg 100 mL^{-1} (BOMFIM *et al*., 2011). These differences are related to the maturity stages (MS), growing conditions and climate, among other factors.

For the carotenoids content, the formation of two groups was seen during physiological maturity, with the group that showed higher levels ranging from 0.49 to 0.80 mg 100 g^{-1}, corresponding to the 65 and Aplle DCG 406 accessions respectively (Table 3). During maturation, there was an increase in the carotenoids content, explained by the synthesis and exposure of pre-existing pigments in the tissue. In the ripe fruit, the Amrapali accession stood out for its higher average of 2.3 mg $100g^{-1}$, followed by the Simmonds, Van Dyke, Winter and Mon Amon (Table 3). A similar result was seen in Haden mangoes, which displayed carotenoids content of 1.91 mg $100g^{-1}$, while the values found for the Tommy Atkins mangoes were higher (2.53 mg 100 g^{-1}) (RIBEIRO *et al*., 2007).

CONCLUSIONS

1. The Chené accession stood out as to weight, size, ascorbic acid content, low fibre content and good post-harvest conservation. The accession Momi-K, added greater firmness to the other characteristics, although it does not have good post-harvest conservation. The Van Dyke accession may represent an important source of the latter characteristic;
2. The Amrapali accession united those characteristics for quality which are consistent with the requirements of most markets, such as pulp with no fibre, high levels of starch and ascorbic acid when harvested, and high levels of SS, AST and carotenoids in the ripe fruit.

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