CHARACTERIZATION OF QUALITY ATTRIBUTES OF MANGO CV. 'ATAULFO' AT DIFFERENT MATURATION STAGES

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The study aimed characterize physically and physico-chemically three stages of maturation of the mango 'Ataulfo', as well as to evaluate the correlation of a non-destructive method, such as the DA Meter absorbance difference index (Turoni), with parameters obtained destructively. The mangoes were harvested at stages 2, 3 and 4, and the following variables were determined: loss of mass, longitudinal and transverse diameter, peel and pulp color and its coordinates L * a * b *, firmness, DA index, yield, pH, soluble solids (TSS), titratable acidity (TTA) and vitamin C. The experimental design was completely randomized with ten repetitions. The results were submitted to the test of means and simple correlation. As the maturation stages advanced, the soluble solids increased considerably, going from 7.32 ºBrix in stage 2 to 21.30 ºBrix in stage 4. The firmness, titratable acidity and vitamin C contents reduced with the maturation process, reaching, respectively, 47.71 N, 0.79% of citric acid and 73.25 mg of ascorbic acid per 100 g of pulp in stage 4. The physical and physical-chemical analyzes such as mass, longitudinal diameter, pulp yield, can be used as a basis for determining the stages of maturation, but through the DA index a better differentiation of the fruits in different classes of ripeness was achieved, in addition to having a good correlation with firmness, TSS, TTA and pH, with high coefficients, -0.92, 0.94, 0.97 and -0.93, respectively. Thus, the determination of this index represents a potential tool based on non-destructive analysis to determine the maturation of mangoes of the variety 'Ataulfo'.

KEYWORDS: Mangifera indica L., MATURATION, NON-DESTRUCTIVE METHOD.

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1 INTRODUCTION

The mango species *Mangifera indica* L., belonging to the Anacardiaceae family, is native to Southwest Asia. Its excellent flavor, combined with the good nutritional characteristics of the fruit, has made mango culture gain economic importance, mainly in Brazil. The states of Bahia and Pernambuco stand out, which had a production in the year 2018 of 378,362 and 496,937 tons of the fruit, respectively (CARVALHO et al., 2019).

European countries and the United States absorb about 85% of exports (REETZ et al., 2015). The mango 'Ataulfo', of Mexican origin, has been gaining these markets due to its sweet and attractive taste, but mainly because it has the following characteristics when mature: bright yellow color, oval shape, creamy texture and almost no fiber.

Maturity stage is an essential characteristic to determine the quality of mangoes, as it is one of the reasons for great losses and the low quality of Brazilian mangoes. The optimal maturity for harvesting mango depends largely on how long it will take to be consumed, since fruit harvested before maturity will not meet the demands of the consumer market. Therefore, proper fruit handling requires knowledge of physiology and post-harvest practices that may help develop and maintain high quality fruit (YAHIA; ORNELAS-PAZ; ARIZA, 2006; BRECHT; YAHIA, 2009).

This theme highlights the need for greater knowledge about the mango 'Ataulfo', based on the correlation between destructively determined parameters, such as fruit firmness and soluble solids involved in the mango ripening process, with non-destructive evaluations such as the DA Meter Index, so that the fruit can be harvested at the right time and with preserved quality.

Thus, this work evaluated the physical and physicochemical characteristics in each of the ripening stages of the 'Ataulfo' mango (2, 3 and 4). We observed the following physical and physicochemical parameters: mass; longitudinal and transverse diameter; firmness; color coordinates L*, a*, b*; DA index; yield; pH; total soluble solids; total titratable acidity and vitamin C.

2 MATERIALS AND METHODS

For this study, the mangoes 'Ataulfo' were donated by the farm CS Líder Agrícola, located in the São Francisco Valley, more precisely in the municipality of Sento Sé - BA. The analyses were performed in the Post-Harvest Laboratory of the Universidade Federal do Vale do São Francisco.

The fruits were separated into three different stages of maturity stages (Figure 1) and selected at each stage when in the presence of mechanical lesions, fungal and insect attack and other defects, keeping them in very uniform batches. They were then washed thoroughly under running water, sanitized with 100 ppm sodium hypochlorite solution for 15 minutes, with subsequent rinsing to remove excess hypochlorite solution, and dried with paper towels.

FIGURE 1 – STAGES OF MATURATION OF THE 'ATAULFO' MANGO.

2.1 PHYSICOCHEMICAL ANALYSIS

After fruit selection, the physical and physicochemical analyses used to determine the different stages of maturity of the 'Ataulfo' mango were: mass loss (GUEDES, 2007); longitudinal diameter and transverse diameter (mm); peel and pulp color parameters, measured in a Konica Minolta CR-400 portable digital colorimeter: lightness (*L**), red intensity (+*a**) and yellow intensity (+*b**). The DA index was obtained using a portable spectrophotometer called DA-meter® (Turoni/ Italy), which estimates the difference between absorbance values measured at 670 and 720 nm (Noferini et al., 2009), enabling field measurement.

Fruit firmness was determined using a manual penetrometer (Instrutherm, model PTR-100) with an 8 mm diameter tip; results were expressed in Newtons (N). The peel, pulp and seed yield were analyzed for total soluble solids (TSS); results were expressed in °Brix. For total titratable acidity (TTA), the results were expressed as percent citric acid. Hydrogen potency (pH) was calculated according to IAL (2008). Finally, Vitamin C content was calculated according to Strohecker and Henning (1967), and results were expressed as mg ascorbic acid 100 g^{-1} pulp.

2.2 STATISTICAL ANALYSIS

The experimental design was completely randomized, with the aid of Assistat software version 7.7 beta (SILVA; AZEVEDO, 2016). The results were submitted to a means test and simple correlation analysis.

3 RESULTS AND DISCUSSION

The results presented in Table 1 show that the mass, longitudinal diameter and pulp yield of mangoes increase with the advancement of maturation stages. Fruit growth occurs concurrently with the ripening process, which is characterized by physiological, biochemical and structural changes in the fruits. For mango, fruits increase in length and diameter, while accumulating carbohydrates (SANTOS et al., 2008), resulting from metabolic reactions of starch conversion; and accumulation of different solids due to changes in the relationship between source and drain of assimilates, inducing the plant to produce fruits with greater size and mass (RAMOS et al., 2011).

TABLE 1 – PHYSICAL CHARACTERISTICS OF 'ATAULFO' MANGO AT THE THREE DIFFERENT MATURATION STAGES.

Variable	Stage 2	Stage 3	Stage 4	C.V (%)
Mass (g)	206.89^{c}	280.64^{b}	320.05^{a}	1.94
Longitudinal diameter (mm)	105.04^{c}	110.35^{b}	117.66^{a}	2.69
Transverse diameter (mm)	67.47^{b}	70.76^{a}	73.40^{a}	2.50
Peel yield (g)	33.23^{b}	39.70^{ab}	42.92^{a}	12.13
Pulp yield (g)	144.82^{c}	197.42^{b}	239.58^{a}	5.43
Seed yield (g)	29.02^{b}	38.68^{a}	39.43^{a}	8.62

Means followed by the same letter in the same line do not differ by the Tukey test at 5% probability (CV: Coefficient of Variation).

With regard to transverse diameter, peel and seed yield, there is a statistical equality for maturation stages 3 and 4. However, the fruits presented lower values for these same variables at maturation stage 2, thus increasing the averages as the fruit maturation stages progressed.

Physical variables may serve as a basis for research on maturation, since nowadays there are other internal and external characteristics of the fruit, such as: firmness, pulp color, aroma, flavor, total soluble solids, total acidity, pH, reducing sugars, volatile substances and ascorbic acid, among others, that can correctly classify the maturation stages of mangoes (JHA; KINGSLY; CHOPRA, 2006; SANTOS et al., 2008; CANUTO; SOUZA NETO; GARRUTI, 2009; ABBASI et al., 2011; AULAR; NATALE, 2013).

Color is a variable widely used in mango crops as a parameter to determine maturity, and as a quality attribute for commercialization. Table 2 shows the relationship between the color coordinates *L**, *a** and *b** of the peel and pulp of 'Ataulfo' mango fruits at each stage of maturity (2, 3 and 4).

TABLE 2 – EVALUATION OF COLOR COORDINATES L*, A*, B* RELATED TO THE DIFFERENT MATURATION STAGES OF 'ATAULFO' MANGO.

Color Variables	Stage 2	Stage 3	Stage 4
Peel Color **L***	43.82[b]	46.75[b]	59.89[a]
Peel Color ***a****	2.67[c]	8.21[b]	27.38[a]
Peel Color ***b****	43.82[b]	46.75[b]	59.89[a]
Pulp Color **L***	76.77[a]	69.50[b]	57.08[c]
Pulp Color ***a****	5.41[c]	9.82[b]	18.85[a]
Pulp Color ***b****	49.10[a]	54.81[a]	54.23[a]

Means followed by the same letter in the line do not differ by the Tukey test at 5% probability.

The variations observed in the lightness of the peel and pulp of the fruits at different stages of maturity were influenced by both the growth and maturation stages of the fruits. Jha et al. (2006), in their studies on mango maturation, found that lightness of the peel decreases during the period of fruit growth and increases at maturation, at which time yellowing occurs. Moreover, according to the same authors, the development of dark green color at early stages and the appearance of light yellow color as the fruits begin to mature are typical of fruits with brighter or higher color. In 'Mahananaka' mango, Saranwong et al. (2004) observed that changes in peel color were not significant during maturation. Nevertheless, it is worth mentioning that this evolution varies with the maturation of the mango, the producing region and the culture management method adopted (LIMA et al., 2009).

When analyzing the results of the *a** coordinate of the peel and pulp, a variation in the values is observed in each stage of maturation of the mangoes. As the fruits mature, they lose greener tones, with lower values (as seen in stages 2 and 3), and gain more orange tones, as found in stage 4.

As for the color coordinate *b** in the peel, the fruits at stages 2 and 3 presented a significant difference when correlated with maturation stage 4. The latter showed a greater value than the other stages, with fruits tending to a more yellow color in relation to the others. However, when pulp color was observed for this same variable, no significant difference was found between the three maturation stages. The mango fruits, regardless of maturation stage, presented a more yellowish pulp.

The results found for peel and pulp color in 'Ataulfo' mango were similar to those found by Morais et al. (2002), who studied the ideal harvest time of 'Tommy Atkins' mango; Basulto et al. (2009), in their studies on post-harvest maturation of papaya; and Lucena et al. (2011), who also used physical parameters such as color to evaluate the maturation of the 'Tommy Atkins' mango. These results also agree with Jha et al. (2006), who stated that the change in pulp color from white to

light yellow characterizes mango maturation. From the representativeness of these changes, Subedi et al. (2007) recommended pulp color as the best maturity index for the cultivars Kesington Pride, Calypso and Celebration.

Metabolic changes that occur during physiological maturation, such as increase in total soluble solids, decreased in acidity, changes in taste, loss of firmness, texture, among others, are essential to guarantee and ensure fruit quality. In their study on the maturation of 'Ataulfo', 'Tommy Atkins' and 'Haden' mangoes, Nassur et al. (2015) found that changes in pulp and peel color are directly related to the levels of chlorophyll and carotenoids.

Through Table 3, it can be seen that the DA index decreased as the maturation stages advanced, whose fruits varied from green to yellow, thus correlating with the chlorophyll content, more specifically with the degradation of this pigment. This degradation may be related to changes in pH, acids and oxidative processes, which also influence the synthesis of other pigments, such as carotenoids.

TABLE 3 – DA INDEX, PHYSICAL AND PHYSICOCHEMICAL CHARACTERISTICS: TOTAL SOLUBLE SOLIDS (TSS), PH, TOTAL TITRATABLE ACIDITY (TTA) AND VITAMIN C AS A FUNCTION OF MATURATION STAGES OF 'ATAULFO' MANGO.

Stages of maturation	DA index	Firmness (N)	TSS (ºBrix)	pH	TTA (% citric acid)	Vitamin C (mg ascorbic acid 100 g^{-1} pulp)
 Stage 2	1.93[a]	150.55[a]	7.32[b]	2.95[c]	4.06[a]	114.26[a]
 Stage 3	1.24[b]	131.94[b]	8.40[b]	3.14[b]	2.81[b]	125.62[a]
 Stage 4	0.24[c]	47.71[c]	21.30[a]	3.98[a]	0.79[c]	73.25[b]

Means followed by the same letter in the same column do not differ statistically by the Tukey test at 5% probability.

In this case, a significant difference was observed between the averages of the DA index (Table 3), showing that this index can be used to determine the maturation stages of the 'Ataulfo' mango. Corroborating this result, Costa et al. (2019) found that the DA Index for 'Tommy Atkins' and

‘Palmer’ mango is an important and promising tool to assess the ripening process in the field and post-harvest ripening in a simple, fast and accurate manner.

Firmness is a quality parameter widely used in research, mainly as an indicator of maturation. It is shown in Table 3 with different values for each stage of maturation, which evidences a significant difference for this parameter. The fruits in stages 2 and 3 presented greater firmness, differently from fruits in stage 4; showing that the more mature the fruits, the less firm they are. In a study using the same maturation stages 2, 3 and 4 with ‘Tommy Atkins’ mango, Lucena (2000) obtained the respective results of 96.97, 55.15 and 14.67 for firmness, values lower than those found in this experiment. Santos et al. (2008) also used the mango ‘Tommy Atkins’ and the same maturation stages (2, 3 and 4), obtaining lower firmness values when compared with the data obtained for ‘Ataulfo’ mango.

Ziosi et al. (2008), in their studies with peaches, and Mcglone et al. (2002), with apples, observed that these fruits were divided into different maturity classes using the absorbance difference index. Goulart et al. (2013) studied the evolution of the DA index by observing the color of ‘Tommy Atkins’ mangoes, and also found that through DA index it was possible to separate the fruits into maturation classes.

The total soluble solids (TSS) (Table 3) of fruits at maturation stages 2 and 3 was 7.32 and 8.40, respectively. According to these values, it was possible to observe an increase in this variable for these two stages, but they did not differ statistically from each other. Stage 4 was statistically different from the other stages, with an increase of approximately three times more in total soluble solids in relation to the previous ones.

The increase in total soluble solids is due to the fruit ripening process, which occurs mainly from the hydrolysis of carbohydrates reserves stored in the plant during fruit growth. Thus, carbohydrate hydrolysis is promoted along with starch degradation, which is converted to total soluble (KAYS, 1991; WILLS et al., 2007; SOUSA et al., 2017).

Hojo et al. (2009), in their study with ‘Tommy Atkins’ mango, found that as the fruits matured, the soluble solids content tended to increase. TSS is currently one of the evaluation parameters for determining of the optimal harvest time of the fruit, and a quality determinant for commercialization.

Table 3 also shows that pH values increased as the fruits matured. Fruits at stages 2, 3 and 4 presented the following values, respectively: 2.95; 3.14 and 3.98. These results are consistent with those found by Santos et al. (2008), whose pH ranged from 2.84 to 4.59 for the ‘Tommy Atkins’ variety.

Unlike pH and total soluble solids, the total titratable acidity (TTA) of fruits is lower as the fruit matures. The reduction in TTA occurs due to respiratory processes and the conversion of some organic acids to sugars during fruit ripening (BRAZ et al., 2008).

The vitamin C content of ‘Ataulfo’ mango at maturation stage 4 (73.25) was lower than at stages 2 and 3 (114.26 and 125.62, respectively). In most fruits, the vitamin C content tends to decrease during ripening processes. Nogueira et al. (2002), in their research with acerola, attributed to the activity of the ascorbate oxidase enzyme the decrease vitamin C content in mature fruits, since in green fruits the values found were higher. Cardello and Cardello (1998), in their studies with ‘Haden’ mango, also observed that the reduction of vitamin C content during fruit maturation was explained by the action of this enzyme.

When the DA index was correlated with firmness, soluble solids, titratable acidity and pH at the three maturation stages (2, 3 and 4), the negative and positive correlation coefficients reached values above 0.90, as shown in Table 4. This means that when the fruits are green, they tend to have positive acidity when correlated with the DA index. On the other hand, the negative TSS and pH values, also correlated with the DA index, showed that the fruits were at a higher maturation stage, i.e., more mature. The weakest correlation with vitamin C content may be related to the instability of ascorbic acid and the low association of the analyzes at the wavelengths used in the determination of the DA index.

TABLE 4 – SIMPLE CORRELATION BETWEEN PHYSICAL AND PHYSICOCHEMICAL VARIABLES AS A FUNCTION OF MATURATION STAGES OF 'ATAULFO' MANGO.

VARIABLES	DA Index	Firmness	TSS	TTA	pH	Vitamin C
Index DA	1	-0.92	0.94	0.97	-0.93	0.78
Firmness	**	1	-0.96	-0.93	0.97	-0.90
TSS	**	**	1	0.96	-0.96	0.86
TTA	**	**	**	1	-0.96	0.77
pH	**	**	**	**	1	-0.85
Vitamin C	**	**	**	**	**	1

DA index - Absorbance difference index; TSS - Total soluble solids; TTA - Total titratable acidity.

The high correlation coefficients of DA index with firmness and pH (negative), and with TSS and TTA (positive) indicate that the fruits are in different stages of maturation and that the DA index is a good indicator of maturation in the 'Ataulfo' mango. Betemps et al. (2011) also evaluated the quality of 'Tommy Atkins' mango with the DA index, correlating this index with physicochemical parameters such as color, total soluble solids, firmness and acidity. The authors found that the DA index values had an excellent relationship with the quality attributes commonly used in the 'Tommy Atkins' mango. Thus, using the DA index it is possible to separate the fruits based on their degree of maturation and the results of quality parameters.

4 CONCLUSIONS

As the maturation stages advanced, the soluble solids increased considerably, reaching 21.30 ºBrix in stage 4. On the other hand, firmness, titratable acidity and the levels of vitamin C decreased with the maturation process, being, respectively, 47.71 N, 0.79% of citric acid and 73.25 mg of ascorbic acid per 100 g of pulp in stage 4.

The determination of the DA index represents a potential tool, based on a non-destructive analysis, to determine the maturation of the 'Ataulfo' mangoes. Through the DA index it was possible to differentiate the three stages of maturation evaluated, in addition to having a good correlation with firmness, SST, ATT and pH, with high coefficients, -0.92, 0.94, 0.97 and -0.93, respectively.

This study opens the possibility of using this technique in the post-harvest classification of this mango variety, improving the selection of fruits in a non-invasive way. In this way, it is possible to increase the repeatability of evaluations without wasting mangoes, taking into account both routinely used analyzes of fundamental importance, such as fruit firmness and soluble solids content, and others that are not normally applied in practice such as the determination of acidity.

RESUMO

CHARACTERIZATION OF QUALITY ATTRIBUTES OF MANGO CV. 'ATAULFO' AT DIFFERENT MATURATION STAGES

Objetivou-se com este estudo caracterizar físico e físico-quimicamente três estádios de maturação da manga 'Ataulfo', bem como avaliar a correlação de um método não destrutivo como o Índice de diferença de absorbância DA Meter (Turoni), com parâmetros obtidos destrutivamente. As mangas foram colhidas nos estádios 2, 3 e 4, sendo determinadas as seguintes variáveis: perda de

massa, comprimento, diâmetro, cor da casca e da polpa e suas coordenadas L* a* b*, firmeza, Índice DA, rendimento, pH, sólidos solúveis, acidez titulável e vitamina C. O delineamento experimental foi inteiramente casualizado com dez repetições. Os resultados foram submetidos a teste de médias e correlação simples. Com o avanço dos estádios de maturação os sólidos solúveis aumentaram consideravelmente, passando de 7,32 ºBrix no estádio 2 para 21,30 ºBrix no estádio 4. Já a firmeza, a acidez titulável e os teores de vitamina C reduziram com o processo de maturação, atingindo, respectivamente, 47,71 N, 0,79% de ácido cítrico e 73,25 mg de ácido ascórbico por 100 g de polpa no estádio 4. As análises físicas e físico-químicas como a massa, comprimento, rendimento de polpa, podem ser utilizadas como base para a determinação dos estádios de maturação, porém através do Índice DA conseguiu-se uma melhor diferenciação dos frutos em diferentes classes de maturação, além de ter uma boa correlação com as variáveis firmeza, SST, ATT e pH, com coeficientes elevados, -0,92, 0,94, 0,97 e -0,93, respectivamente. Desse modo, a determinação desse índice representa uma ferramenta potencial baseada em análise não destrutiva para determinação da maturação de mangas da variedade 'Ataulfo'.

PALAVRAS-CHAVE: Mangifera indica L., MATURAÇÃO, MÉTODO NÃO DESTRUTIVO.

REFERENCES

1 ABBASI, K.S., ANJUM, N., SAMMI, S., MASUD, T.; ALI, S. Effect of coatings and packaging material on the keeping quality of mangoes (*Mangifera indica* L.) stored at low temperature. **Pakistan Journal of Nutrition**, v.10, n.2, p. 129-138, 2011.

2 AULAR, J.; NATALE, W. Nutrição mineral e qualidade do fruto de algumas frutíferas tropicais: goiabeira, mangueira, bananeira e mamoeiro. **Revista Brasileira de Fruticultura**, v.35, n.4, p. 1214-1234, 2013.

3 BASULTO, F. S.; DUCH, E. S.; GIL, F. E.; PLAZA, R. D.; SAAVEDRA, A. L.; SANTAMARIA, J. M. Postharvest ripening and maturation indices for Maradol papaya. **Interciencia**, v.34, n.8, p. 583-588, 2009.

4 BETEMPS, D. L.; FACHINELLO, J. C.; GALARÇA, S. P. Espectroscopia do visível e infravermelho próximo (vis/nir) na avaliação da qualidade de mangas Tommy Atkins. **Revista Brasileira de Fruticultura**, v. especial, p. 306-313, 2011.

5 BRECHT J.; YAHIA, E. M. **The mango**: Botany, production and uses. Postharvest physiology, In: Litz, R. (Ed) CAB International, Wallingford, UK, 2nd ed., p. 484-528, 2009.

6 CANUTO, K. M.; SOUZA NETO, M. A.; GARRUTI, D. S. Composição química volátil, em diferentes estádios de maturação, de manga 'Tommy Atkins' produzida no Vale do São Francisco. **Química Nova**, v.32, n.9, p. 2377-2381, 2009.

7 CARDELLO, H. M. A. B.; CARDELLO, L. Teor de vitamin C, atividade de ascorbate oxidase e perfil sensorial de manga (*Mangifera indica* L.) var. Haden, durante o amadurecimento. **Ciência e Tecnologia de Alimentos**, v.18, n.2, 1998.

8 CARVALHO, C.; KIST, B, B.; BELING, R. R. **Anuário Brasileiro De Horti e Fruti 2020**. Santa Cruz do Sul, 2019, p. 96.

9 CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-colheita de frutos e hortaliças:** fisiologia e manuseio. Lavras: ESAL/FAEPE, p.735, 2005.

10 COSTA, J. D. S.; FIGUEIREDO NETO, A.; COSTA, M. S.; GOMES, J. P.; SILVA, J. C.; SILVA, E. P. Maturação de mangas 'Palmer' e 'Tommy Atkins' avaliadas por espectroscopia baseada no índice *DA*. **Revista Iberoamericana de Tecnología Postcosecha**, v. 20, n. 1, p. 16–25, 2019.

11 GOULART, C.; LOY, F. S.; GALARÇA, S. P.; GIOVANAZ, M. A.; MALGARIM, M. B.; FACHINELLO, J. C. Evolução do índice da e coloração da epiderme de mangas da cultivar Tommy Atkins. **Revista Iberoamericana de Tecnología Postcosecha**, v.14, n.1, p. 8- 13, 2013.

12 GUEDES, P. A. **Utilização de biofilme comestível na conservação pós-colheita de manga, cv. Rosa**. 2007. 67 f. Dissertação (Mestrado em Agronomia. Área de Concentração em Fitotecnia) - Universidade Estadual do Sudoeste da Bahia, Vitória da Conquista - BA, 2007.

13 HOJO, R. H.; SÃO JOSÉ, A. R.; HOJO, E. T. D.; ALVES, J. F. T.; REBOUÇAS, T. N. H.; DIAS, N. O. Qualidade de manga 'Tommy Atkins' pós-colheita com uso de cloreto de cálcio na pré-colheita. **Revista Brasileira de Fruticultura**, v.31, n.1, p. 062-070, 2009.

14 INSTITUTO ADOLFO LUTZ - IAL. **Métodos físico-químicos para análise de alimentos** / coordenadores Odair Zenebon, Neus Sadocco Pascuet e Paulo Tiglea - São Paulo, 1020p, 2008.

15 JHA, S. N.; KINGSLY, A. R. P.; CHOPRA, S. Physical and mechanical properties of mango during growth and storage for determination of maturation. **Journal of Food Engineering**, v.72, p. 73-76, 2006.

16 KAYS, J. S. **Postharvest physiology of perishables plant products**. New York: AVI, 1991.

17 LUCENA, E. M. P.; ASSIS, J. S.; ALVES, R. E.; ENÉAS FILHO, J. Alterações físicas e químicas durante o crescimento e desenvolvimento de mangas 'Tommy Atkins' produzidas no Vale do São Francisco, Brasil. **Journal Interamerican Society for Tropical Horticulture**, v.55, p. 48-51, 2011.

18 LUCENA, E. M. P.; SILVA JUNIOR, A.; CAMPELO, I. K. M. Caracterização físico-química da manga (*Mangifera indica* L.), variedade Tommy Atkins, em diferentes estádios de maturação. In: Congresso Brasileiro de Ciência e Tecnologia de Alimentos, Fortaleza. Anais...p. 5246, 2000.

19 MCGLONE, V. A.; JORDAN, R. B.; MARTINSEN, P. J. Vis/Nir estimation at harvest of pre-and post estorage quality indices for 'Royal Gala' apple. **Postharvest Biology and Tecnology**, v.25, p. 135-144, 2002.

20 MORAIS, P. L. D.; FILGUEIRAS, H. A. C.; PINHO, J. L. N.; ALVES, R. E. Ponto de colheita ideal de mangas 'Tommy Atkins' destinadas ao mercado europeu. **Revista Brasileira de Fruticultura**, v.24, n.3, p. 671-675, 2002.

21 NASSUR, R. C.M; SARA GONZÁLEZ-MOSCOSO, G. M. C; LIMA, L. C. O; VILAS BOAS, E. V. B; CRISOSTO, C. H. Describing Quality and Sensory Attributes of 3 Mango (*Mangifera indica* L.) Cultivars at 3 Ripeness Stages Based on Firmness. **Journal of Food Science**, v.80, n.9, 2015.

22 NOFERINI, M.; FIORI, G.; FARNETI, B.; COSTA, G. **Impiego di um índice non distruttivo per determinare la correta época di Raccolta Del fruto di actinidia chinensis**. In: MACFRUT, 2009.

23 NOGUEIRA, R. J. M. C.; MORAES, J. A. P. V.; BURITY, H. A.; SILVA JÚNIOR, J. F. Efeito do estádio de maturação dos frutos nas características físico-químicas de acerola. **Pesquisa Agropecuária Brasileira**, v.37, p. 463- 470, 2002.

24 RAMOS, D. P.; LEONEL, S.; SILVA, A. C.; SOUZA, M. E.; SOUZA, A. P.; FRAGOSO, A. M. Épocas de poda na sazonalidade, produção e qualidade dos frutos da goiabeira 'Paluma'. **Semina**: Ciências Agrárias, v.32, n.3, p. 909-918, 2011.

25 REETZ, E. R.; KIST, B, B.; SANTOS, C. E.; CARVALHO, C.; DRUM, M. **Anuário Brasileiro da Fruticultura 2014**. Santa Cruz do Sul: Gazeta Santa Cruz, 2015, 108p.

26 SANTOS, D. B.; PEREIRA, M. E. C.; VIEIRA, E. L.; LIMA, M. A. C. Caracterização físico-química dos estádios de maturação da manga 'Tommy Atkins' produzida no município de Iaçú - BA. **Magistra**, v. 20, n. 4, p. 342-348, 2008.

27 SILVA, F. A. S; AZEVEDO, C. A. V. **ASSISTAT Software**: Assistência Estatística. Versão 7.7 beta., 2016.

28 STROHECKER, R.; HENNING, H. M. **Analisis de vitaminas**: métodos comprobados. Madrid: Paz Montalvo, 1967. 428p.

29 WILLS, R. B. H.; MCGLASSON, W. B.; GRAHAM, D.; JOYCE, D. C. **Postharvest: na introduction to the physiology and handling of fruit, vegetables and ornamentals**. 5. ed. Wallingford: New South Wales University, 2007. 227p.

30 YAHIA, E. M.; ORNELAS-PAZ, J. de J.; ARIZA, F. R. **The mango**. Ciudad del Mexico: Trillas, 2006. 224 p.

31 ZIOSI, V.; NOFERINI, M.; FIORI, G.; TADIELLO, A.; TRAINOTTI, L.; CASADORO, G.; COSTA, G. A 2008. New index based on vis spectroscopy to characterize the progression of ripening in peach fruit. **Postharvest Biology and Technology**, v.49, p.319–329.