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Physico-chemical properties of 'UBÁ' mango for identification of the ideal harvest point

Propriedades físico-químicas de manga 'UBÁ' para identificação do ponto ideal de colheita

Propiedades físico-químicas del mango 'UBÁ' para la identificación del punto ideal de cosecha

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Abstract

Harvesting mangoes at the wrong time of maturation impairs the final quality of the product, therefore, deciding the correct time for the shape of the same is an essential factor for the fruits to have better physical, chemical and nutritional properties. Therefore, due to the lack of information to help in the proper choice of harvest time for this variety, the objective was to analyze physicochemical characteristics of fruits in four stages of development, aiming to identify the ideal harvest point for 'Ubá' mango. A completely randomized design was used, with nine replications for each stage. The skin and pulp color of 'Ubá' mango were evaluated through L*, a* and b coordinates, soluble solids content, titratable total acidity, pH and ratio. Thus, the results of this study concluded that the 'Ubá' mango can be harvested at the greenish stage, as it has a total soluble solids content of 12.05, a pH of 3.89 and a ratio of 89.63, values that are satisfactory according to the legislation. current, correlated with the yellowish color of the pulp, defined by the increase of the a* coordinate from 4.12 to 23.78 and the b* coordinate from 60.43 to 81.71, an important criterion for the commercialization of the fruit.

Keywords: *Mangifera indica;* Ripening; Color; Soluble solids.

Resumo

A colheita da manga no momento incorreto de maturação prejudica a qualidade final do produto, portando, decidir qual o momento correto para o feitio da mesma é um fator essencial para que os frutos tenham melhores propriedades físicas, químicas e nutricionais. Portanto, devido à falta de informações que auxiliem na escolha adequada da época de colheita desta variedade, objettivou-se analisar características físico-químicas de frutos em quatro estádios de desenvolvimento, visando identificar o ponto de colheita ideal para manga 'Ubá'. Utilizou-se o delineamento inteiramente casualizado, com nove repetições para cada estádio. Avaliaram-se a cor da casca e da polpa da manga 'Ubá', através das coordenadas L*, a* e b, teor de sólidos solúveis, acidez total titulável, pH e ratio. Assim,os resultados deste estudo concluíram que a manga 'Ubá' pode ser colhida no estádio verdoengo, pois possui teor de sólidos solúveis totais de 12,05, pH de 3,89 e ratio de 89,63, valores esses satisfatórios segundo a legislação vigente, correlacionada com à coloração amarelada da polpa, definida pelo aumento da coordenada a* de 4,12 para 23,78 e da coordenada b* de 60,43 para 81,71, critério importante para a comercialização do fruto.

Palavras-chave: *Mangifera indica*; Amadurecimento; Cor; Sólidos solúveis.

Resumen
Cosechar mangos en un mal momento de maduración perjudica la calidad final del producto, por lo que decidir el momento correcto para la forma del mismo es un factor fundamental para que los frutos tengan mejores propiedades físicas, químicas y nutricionales. Por lo tanto, debido a la falta de información que ayude en la elección adecuada del momento de cosecha para esta variedad, el objetivo fue analizar las características fisicoquímicas de los frutos en cuatro etapas de desarrollo, con el objetivo de identificar el punto ideal de cosecha para el mango 'Ubá'. Se utilizó un diseño completamente al azar, con nueve repeticiones para cada etapa. Se evaluó color de piel y pulpa de mango 'Ubá' mediante coordenadas L*, a* y b, contenido de sólidos solubles, acidez total titulable, pH y ratio. Así, los resultados de este estudio concluyeron que el mango 'Ubá' se puede cosechar en estado de verdoengo, ya que presenta un contenido de sólidos solubles totales de 12,05, un pH de 3,89 y una relación de 89,63, valores que son satisfactorios según a la legislación vigente, correlacionado con el color amarillento de la pulpa, definido por el aumento de la coordenada a* de 4,12 a 23,78 y de la coordenada b* de 60,43 a 81,71, criterio importante para la comercialización del fruto.
Palabras clave: *Mangifera indica;* Maduración; Color; Sólidos solubles.

1. Introduction

The Brazilian fruit industry has a privileged position in world production, occupying the third position, only behind China and India. Annual fruit production is around 40 million tons, occupying an area of over 2 million hectares (FAO, 2017; Andrade, 2020). In the export scenario, mango is the most exported fruit in Brazil, with an increase of 30% in the year 2019 compared to the previous year, with around 221,913 thousand tons of fruit exported. (Anuário Brasileiro de Horti&Fruti, 2019).

In addition to the economic importance of mango, both for export and for local industries, it has a high nutritional value, being a source of antioxidants and with high levels of vitamin A and C. It is also a source of fiber and mineral salts, essential components in the blood, hormones, muscles and enzymes composition (Roizen & Puma, 2001).

Mangifera indica L. var. Ubá is widely cultivated in the Zona da Mata region, being grown for both domestic and commercial purposes, with production destined for local agribusinesses of juices and nectars (Ramos et al., 2005). Its fruit is small, weighing between 85 and 171 g, oblong-oval, with a thin, yellowish rind and firm pulp, tasty, succulent and with few fibers (Manica et al., 2001). When processed, 'Ubá' mango fruits maintain their color and aroma characteristics, while also maintaining nutritional values such as vitamin A and C and potassium contents (Benevides et al., 2007). In local juice-producing industries, 'Ubá' mango is the main cultivar used due to the yellow-orange color of its pulp and extremely pleasant flavor, pleasing consumers (Silva et al., 2012).

Due to these characteristics, the juice of the mango fruit ‘Ubá’ has been widely used in the juice and nectar industry to be mixed with the juice of other cultivars to enhance the color and flavor. With the increase in the consumption of industrialized fruit juices in recent times (Linhares & Do Carmo, 2018), the juice industry sector in Brazil is booming, increasing the demand for better quality raw materials. However, one of the great problems faced by producers and industries is the identification of the ideal harvest point, ensuring the best physical, chemical and nutritional qualities of the fruits.

Color is commonly used as an indicator of fruit shelf life. The ripening stage of the fruits can be correlated with the color, objectively analyzed by different systems, and the CIE 1976 system, which uses the coordinates L*, a* and b*, is the most widespread in the scientific community. One of the advantages of colorimetry is that it is a non-destructive analysis, which in the case of evaluation of fruit ripening stages allows to determine characteristics without removing samples or using materials (Motta et al., 2015).

Physical-chemical, biochemical and microbiological transformations continue to occur after the mango harvest, as this is a climacteric fruit. These changes accelerate its ripening, reducing its shelf life and its market price, as consumers prefer fruits with a certain color pattern and free from signs of disease. However, a single ripening pattern cannot be applied to all species, due to the involvement of different routes in the production of pigments, flavor and aroma components and the variation of accumulation and metabolism mechanisms in the softening process (Abeles et al., 1997).

During the mango ripening process, several changes can be seen, such as pulp firmness, sugar content, skin and pulp color, composition and organic acid content and weight loss (Fuchs et al., 1975). It is important to know these changes for specific products, aiming to establish adequate technologies for handling and post-harvest treatments. Thus, this work aimed to evaluate the physicochemical properties of 'Ubá' mangoes at different stages of maturation at harvest, in order to define the best time for harvesting the fruits.

2. Methodology

Mangoes of the variety 'Ubá', from the municipality of Guidoval, MG – Brazil (21º14'97" S and 42º75'90" W) were used, manually harvested at four maturation stages: green, greenish, semi-ripe and mature, in the month of December 2020. The fruits were selected in order to obtain homogeneous and high-quality samples. The mangoes used in this work came from organic farming, due to the growing world demand for sustainable products and because most of the region's production comes from family farmers who mostly have their crops on an agroecological basis.

The fruits were collected in the middle part of the plant, in the same branch or in nearby branches and transported on the same day of harvest to Viçosa, MG - Brazil, where the analyzes were performed. In the laboratory, the fruits were washed with water and 0.1% neutral detergent for 5 minutes for latex coagulation, and then dried in ambient air.

To assess the difference in color at different stages of mango maturation, a tristimulus colorimeter (CIE 1976 system) was used, with direct reading of the L* coordinate reflectance (brightness) on a scale from 0 (completely black) to 100 (completely white). Intermediate values comprise a gray scale. The coordinate a* (red/green hues) and b* (yellow/blue hues) were also measured using the Hunter-Lab scale. To quantify the color, the direct reflectance reading of coordinates L*, a* and b* was performed at three different points of the fruit. The device was previously calibrated according to the manufacturer's instructions. From the values of L*, a* and b*, the hue angle, hue (h*), the chromatic saturation index (C*) and the color difference (ΔE) were calculated for each maturation stage, according to equations (1), (2) and (3):

$$C^* = \sqrt{a^{*2} + b^{*2}} \qquad \text{(Eq.1)}$$

$$h^* = actg\,\frac{b^*}{a^*} \qquad \text{(Eq.2)}$$

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} \qquad \text{(Eq.3)}$$

The soluble solids content was measured in the pulp juice after crushing the fruit in a blender and passing it through a sieve with 1 mm diameter holes to remove the fibers. For a better result, a sufficient quantity of homogenized sample of the pulp juice was transferred to a cotton, in order to provide a better reading, where three drops of sample were placed in the prism of the portable refractometer, Nova brand, model 113. After about one minute, a direct reading was taken in degrees Brix, at an ambient temperature of 20 °C (IAL, 2008). The refractometer was calibrated with distilled water before carrying out the analyzes and cleaned with distilled water after each analysis.

The pH was determined with the aid of a digital pH meter (Model PHS-3E, Even), calibrated with the acid (4) and basic (7) pH standard solutions and tested before the analyzes according to the Analytical Standards of the Instituto Adolfo Lutz (2008).

The total titratable acidity was determined by acid-base volumetry, by titrating the sample with a 0.1 N sodium hydroxide (NaOH) solution as a titrant and a 1% phenolphthalein solution as an indicator of the solution's turning point. The

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samples were obtained according to the methodology of Instituto Adolfo Lutz (2008). The sodium hydroxide solution was placed in a 25 mL burette and the sample was titrated under agitation, until it reached a pink color.

The total titratable acidity was expressed as a percentage of citric acid, as it is the predominant acid in mango fruits, and obtained by equation 4 (IAL, 2008):

$$\%\ Citric\ Acid = \frac{Vb\ x\ f\ x\ M\ x\ MW}{10\ x\ Va\ x\ n} \qquad \text{(Eq.4)}$$

Where:

Vb = 0.1N NaOH volume used, in ml;

f = 0.1N sodium hydroxide solution correction factor;

M = molarity of the sodium hydroxide solution;

MW = molecular weight of citric acid (192);

Va = sample volume, in ml;

n = number of ionizable citric acid hydrogens (3).

The total soluble solids/total titratable acidity ratio (SS/AT) was obtained according to IAL (2008), by the direct relationship of the values of soluble solids and titratable acidity (Equation 5).

$$RATIO = \frac{total\ soluble\ solids}{total\ titratable\ acidity} \qquad \text{(Eq.5)}$$

The experiment was carried out in a completely randomized design, with nine replications for each maturation stage. The results were submitted to Analysis of Variance (ANOVA), and when pertinent to the mean comparison test (Tukey) at the level of 5% probability, using the Sisvar 5.8 software (Ferreira, 2015).

3. Results and Discussion

3.1 Evolution of 'L', 'a' and 'b' coordinates

The maturation stage significantly affected the a*, b* and L* coordinates by the F test at 1% probability. Thus, the mean values were submitted to the Tukey test, at 5% probability, to compare the means.

Table 1. Mean values of coordinates L*, a* and b* for the Ubá' mango peel and pulp at different maturation stages.

		Coordinates		
	Stadium	a*	b*	L*
Peel color	Green (1)	-12.32 d	36.06 c	55.17 c
	Greenish (2)	-5.17 c	37.35 c	57.38 bc
	Semi-ripe (3)	7.59 b	48.08 b	62.15 b
	Mature (4)	20.38 a	66.59 a	72.79 a
Pulp color	Green (1)	4.12 c	60.43 d	87.39 a
	Greenish (2)	13.59 b	71.22 c	87.29 a
	Semi-ripe (3)	23.61 a	79.63 b	68.66 b
	Mature (4)	23.78 a	81.71 a	69.34 b

Means followed by the same letter in the column, for each analysis, do not differ statistically from each other, by Tukey's test at 5% probability. Source: Authors.

The mean values for the coordinate a* in stages 1 and 2 for shell color presented negative values, as this attribute defines the color between green and red, and the lower its value, the greener the color of the skin. fruit. It is possible to verify that, according to the advance of the maturation degree, the values turn from negative to positive in stages 3 and 4, indicating that the peel color changed from a darker green color in stage 1 to a less intense green in stage 2, acquiring a yellowish color in stage 3 and yellow-orange in stage 4.

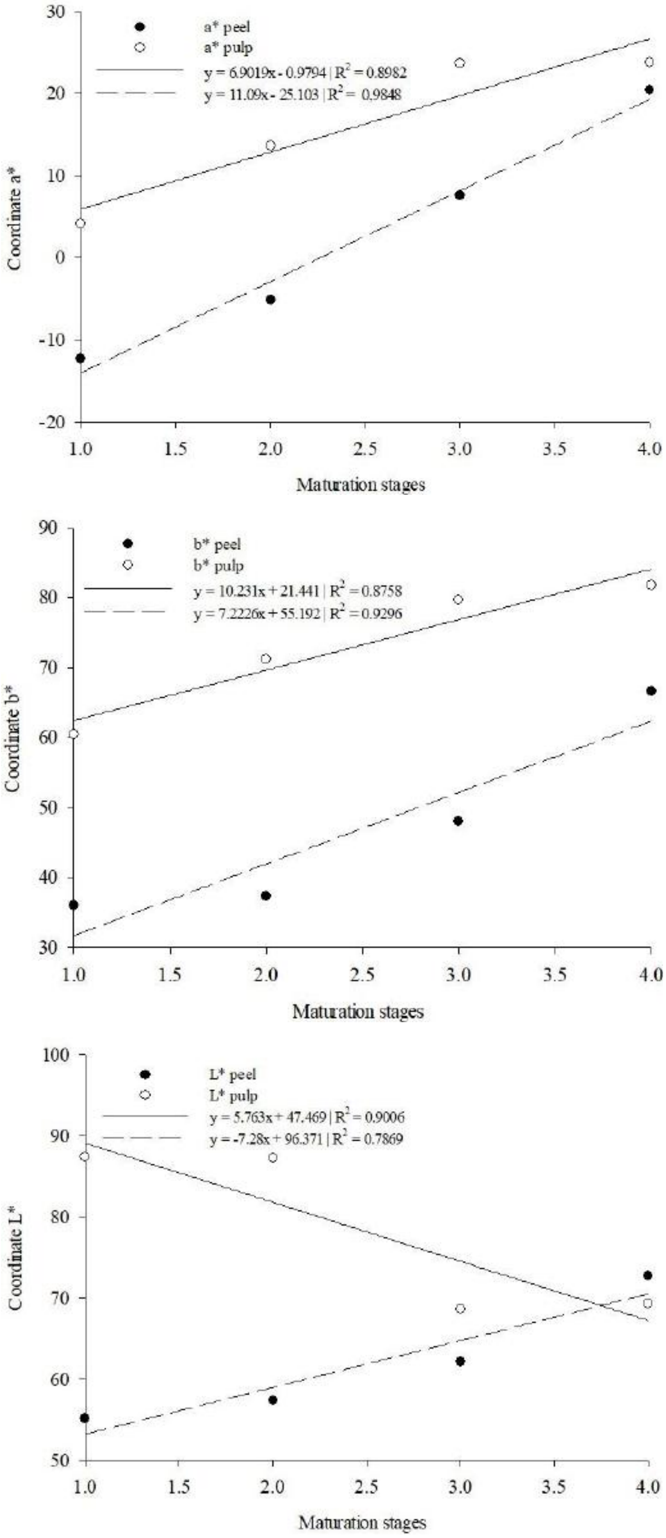
For pulp color, the a* coordinate did not show negative values, since even the fruits in the initial stage of ripening, their color does not tend to be green. It can be noted that, in the same way as for the skin color, the a* coordinate values increased as the maturation stage progressed.

For the b* coordinate, there was an increase in its values for both the peel and the pulp, demonstrating the change in the hue of the yellow color, which increased its intensity mainly in stages 3 and 4 (Table 1). This color change is due to the yellowing process of the skin and pulp, characteristic of the species. According to Benevides et al. (2008), higher values of b* are related to the predominance of carotenoids over the other pigments present in the 'Ubá' mango fruit.

The L* parameter, which measures color luminosity, showed no significant difference between stages 1 and 2, and 2 and 3 for the peel, different from what was observed for the pulp, where the values differed statistically between stages 2 and 3, but not between stages 1 and 2, and 3 and 4 (Table 1). We can observe for bark that as the yellow color increases, indicated by the b* coordinate, there is an increase in the luminosity index, with the highest values found in stage 4 (Table 1). Opposite behavior was observed for the pulp, where higher values of L* were found for stages 1 and 2. Lower values of L* for the skin and higher values for the pulp of green fruits were expected, since the skin of these has more color dark in the initial stages of ripening becoming lighter during ripening, a process contrary to what happens with the pulp, which has its color intensified with the ripening of the fruit. As the L* value ranges from 0 to 100, where zero is black and 100 is white, the smaller the L* value, the darker the product.

Figure 1 shows the representation of the coordinates a*, b* and L*, in the different stages of maturation.

Figure 1. Behavior of the 'a*', 'b*' and 'L*' coordinates of the peel and pulp of the 'Ubá' mango fruits, in four maturation stages: (1) Green; (2); Greenish; (3) Semi-ripe; (4) Mature.



Source: Silva (2021).

It is possible to notice in Figure 1 that the a* and b* coordinates varied similarly for the skin and pulp color, following a linear model, proving a relationship between them. Larger values of a* are associated with larger values of b. This relationship is justified by the evolution of fruit color during ripening, from green to yellow. For the a* coordinate, it is observed that the lines of the skin and pulp color tend to meet the evolution of the maturation stages, which is not so evident for the b* coordinate. As well as coordinates a* and b*, the luminosity for skin color increased throughout ripening, contrary to what was found for pulp color.

3.2 Total difference in color and evolution of chromatic indices Hue and chroma

It was observed by the analysis of variance that the maturation stage significantly influenced the chroma (C), the hue angle (Hue) and the total color difference, by the 1% F test. Thus, the mean values were submitted to the Tukey test at 5% probability (Table 2).

Table 2. Mean values of colorimetric indices chroma (C), Hue angle and total color difference (ΔE), for 'Ubá' mango peel and pulp at different maturation stages.

		Analysis		
	Stadium	C	Hue	ΔE
Peel color	Green (1)	38.12 c	108.95 a	0.0 d
	Greenish (2)	37.80 c	98.19 ab	11.83 c
	Semi-ripe (3)	48.84 b	61.56 c	25.83 b
	Mature (4)	69.87 a	73.21 bc	48.94 a
Pulp color	Green (1)	60.55 d	86.13 a	0.0 c
	Greenish (2)	72.52 c	79.19 b	14.42 b
	Semi-ripe (3)	83.07 b	73.53 c	33.20 a
	Mature (4)	85.14 a	73.78 c	34.65 a

Means followed by the same letter in the column, for each analysis, do not differ statistically from each other, by Tukey's test at 5% probability. Source: Authors.

An increase in chroma (C) is observed both for the peel and for the pulp, proving the increase in pigmentation according to the maturation stages. As the chromaticity is related to the saturation of colors, and its increase shows the gain in pigmentation of the skin and pulp of the fruits during ripening. Thus, the chroma index (C) can be used to indicate the ripeness of the fruits, as higher values lead to purer colors, making it difficult to differentiate between shades.

The samples for skin color showed a Hue angle greater than 90° at stages 1 and 2 and less than 90° at stages 3 and 4, for the fruit skin (Table 2). The inclination greater than 90° of this parameter emphasizes the greenish color presented by fruits in the initial stages of maturation. Note that there was no significant difference between stages 1 and 2, 2 and 4 and 3 and 4. For the pulp color, there is a decline in the Hue angle values as the maturation stage increases, and from stage 3 to 4 the values did not differ statistically, from 73.53 to 73.78 respectively (Table 2). It is verified that the values presented for the pulp color are in the hue range between 0° (red) and 90° (yellow), with the results found closer to yellow, due to the angulation greater than 70°, confirming the yellowish hue of the pulp.

Table 2 shows that the total color difference (ΔE) varied significantly between all maturation stages for skin color. As for the pulp, stages 3 and 4 did not differ from each other. As the ΔE is calculated through the differences contained in the colorimetric coordinates a*, b* and L*, and there was an increase in the variables a* and b*, the observed growth of this index was expected.

The color difference indicates the color variation in relation to the maturation stages, where its value is obtained taking into account the green maturation level as a base, so the value for stage 1 is zero. For the pulp, it is noted that the values

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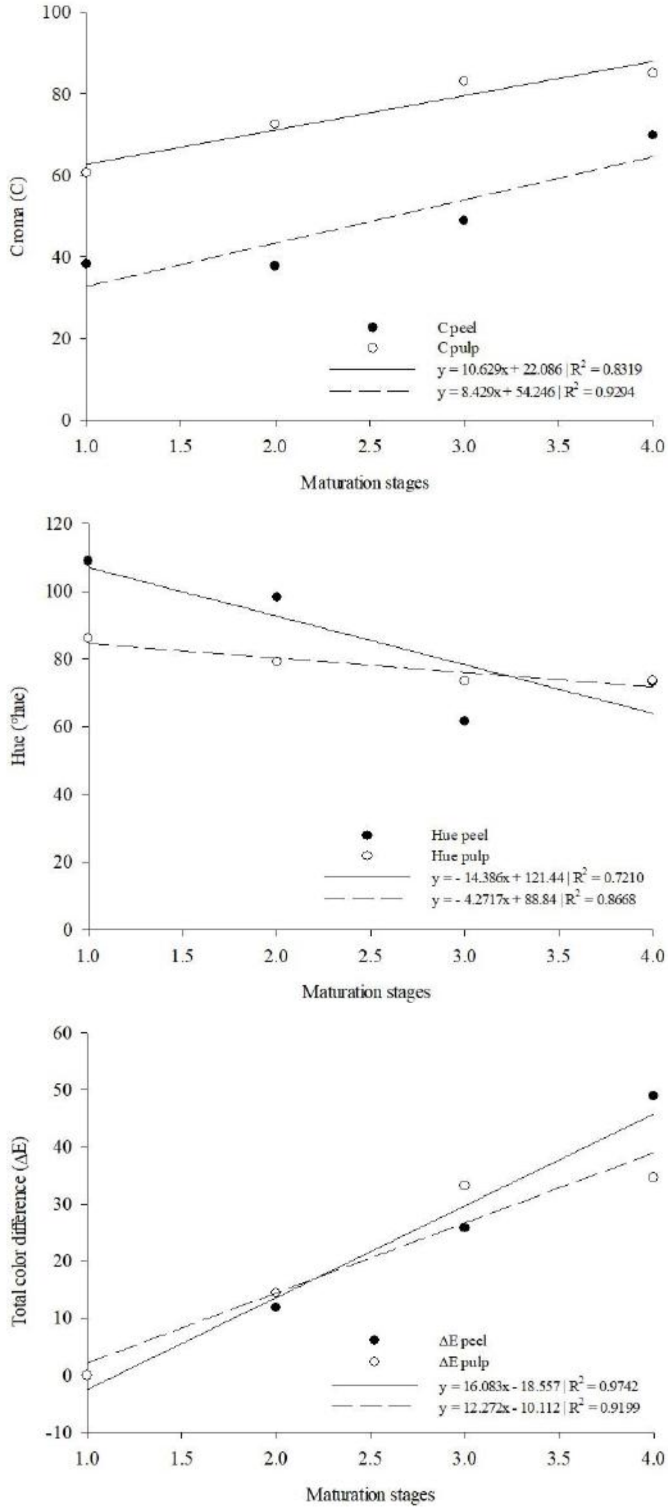
increased and that stage 3 did not differ significantly from stage 4. As for the peel, all stages obtained gains in their values and significant differences between them (Table 2).

Figure 2 shows the evolution of the chroma indices, Hue angle and the total color difference, according to the maturation stage.

Figure 2. Chroma (C), Hue angle (°hue) and total color difference (ΔE), for 'Ubá' mango peel and pulp at different maturation stages: (1) Green; (2) Greenish; (3) Semi-ripe; (4) Mature.

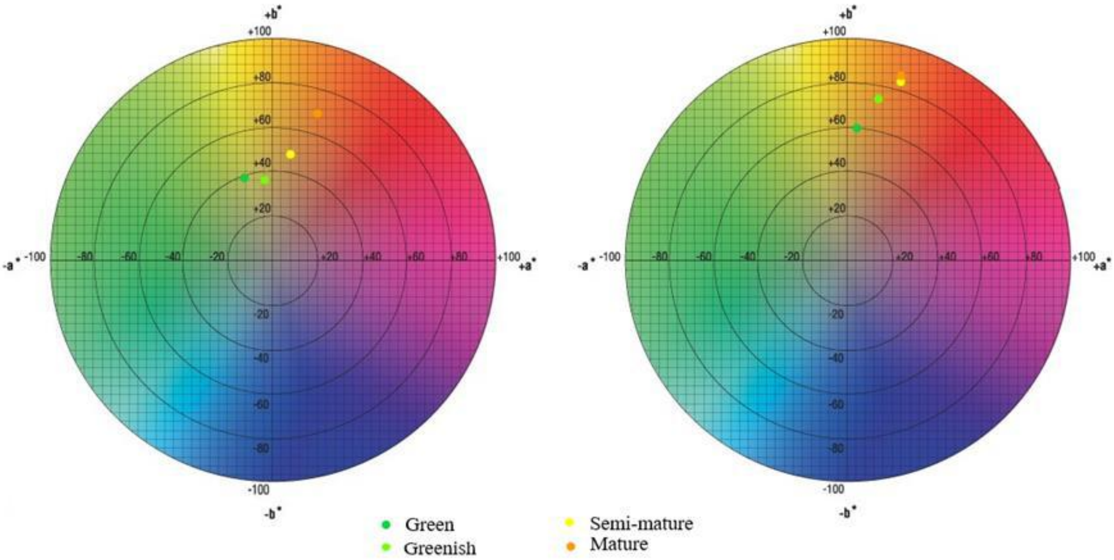


Source: Silva (2021).

From Figure 2, it can be seen that the chroma varies in a similar way for the peel and the pulp, increasing its value, indicating a decrease in the hue or hue of the color. The hue angle, on the other hand, tended to decrease with ripening, suggesting a change in the peridermis of the fruits from green to yellow and the pulp from pale yellow to orange-yellow. The total color difference increased with the advancement of the maturation stages, with a greater gain for the flesh color than for the skin color at stages 2 and 3, and at stage 4 the skin had a higher value for the total difference by heart.

Figure 3 shows the colorimetric behavior in the CIELab color space of the four maturation stages of 'Ubá' mango, for the skin and pulp, according to the mean values of a* and b*.

Figure 3. Colorimetric behavior in the CIELab color space of the four maturation stages of 'Ubá' mango.



Source: Silva (2021).

The CIE system defines the sensation of color based on three elements: luminosity or clarity, hue or hue, and saturation or chromaticity (Ferreira & Spricigo, 2017). It is observed that for the bark, stages 1 and 2 are inserted in the negative quadrant, emphasizing the green color, and stage 1 is farther from the +b* axis, therefore, with a darker green hue than stage 2. Stages 3 and 4, on the other hand, are in the positive quadrant, with stage 3 closer to the +b* axis, showing the yellow coloration, and stage 4 showing the yellow-orange tone. For the pulp, the distance from the +b* axis is noted with the evolution of the maturation stages, confirming that the pulp tonality becomes more yellow throughout the ripening, tending to yellow-orange.

3.3 Evaluation of chemical properties

The analysis of variance for the chemical analyzes showed that the treatments significantly affected the soluble solids content, the pH, the total titratable acidity and the ratio by the F test at 1% probability. Table 3 shows the mean values found for each attribute of the chemical analysis submitted to Tukey's test at 5% probability.

Table 3. Mean values for total soluble solids (TSS), pH, total titratable acidity (TT) and 'Ubá' mango ratio at different maturation stages.

	Analysis			
Stadium	SST (˚Brix)	pH	ATT (% cítric acid)	Ratio
Green (1)	8,57 d	3,64 d	0,23 a	37,55 c
Greenish (2)	12,05 c	3,89 c	0,13 b	89,63 c
Semi-ripe (3)	20,31 b	4,45 b	0,09 c	238,51 b
Mature (4)	21,63 a	4,58 a	0,07 c	307,62 a

Means followed by the same letter in the column do not differ statistically from each other, by the Tukey test at 5% probability.
Source: Authors.

According to the observed results, an increase in the total soluble solids content is noted as the ripening stage progresses. This increase occurred more moderately from stage 3 to stage 4, and more pronounced from stage 2 to 3, with significant variation between all stages of maturation. This increase may be related to the accumulation of reserve carbohydrates in the fruit during development in the plant, which with ripening undergo hydrolysis resulting in the formation of soluble sugars (Lizada, 2012). According to Normative Instruction No. 37 of October 18, 2018, the minimum accepted value of soluble solids is 11ºBrix at 20ºC (Brasil, 2018), and this value is reached from stage 2 of maturation.

Gonçalves et al. (1998) and Benevides et al. (2008) studying 'Ubá' mango fruits reported soluble solids content of 16.8 and 18 °Brix respectively, lower than those found in this work in stages 3 and 4. According to Kader (2002), the harvest of the fruits can be carried out when the they reach from 12 to 14 °Brix, already being considered as mature. Higher TSS values are important for fresh consumption, in view of the consumers' preference for sweeter fruits, being also important for the pulp and nectar industries, which increase the yield per fruit.

The pH, similarly to that observed for TSS, also increased with the advance of the maturation stages, ranging from 3.64 in stage 1 to 4.58 in stage 4 (Table 3), all of which are considered acidic. According to Normative Instruction No. 37 of October 18, 2018, the minimum acceptable value for mango juice is 3.5 (BRASIL, 2008), not specifying a maximum value. The General Technical Regulation for Setting Identity and Quality Standards for Fruit Pulp (BRASIL, 2000) establishes that mango pulps must have a pH between 3.3 and 4.5, which was observed for stages 1, 2 and 3. Gonçalves et al. (1998) and Faroni, Ramos and Stringheta (2009), studying the 'Ubá' mango variety, obtained values of 4.20 and 4.30 respectively, close to those found for stages 3 and 4 of this work.

The values of total titratable acidity varied according to the maturation stage (Table 3). This is linked to the state of preservation of the pulp, conferring flavor, odor, color and stability, in addition to being able to indicate food deterioration (Oliveira et al., 2018). A decrease in ATT is noted as the maturation stage progresses, from 0.23 in stage 1 to 0.07 in stage 4 (Table 3). Such results are lower compared to those reported by Benevides et al. (2008), who found values of 0.44 and 0.63 for the first harvest of 'Ubá' mangoes and 0.51 and 0.68 for the second harvest, and those defined by Normative Instruction No. 37 of October 18 of 2018, of 0.3. According to these authors, the processing industry in the Zona da Mata Mineira sets the ATT value between 0.40 and 0.80 to meet safety standards.

According to Kader (2002) after harvesting the fruits and during the storage period, the concentration of fatty acids decreases due to the increase in the breathing process or because they are transformed into sugar. Due to the scarcity of rain in the 2020/2021 season, the respiration process may have been anticipated due to the water stress suffered by the plants, justifying the low values for total titratable acidity.

Low pH and total titratable acidity values such as those observed in this work are desired by the industry, as they favor the industrialization process of the product as pulp, as they are outside the range that favors microbial growth.

With regard to ratio values, it is observed that despite the increase in mean values between stages 1 and 2, there was no significant difference between them, which did not occur between stages 3 and 4, which differed statistically. This increase during the evolution of the maturation stage is justified by the increase in the content of total soluble solids and by the low values of the total titratable acidity (Silva et al., 2019). Benevides et al. (2008) suggested that due to the absence of legislation with the minimum and maximum values for the ratio, its value can be obtained through the relation of the soluble solids content and the total titratable acidity stipulated by the legislation. Thus, considering the values established by Normative Instruction No. 37 of October 18, 2018 (Brasil, 2018), the ratio assumes a value of 36.67 and all stages of maturation fit the authors' suggestion (Table 3).

According to Chitarra and Chitarra (2005), the relationship between soluble solids and acidity indicates the physiological maturity stage of the fruits and their flavor, being, therefore, an important attribute for producers and for the industry.

4. Conclusions

The harvest of 'Ubá' mango can be carried out at the greenish stage, as it presents total soluble solids values of 12.05, pH of 3.89 and ratio of 89.63, complying with the norms present in current legislation, associated with color yellowishness of the pulp, defined by the increase of coordinate a* from 4.12 to 23.78, and coordinate b*, from 60.43 to 81.71, an important parameter for the commercialization of fruits.

For future studies, it is suggested to further evaluate the physicochemical properties between the green and greenish stages, considering that the mango is a climacteric fruit and continues to ripen after harvest.

Conflict of Interest and Ethical Standards

All authors declare no conflict of interest, and this article does not contain studies with human or animal participants performed by any of the authors.

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