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Post-harvest quality in the 'Tommy Atkins' mango for different harvest times

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ABSTRACT

Determining the correct harvest time is essential for maintaining post-harvest fruit quality. The aim of the present study was to investigate the biochemical and physiological effect of three different harvest times on maintaining post-harvest quality in 'Tommy Atkins' mangoes from the state of Roraima, sold in markets in the city of Manaus. The treatments consisted of the different harvest times: control, harvested 90 days after anthesis; early harvest, harvested 70 days after anthesis; and late harvest, harvested 105 days after anthesis. At the end of the experimental period, mangoes harvested at 70 DAA were found to have a low carotenoid content, with the pulp unable to reach commercial maturity; the pulp had a high level of firmness, with the highest concentrations of vitamin C and phenolics, and the greatest antioxidant activity. When the mangoes were harvested at 105 DAA, the pulp had the least firmness and a sugar content very close to that of the early-harvested fruit, with lower concentrations of phenolics and vitamin C, and lower antioxidant activity. On the other hand, the fruit harvested at 90 DAA showed adequate physical resistance and acceptable results for sensory quality, functional compounds and antioxidant activity.

Keywords: *Mangifera indica* L, Harvest time, Quality

Qualidade pós-colheita da manga 'Tommy Atkins' para diferentes épocas de colheita

RESUMO

A correta determinação do ponto de colheita é fundamental para a manutenção da qualidade pós-colheita de frutos. Por esse motivo, a execução do presente estudo visou estudar o efeito bioquímico e fisiológico na manutenção da qualidade pós-colheita de mangas cv. Tommy Atkins, colhidas em três diferentes períodos, no estado de Roraima e comercializadas em mercados no município de Manaus. Os tratamentos realizados nas mangas consistiram na colheita dos frutos em diferentes períodos, sendo eles: controle (colheita aos 90 dias após a antese), colheita precoce aos 70 dias após a antese e colheita tardia, aos 105 dias após a antese. Ao final do período experimental verificou-se que as mangas colhidas aos 70 DAA apresentaram baixo teor de carotenoides pois não conseguiram completar a maturação comercial da polpa. Contudo, esses frutos apresentavam-se com elevada firmeza de polpa e as maiores concentrações de vitamina C, fenólicos e a maior atividade antioxidante. Quando colhidas aos 105 DAA, as mangas apresentaram as menores firmezas de polpa e valores muito próximos aos frutos colhidos precocemente quanto aos teores de açúcares e menores concentrações de fenólicos, vitamina C e atividade antioxidante. Por outro lado, frutos colhidos aos 90 DAA demonstram satisfatória resistência física e resultados adequados quanto aos aspectos sensoriais, aos compostos com potencial funcional e a própria atividade antioxidante.

Palavras-chave: *Mangifera indica L*, Ponto de colheita, Qualidade.

1. Introduction

The mango (Mangifera indica L.) is one of the most consumed fruit in the world. Originally from India, it was introduced into Brazil in the 16th century by the Portuguese (Moreira et al, 2013). According to Xavier et al. (2009), the Tommy Atkins cultivar was developed in Florida in the USA during the 1920s and produces fruit with an average weight of 460 g, thick skin and oval shape. It has an orange-yellow pulp and an intense red-purple skin. The pulp is firm, juicy, with a medium fibre content, and is characterized as resistant to mechanical damage. The fruit is precocious, and can be harvested before completely ripe, without harming its normal development.

The mango can be classified as a climacteric fruit (Souza et al., 2013), which means that during the maturation and ripening process, the fruit presents intense respiratory activity, resulting in several biochemical and physiological changes, including changes in colour and the level of sugars, organic acids and vitamins (Jongsri et al., 2016). Thus, both the potential for consumption and post-harvest conservation are influenced by the developmental stage of the fruit at the time of harvest; according to Morais et al. (2002), fruit that has not reached full physiological development in the field may even be conserved for long periods, but will never reach the optimal quality for consumption. Similarly, fruit harvested when overripe will not reach its maximum potential for quality or post-harvest conservation. According to Beling et al. (2021), in domestic terms, the mango, with a total of almost 1.5 million tons, is among the 10 most cultivated crops, generating values close to almost BRL1.7 million. It can therefore be assumed that insufficient maturity is one of the main problems related to loss and/or poor quality in Brazilian mangoes sold both in Brazil and abroad. (Coelho et al., 2019).

In the state of Roraima, due to long episodes of Bactrocera carambolae infestation and sanitary barriers, mango production has dropped from being the choice of many rural producers, to having a production estimated at around 850 tons (MAPA, 2022).

Considering all the problems faced by fruit growers in Brazil, both during and after harvest, incorrect harvesting appears to be one of the main causes of loss, leading to unviable markets and resulting in incalculable damage (Guerra et al., 2017). The aim of the present study, therefore, was to evaluate the expected quality potential of the 'Tommy Atkins' mango produced in Roraima.

2. Material and Methods

The 'Tommy Atkins' mango, obtained from an agricultural property in the rural area of Boa Vista, Roraima (2º50'06" N, 60º40'28" W), was used in the experiment, which was conducted at the Food Technology Laboratory of the Federal University of Roraima (29 ± 2 ºC and 75 ± 3% RH). The samples were selected based on the absence of damage and/or rot, standardised based on the visual attributes of the fruit (colour and size), and placed in 20 kg boxes. The treatments comprised three harvest times, for each of which firmness, soluble solids and fresh weight were determined, and the colour of three fruit was assessed to establish a starting point. The conditions of each harvest can be characterized as follows: at 70 DAA, the fruit had an average pulp firmness of 14.5 ± 0.5 N, average soluble-solids content of 3.7 ± 0.5ºBrix, average fresh weight of 334 ± 25 g, and a greenish-purple colour (70/30); fruit harvested at 90 DAA had an average pulp firmness of 12.2 ± 0.5 N, average soluble-solids content of 4.2 ± 0.5 ºBrix, average fresh weight of 392 ± 25 g, and a greenish-purple colour (50/50); while fruit harvested at 105 DAA had an average pulp firmness of 9.6 ± 0.5 N, average soluble-solids content of 5.6 ± 0.5ºBrix, average fresh weight of 376 ± 25 g, and a reddish-purple colour (50/50).

After harvesting, the fruit from each of the crops was sanitized in an acidic sodium hypochlorite (NaOCl) solution (pH=3.0) at 10 mg.L-1 for three minutes. After rinsing and drying, the fruit was exposed to the atmosphere (29 ± 2 ºC and 75 ± 3% RH) and the following treatments were applied: control (harvest at 90 DAA), late harvest (harvest at 105 DAA), early (harvest at 70 DAA). The fruit from each treatment was stored for 28 days with no control over temperature or humidity (29 ± 2 ºC and 75 ± 3% RH) in a covered area with no direct exposure to light. After setting up the treatments, the following analyses were carried out at 4, 8, 12, 16, 20, 24 and 28 days:

a) External appearance of the fruit: a visual colour scale was used to characterise the appearance of the fruit, as per the method adapted from Braz et al. (2008), where 4 = greenish-purple, 3 = yellowish-purple, 2 = more orange-purple than purple, 1 = withered orange-purple, and 0 = with marked dark and/or grey spots; b)Firmness of the pulp: using the Extralab TAXT Plus electronic texture analyzer (Stable Micro Systems, Surrey, United Kingdom), expressed in N (Latimer, 2012); c)Loss of fresh fruit weight (L): the fruit was weighed on a semi-analytical scale (Marte AD500, Brazil), as per Latimer (2012);

$$Loss\ of\ fresh\ fruit\ weight = \frac{Ws\ x\ 100}{FW}$$

Ws: weight after storage

FW: average fresh weight at harvest.

d) Hydrogen potential (pH): determined directly in the pulp using a digital potentiometer, as per Latimer (2012); e) Soluble-solids content (SS) and Titratable Acidity (TA): measured in degrees Brix and in % citric acid, respectively, following the methodology described by Latimer (2012); f) Total fresh-weight sugars

and reducing sugars: evaluated as per Latimer (2012), with the results expressed in g.100 g^{-1}; g) Respiratory activity (CO_2 concentration): following the methodology described by Latimer (2012), with the results expressed in mL CO_2 kg^{-1} h^{-1}; h) Ethylene production: carried out as per the methodology described by Latimer (2012), with the results expressed in mL C2H4 kg^{-1} h^{-1}; i) Ascorbic acid (vitamin C) content: evaluated as per Latimer (2012), with the results expressed in mg.100g^{-1}; j) Total fresh-weight phenolic content: expressed in mg of gallic acid 100 g^{-1} of sample using the Folin-Ciocalteau method with some modifications; the absorbance of the sample was read against the blank at 725 nm using a spectrophotometer. The total phenolic content (TF) of the extracts was determined by comparison using a gallic acid calibration curve (Vieira et al.,2015) as standard, where R2 = 0.9973:

$$Absorbance\ concentration = 0.0628\ x\ (Gallic\ Acid\ Conc, mg\ mL^{-1}) - 0.0521$$

k) Total carotenoid content: the carotenoid content of the samples was determined using the FEMTO model 800 XIa UV-VIS spectrophotometer, based on the analytical separation and extraction of compounds by organic solvents. For lycopene, the absorbance was read at 470 nm and for beta-carotene, at 450 nm. The carotenoids were determined as per the following equation (Rodriguez-Amaya, 2001; Rodriguez-Amaya; Kimura, 2004):

$$\text{Carotenoid content (mg 100 g}^{-1}) = \frac{A\ x\ V\ x\ 10.000}{A_{1cm}^{1\%}\ x\ W}$$

where:

A = absorbance of the solution at a wavelength of 470 nm for lycopene and 450 nm for beta-carotene;

V = final volume of the solution;

$A_{1cm}^{1\%}$ = extinction coefficient or molar absorptivity coefficient of a pigment in a specific solvent (3450 for lycopene and 2592 for beta-carotene);

W = weight of the sample for analysis;

l) Antioxidant capacity using the DPPH method (1,1-diphenyl-2-picrylhydrazyl radical): following methodology described by Vieira et al. (2015), with the results expressed in molEq Trolox.100 g^{-1} of sample:

$$\%DPPH = \frac{Abs_{DPPH} - Abs_{\ sample}}{Abs_{DPPH}}\ x\ 100$$

Abs_{DPPH} = absorbance of the control

Abs_{sample} = absorbance of the sample

m) Antioxidant capacity using the ORAC method (Oxygen Radical Absorption Capacity): based on the method by Ou et al. (2001):

Net AUC = AUC (Antioxidant) – AUC (blank)

with the results expressed in mmolEq Trolox.100 g^{-1} of sample.

The experiment was conducted in a completely randomised design (CRD) in a 7 x 3 factorial scheme consisting of seven points of analysis and three harvest times, with four replications, each replication comprising 10 pieces of fruit (sample units). The variables under evaluation were subjected to analysis of variance and polynomial regression using the R Core Team (2020) statistical software. The regression models were adjusted using the F-test at a level of 5% to measure the significance of the proposed model.

3. Results and Discussion

The external appearance of the fruit is essential in consumer decision-making (Souza et al., 2008). When the fruit was harvested at 70 or 105 DAA, the likelihood of the end consumer purchasing the early- or late-harvested fruit decreased significantly over the 28 days of storage with no control over temperature or humidity (Figure 1). As a recommendation to the producer/middleman, Figure 1 shows the results for appearance, where fruit harvested at 90 DAA had a score of 2 by the end of the experimental period, based on a subjective rating scale.

However, after 20 days of storage, fruit harvested at 70 DAA showed the same appearance (grade 2), while fruit harvested at 105 DAA had a similar appearance (grade 2) by day 16 of the experiment (Figure 1). On average, fruit harvested at the ideal time has between a 45% and 65% longer shelf life and higher sales potential than fruit harvested out of season.

The results showed a similar pattern when analysing the loss in fresh weight (Figure 2A), where fruit harvested at 90 DAA remained stable relative to the control in terms of moisture loss, reaching the end of the experimental period with average losses not exceeding 6% in relation to the initial weight. Similar results were found by Souza et al. (2013), who explain that the loss of fresh weight in the 'Tommy Atkins' mango is an initial symptom of water loss and, intensified by damage to the fruit, causes a rapid increase in metabolism leading to the damaged appearance. The same result was seen for fruit harvested at 70 DAA, however, after an overall analysis of the present results, this fruit very quickly lost its sensory quality, meaning it cannot be classified as having the same conservation potential or even quality as fruit that is normally harvested at 90 DAA, whereas late-harvested fruit showed an average loss of up to 25% by the end of the study. In the above research it is reported that a loss of greater than 8% in the fresh weight of vegetable products is unacceptable. Regardless of harvest time, all the fruit showed a significant drop in pulp firmness over the 28 days of storage with no control over temperature or humidity (Figure 2B); this was due to the loss of moisture in the fruit during the natural process of senescence.

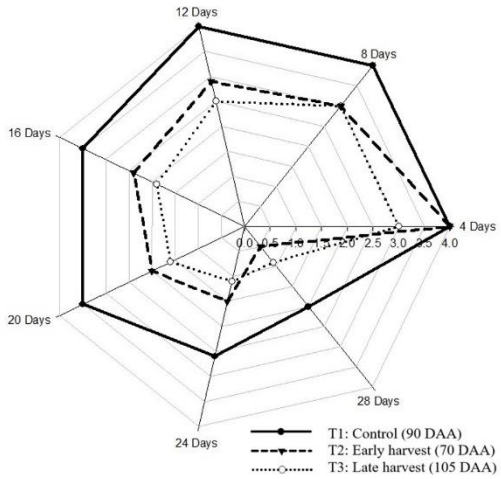
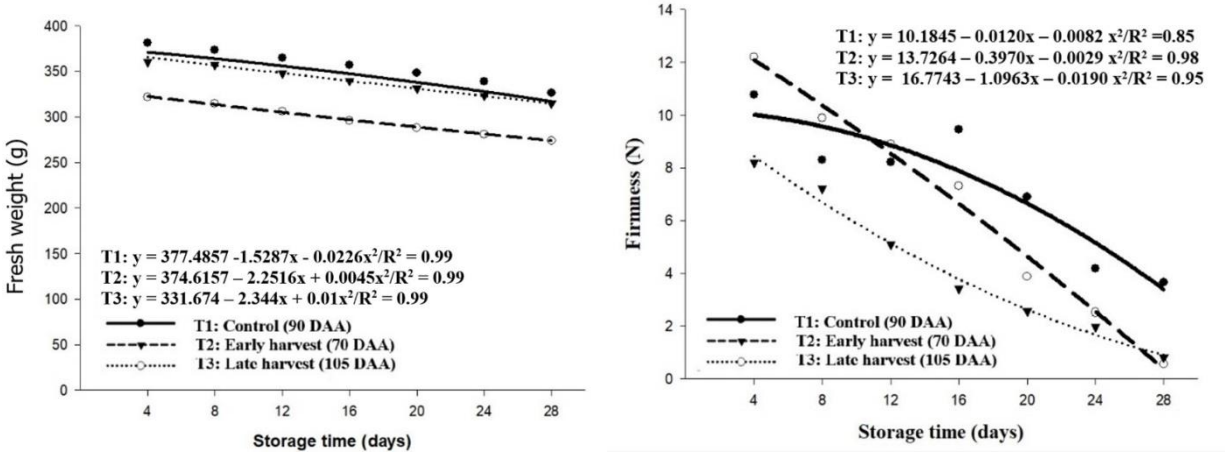


Figure 1: External appearance (subjective value) of ‘Tommy Atkins’ mangoes harvested at 70, 90 and 105 days after anthesis (DAA).



(A) (B)

Figure 2: Loss in fresh weight, in grams (A); and pulp firmness, in Newtons (N) (B), in ‘Tommy Atkins’ mangoes harvested 70, 90 and 105 days after anthesis (DAA).

By the end of the experimental period, the fruit harvested at 90 DAA had lost around 72% of its initial firmness, while fruit harvested at 70 and 105 DAA lost, respectively, 96% and 93% firmness by the end of the 28 days of storage. By comparison, when harvested at 70 and 105 DAA, the fruit lost on average 23% and 21% more firmness than did fruit in the control group, which was harvested at the correct time. This demonstrates the importance of correctly determining the harvest time for maintaining the post-harvest quality of the fruit (Neves et al., 2008; Lima et al., 2007), particularly in relation to distance and travel time when the fruit is to be marketed. In this respect, it is obvious that fruit harvested at 105 DAA would not survive for marketing purposes for more than three to five days after the harvest, whereas fruit harvested at 70 DAA, given its abnormal ripening, could not even be marketed and/or consumed. During ripening, the 'Tommy Atkins' mango shows an increased loss of firmness (Hojo et al., 2007; Fante et al., 2013), caused by changes in the structure of the cell wall resulting from the increase in enzyme activity as the fruit ripens and ages.

According to the report by Vilas Boas et al. (2004), the variation in pH (Figure 3A) in fruit harvested at 90, 70 and 105 DAA is within the optimal range, establishing for the ‘Tommy Atkins’ mango an ideal limit of between pH 2.15 and 4.73 as being normal and expected for this species and cultivar. There was no significant difference in pH between the treatments under test during the 28 days of storage. These data comply with current legislation, as the pulp must have a pH of less than 4.5 to guarantee its conservation without the need for ultra-heat treatment, so as not to compromise its quality (Benevides, 2008).

Regarding soluble solids (Figure 3B), the fruit harvested at 70 and 105 DAA reached its maximum level, respectively, 8 and 16 days after harvest, with values not exceeding 6ºBrix. This shows that the fruit harvested at 70 DAA, given its irregular metabolic activity, which was

due to the forced anticipation of the harvest and caused possible physiological disturbance, very quickly depleted its reserves, impairing the sweetness of the fruit (not evaluated) and reducing its useful potential. On the other hand, fruit harvested at 105 DAA reached maximum ripeness before the end of the storage period, which in itself does not disqualify it from the consumer market, albeit greatly restricting the distance and travel time, as discussed above. According to Guerra et al. (2017), ripe ready-to-eat 'Tommy Atkins' mangoes can present, on average, a Brix value of 12. Based on the above data, and understanding that this is generally the midpoint of the climacteric peak in the 'Tommy Atkins' mango, it seems the fruit of the control group, harvested at 90 DAA, did not even reach its climacteric peak, the curve continuing to increase after 28 days of storage, as seen in Figure 4.

In other words, during the 28 days of storage, the soluble-solids content continued to increase, without stabilising or falling, which is a typical feature of the climacteric peak (Souza, 2013). As such, this result supports the idea that there was still time for conserving, transporting and marketing the fruit, assuming adequate maintenance of this quality attribute. The early (70 DAA) and late (105 DAA) harvests therefore hampered the accumulation and maintenance of soluble solids, and possibly compromised both the biochemical metabolism and the sensory aspect, by excessively accelerating the respiratory metabolism of the fruit (Figure 4A), forcing excessive use of its reserves before the usual time (Lima, 2012). During the 28 days of storage, the titratable acidity (Figure 3C) decreased significantly in the fruit harvested at 90 and 105 DAA, unlike the soluble solids. Mangoes harvested at 70 DAA do not reach commercial maturity, and those harvested at 105 DAA are for immediate consumption only and cannot be stored.

Similar results were found by Vélez-Rivera et al. (2014), Vasconcelos et al. (2019) and Costa et al. (2017), who pointed out that in the Tommy Atkins mango, the high level of acid degradation is a consequence of the normal maturation process as well as the high pH levels in the pulp. For the fruit harvested at 70 DAA, after a small drop between four and eight days of storage, there were progressive increases in titratable acidity up to the end of the experimental period, which is possibly related to the state of physiological immaturity and the inability of the fruit to produce ethylene gas to complete the climacteric cycle (Silva, 2008). In this respect, titratable acidity decreases with the acceleration of respiratory metabolism, as a metabolic reserve induced by ethylene production and fruit respiration during post-harvest storage (Souza et al., 2013). During the respiration of climacteric fruit, acid consumption is accelerated, which raises and then lowers the pH, following the curve of the climacteric peak (Souza et al., 2013). In the mangoes harvested at 70 and 105 DAA, there was a constant and marked reduction in the levels of total and reducing sugars in the fruit pulp (Figures 3D and 3E, respectively), indicating abnormal metabolic behaviour in the early-harvested fruit (70 DAA). Late-harvested fruit (105 DAA), are assumed to be at an advanced stage of ripening.

Therefore, in addition to the drastic reduction in respiratory reserves, which doubtless led to a reduction in the potential post-harvest shelf life of the fruit, sensory damage in terms of taste can also be expected, since the number of available sugars is well below the ideal for the fruit to ripen, as discussed by Guerra et al. (2017). However, for fruit harvested at 90 DAA, and following the increase in ethylene production that was seen after 12 days of storage, the sugar concentration reached a maximum plateau at between 12 and 16 days (Figure 3D), while for the same fruit, the concentration of reducing sugars remained at a maximum between 16 and 20 days (Figure 3E), probably a reflection of the depolymerisation of non-reducing sugars induced by the need for energy, given the intense respiratory metabolism of the fruit during this treatment (Bezerra et al, 2011).

According to Figure 4B, fruit harvested at 70 and 105 DAA showed a constant reduction in ethylene production throughout the experimental period at concentrations not exceeding 0.15 ml ethylene $kg^{-1}.h^{-1}$; by the end of the 28 days of storage, the concentrations were close to zero. The fruit also showed a similar continuous drop in respiratory metabolism, with concentrations of no more than 50 mL CO_2 $kg^{-1}.h^{-1}$, reaching the end of the storage period with an almost negligible level of respiratory activity (Figure 4A). According to the present results, in both treatments, there was early and excessive consumption of the respiratory reserves of the fruit, as seen when analysing the soluble solids (Figure 3B), total sugars (Figure 3D) and reducing sugars (Figure 3E).

From the above, it can be concluded that both treatments resulted in a total (70 DAA) or partial (105 DAA) loss of quality and a reduction in the potential shelf life of the fruit, drastically limiting any possibility of improving the marketability of the fruit products, especially in places far from the production area. However, for fruit in the control group, harvested at 90 DAA, ethylene production peaked between 16 and 20 days. On the other hand, at least in the proposed time interval, there was no maximum peak in respiration (also known as the climacteric peak). It can be assumed that the fruit would have at least 8 to 12 more days conservation under the conditions of the test. According to Alós et al. (2019), the increase in ethylene production does not always define the start of climacteric respiration, as it depends on the species, where the maximum activity for each process may not occur simultaneously.

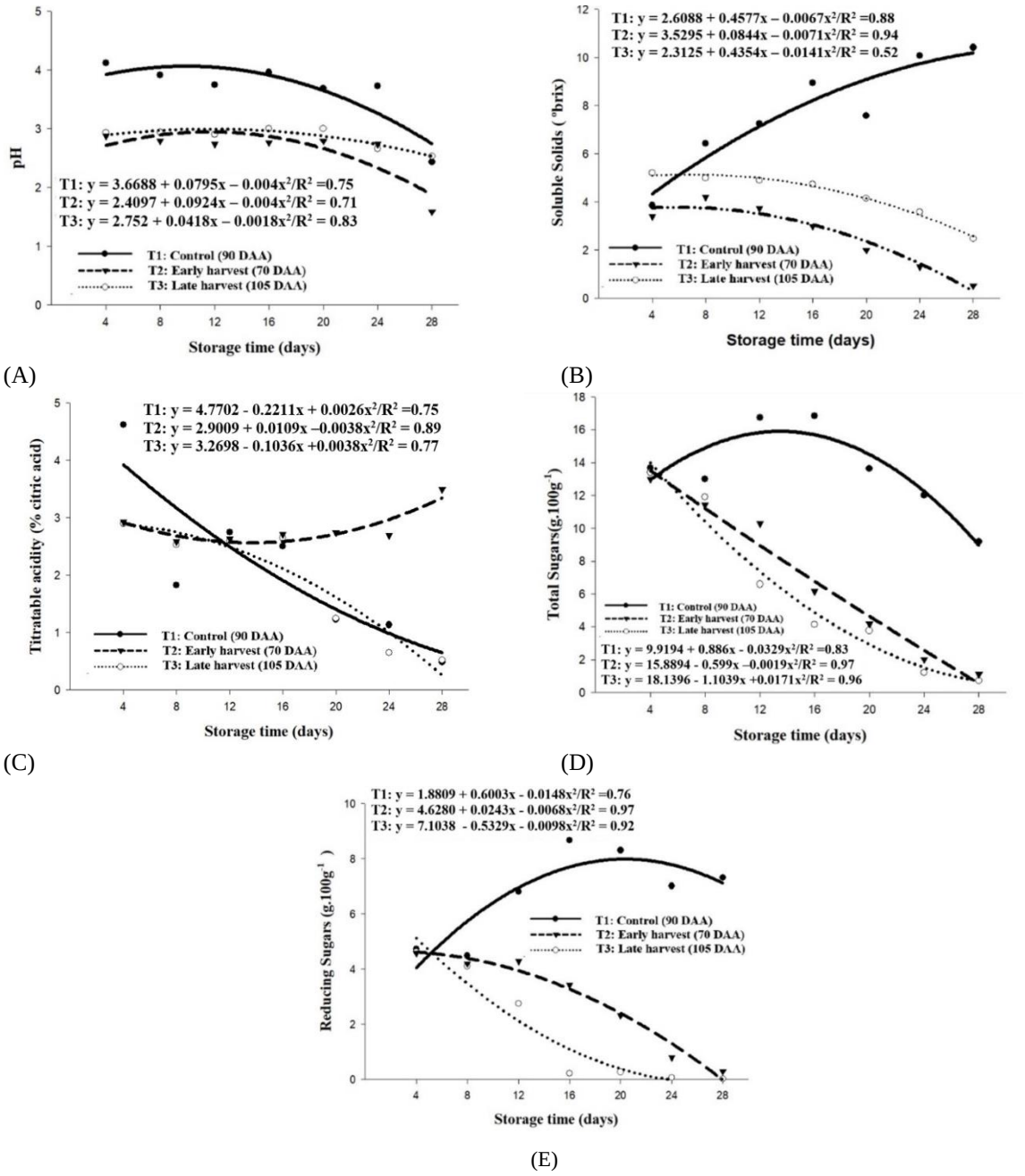


Figure 3: Hydrogen potential – pH (A); soluble solids, in ºBrix (B); titratable acidity, in % citric acid (C); total sugars (D); and reducing sugars (E) in g.100 g^{-1}, in 'Tommy Atkins' mangoes harvested at 70, 90 and 105 days after anthesis (DAA).

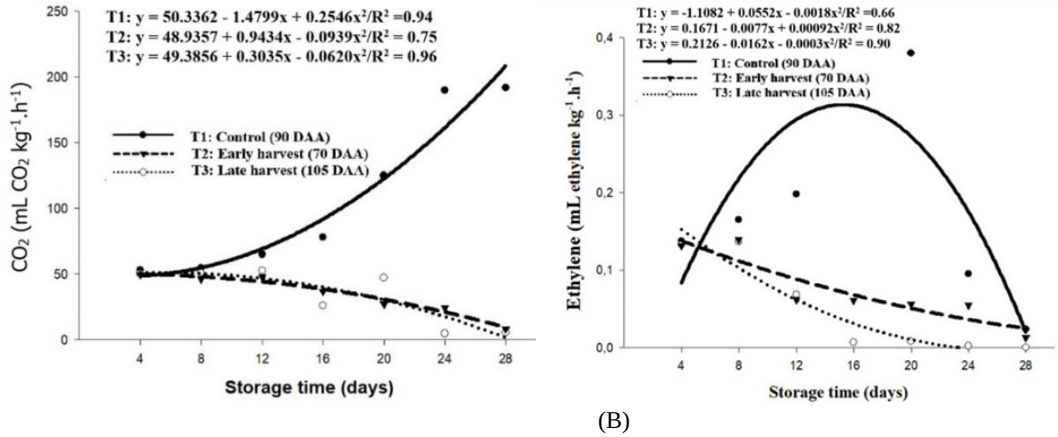


Figure 4: CO_2 production, in mL $CO_2.kg^{-1}.h^{-1}$ (A) and ethylene production, in mL ethylene $kg^{-1}.h^{-1}$ (B), in 'Tommy Atkins' mangoes harvested at 70, 90 and 105 days after anthesis (DAA).

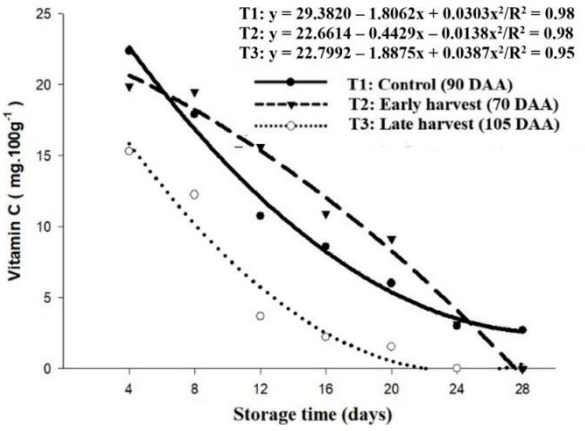
However, climacteric respiration can indeed be considered to be regulated mainly by ethylene (Grierson, 2013). In other words, in comparison to late-harvested fruit, at 105 DAA, it was found that the fruit harvested at 90 DAA showed an average gain of up to 24 days in terms of conservation potential, affording greater flexibility in relation to conservation, transportation, marketing and post-harvest consumption. As for the fruit that was harvested early, at 70 DAA, it can be assumed that, due to its irregular metabolic behaviour, the fruit would not be suitable for marketing.

Changes in the appearance of the fruit could be related to several factors, for example, the loss of fresh fruit weight (Figure 2A), or even uncharacteristic respiratory activity, as seen in Figure 4A. Throughout the experiment, mangoes harvested at 70 and 90 DAA had higher amounts of vitamin C than the fruit harvested at 105 DAA (Figure 5A). Fruit in general undergoes a reduction in vitamin C concentration over time, especially following the harvest and during the post-harvest storage period. It can therefore be said that fruit at less advanced stages of ripening present higher concentrations of vitamin C than fruit that is ripe and/or close to senescence (Alves, 2010).

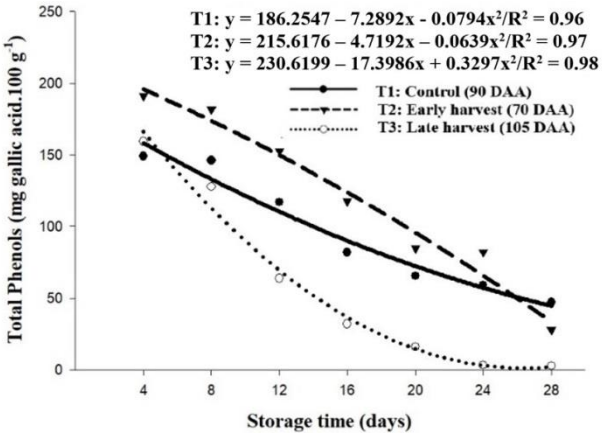
There was no significant difference between harvesting at 70 or 90 DAA in terms of the vitamin C concentration. Similar behaviour was seen when analysing total phenolics (Figure 5B), where fruit harvested at 70 and 90 DAA, with a slight advantage for the early-harvested fruit, presented a higher phenolic concentration throughout the experimental period compared to fruit harvested at 105 DAA, and reached the end of the 28 days of storage with values close to 50 mg gallic acid 100 g^{-1}. However, from 20 days onwards, the fruit harvested at 105 DAA, showed an almost negligible total concentration of phenolics.

In terms of the carotenoid analysis, mangoes harvested at 70 DAA showed carotenoid concentrations well below those of fruit harvested at 90 and 105 DAA, precisely because they were unable to complete their physiological development in the field (Soares and José, 2013), which is thought to have not only affected production of this compound, but also affected the ripening of the fruit, making it impossible to market. The same was seen in the fruit harvested at 105 DAA, which, due to the advanced stage of ripening, presented higher concentrations throughout the experimental period than the fruit harvested at 70 DAA. The same was seen in the fruit harvested at 105 DAA, which, due to the advanced stage of ripening, presented higher concentrations throughout the experimental period than fruit harvested at 70 DAA. However, this fruit was also inferior throughout the experimental period to fruit harvested at 90 DAA, which despite the constant reduction, remained at higher levels when compared to the fruit from the other treatments. Similar results were presented by Soares and José (2013), who found comparable levels of carotenoids to those seen here for fruit harvested at 90 DAA.

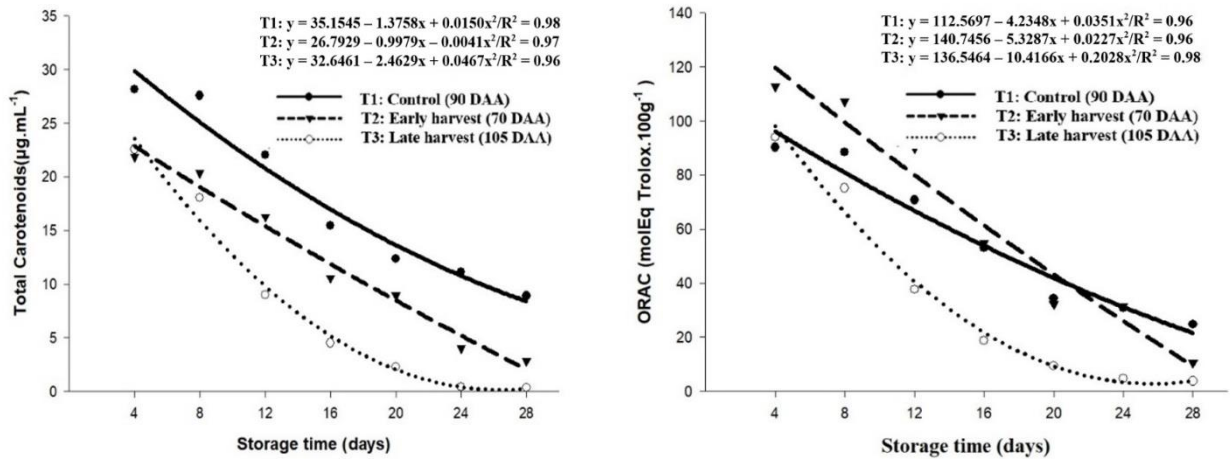
As with the total phenolic compounds, the oxidising activity of the fruit, both by the ORAC method (Figure 5D) and by the DPPH method (Figure 5E), showed decreasing behaviour during the experimental period of 28 days. However, the Tommy Atkins cultivar harvested at 70 and 90 DAA, with a slight advantage to those harvested early, had the highest antioxidant activity when compared to the fruit harvested at 105 DAA. In other words, it is possible to identify a certain relationship between the production of phenolic compounds and the oxidising activity of the fruit, suggesting a metabolic link between greater antioxidant activity and higher concentrations of phenolic compounds.



(A)



(B)



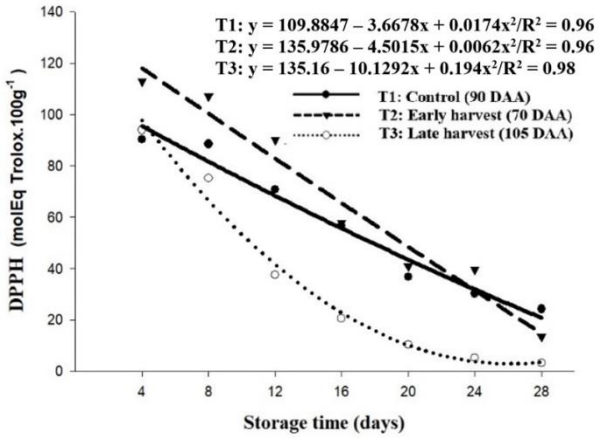


Figure 5: Vitamin C content, in mg.100g^{-1} (A); total phenolics, in mg of gallic acid.100 g^{-1} of sample (B); carotenoids (C), in µg.mL; antioxidant capacity by the ORAC method (D) and the DPPH method (E), in molEq Trolox.100g^{-1} of sample, in 'Tommy Atkins' mangoes harvested at 70, 90 and 105 days after anthesis (DAA).

Figure 6 shows a positive correlation between the phenolic compounds and the antioxidant, carotenoid and enzyme activity. Indeed, Ediriweera et al. (2016) demonstrated that the mango can be considered an excellent source of polyphenols, showing significant concentrations, well above other tropical fruits such as papaya and pineapple (Ediriweera et al., 2016). In this respect, the high concentration of phenolic compounds would play an important role in neutralising or eliminating free radicals and in the chelation of transition metals, acting both during the initiating stage and in propagating the oxidising process, thereby showing excellent antioxidant potential (Chun et al., 2005).

Figure 6: Pearson Correlação. Legend: pH – Hydrogen potencial; SS – Total soluble solids; AT – Titratable Acidity; Atot – Total acidity; Ared – Reduced acidity; VitC - Vitamine C; Fen – Total extractable phenols; ET – Ethylene; Carot – Carotenoids; CO - CO_2; ORAC - Oxygen Radical Absorbance Capacity; DPPH - 2,2,1-diphenyl-1-picrylhydrazyl, FIRMEZA= FIRMNESS.

4. Conclusions

The fruit harvested at 90 DAA, considered the ideal harvest time for the 'Tommy Atkins' mango stored for 28 days with no control over temperature or humidity (29 ± 2 ºC and 75 ± 3% RH), had a better shelf life than the fruit harvested at 70 DAA or 105 DAA.

Authors' Contribution

Work extracted from the master's thesis of Oswald Renaud Koblam Ahouangbonou, under the direction and execution of the research by Leandro Timoni Buchdid Camargo Neves and the support for the execution of the research by Ozimar de Lima Coutinho.

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