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Physical and chemical characteristics and instrumental color parameters of passion fruit (*Passiflora edulis* Sims)

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The aim of this study was to evaluate the physical and chemical characteristics and variations of instrumental color parameters of passion fruit (*Passiflora edulis* Sims) at different maturation stages. Fruits were harvested directly from passion fruit plants, selected according to maturation stage and distributed into three distinct groups: Fruits with 1/3 yellow peel (stage 1); fruits with 2/3 yellow peel (stage 2) and yellow fruits (stage 3). Physical characteristics (length, equatorial diameter, length / equatorial diameter ratio, volume, weight and peel thickness), aryl, peel, pulp and seed yield, maturation index and physicochemical characteristics (pH, total soluble solids (TSS), titratable acidity and vitamin C) were evaluated. Instrumental color parameters (L *, a *, b *, chroma and H °) of peel and pulp were evaluated for passion fruits at the three maturation stages. The results were analyzed using a completely randomized design. Passion fruits showed high peel yield. Parameters pH, titratable acidity and TSS of passion fruit pulp were consistent with minimum values established by Brazilian legislation. Peel and pulp lightness were inversely proportional and pulp decreased lightness with increasing maturation stages. Color parameters could be used to assess color changes during maturation of passion fruit with more suitable results for maturation stages 2 and 3.

Key words: Passiflo*raceae*, chroma, maturation stage, yield.

INTRODUCTION

The passion fruit (*Passiflora edulis* Sims) are produced in all Brazilian states, the Northeast's largest producer, followed by the Southeast, North and South of the country, such production extends worldwide (Silva et al., 2005). Thus, the passion fruit has significant social and economic importance in Brazil. It is a versatile fruit that can be marketed in different forms, such as raw fruits, frozen pulps, juices, jams, yogurts, milk drinks and ice cream.

The exotic and distinct aroma of passion fruit is a

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Figure 1. Passion fruits (*Passiflora edulis* Sims) at different maturation stages (Stages 1, 2 and 3).

determining factor for the marketing of it. This fruit present with rounded shape, diameter between 4 and 6 cm and external appearance of green color. The interior of the fruit is characterized by the presence of seeds surrounded by yellow squash with gelatinous consistency bittersweet taste and intense flavor (Jiménez et al., 2011; López -Vargas et al., 2003).

The visual characteristics of passion fruits are extremely important for marketing (Abreu et al., 2009). Fruits of commercial quality are those that meet expectations of different customer segments, both in external (brightness and firmness) and internal characteristics (flavor, soluble solids and acidity), and for industrialization, juice yield (Cavichioli et al., 2011).

Silva et al. (2005) reported that there is little information on growth, development, fruit ripening passion causing delay in the shelf life of this product. Criteria to assess the harvest of the fruit were evaluated by Marchi et al. (2000) providing better quality industrial products to the passion fruit base.

The knowledge of the physical characteristics of passion fruits at different maturation stages assists in defining the harvest point without the use of destructive methods and contributes for the performance of selection criteria in the field. Thus, management and crop productivity are improved (Alves et al., 2012).

On the above, the aim of this study was to evaluate the physical and chemical characteristics and variations of instrumental color parameters of passion fruit (*Passiflora edulis* Sims) at different maturation stages.

MATERIALS AND METHODS

Passion fruits were obtained from a farm located in the municipality of Santa Helena de Goiás, GO, Brazil, with 525 m of altitude (17° 37' 58" S and 50° 33' 20" W) in months from April to June 2013. Fruits were classified as *P. edulis* Sims because it is a mixed culture with predominantly yellow cultivar. The municipality of Santa Helena de Goiás has climate that fits into Aw of Köppen. With gently rolling topography and prevailing cerrado vegetation. The soil has eroded and is rated Oxisoil clayey.

The crop had drip irrigation, with seedling renewal of two years, four rows of 200 m in length, 1.80 m in height and spacing of 2.50 m between rows. Flowering pollination was manually performed every day in the afternoon.

Harvest was done with passion fruits fallen to the ground or still on the branches of plants, pulling away easily from the stalk, without injuries or wrinkled bark. Then, passion fruits were sent to the Laboratório de Frutas e Hortaliças, Setor de Engenharia de Alimentos, Instituto Federal de Educação, Ciência e Tecnologia de Goiás, Rio Verde Campus, GO, Brazil, for experiments.

Fruits were selected according to maturation stage and distributed into three distinct groups: Fruits with 1/3 yellow peel (stage 1, n = 31); fruits with 2/3 yellow peel (stage 2, n = 30) and yellow fruits (stage 3, n = 30) (Figure 1).

To assess the physical measurements of passion fruits, dirt was removed from fruits with paper towels. Length (mm) and equatorial diameter (mm) was measured using digital caliper. The length /diameter equatorial ratio was determined by dividing the length by the diameter. Volume was determined by immersing the fruit in graduated polypropylene jar with distilled water, recording the volume (ml) of liquid displaced.

Fruit weight was determined by weighing on analytical scale with accuracy of three decimal places, and the results were expressed in grams (g). Subsequently, passion fruits were sanitized with chlorine solution at 100 ppm / 10 min and dried at room temperature. Fruits were aseptically cut in half (Figure 2), separating peels, aryls with seeds and pulp. Pulps with seeds were submitted to pulping using industrial fruit depulper. Then, aryl, peel, pulp and seed weight was determined, with results expressed in grams (g) to determine the yield of these variables in relation to the weight of passion fruits, whose results were expressed in percentage (%). To estimate the aryl, peel, pulp and seed yield, peel thickness (mm) was measured using a digital caliper.

Parameters pH, total soluble solids (° Brix), total titratable acidity (%) and Vitamin C (mg ascorbic acid.100g^{-1}) according to AOAC (2005) were evaluated. Maturation index was obtained by dividing total soluble solids by total titratable acidity.

To evaluate the peel color of passion fruits at maturation Stages 1, 2 and 3, fruits were divided into two hemispheres towards the equatorial diameter and each hemisphere was divided into four quadrants (Figure 3) for the evaluation of three distinct points per quadrant, totaling 24 measurements per fruit.

Passion fruit pulps corresponding to the different maturation stages, after pulping, were stored in polyethylene bags for color assessment with measurement at 12 different points.

Passion fruit peel and pulp color was determined with a colorimeter (ColorQuest II, Hunter Lab Reston , Canada). The

Figure 2. Passion fruits at different maturation (Stages 1, 2 and 3).

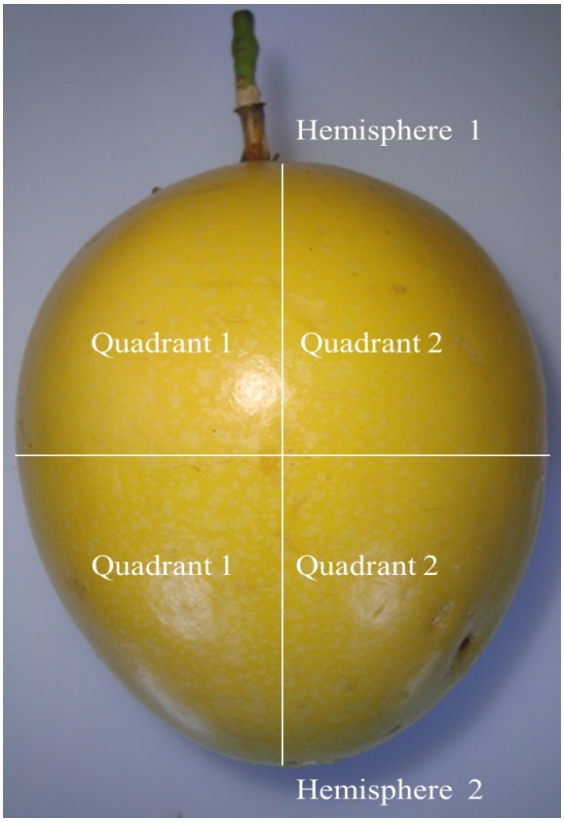

Figure 3. Schematic representation of the division of passion fruit for assessing peel color.

results were expressed in L*, a* and b*, with L* values (lightness or brightness) ranging from black (0) to white (100), chroma a* values from green (-60) to red (+ 60), and chroma b* from blue (-60) to yellow (60), as reported by Paucar-Menacho et al. (2008). Chroma was calculated using Formula 1, and the Hue Angle (° H) was calculated using Formula 2.

$$C = \sqrt{a^2 + b^2} \quad (1)$$

$$H^\circ = \tan^{-1}\left(\frac{b}{a}\right) \quad (2)$$

Statistical evaluation of physical, chemical and color parameters was performed using the SISVAR software (Ferreira, 2011) in a completely randomized design. Means were compared by Tukey test at 5% probability.

RESULTS

According to Table 1, it was possible to verify that there is no influence of the maturation stages ($p > 0.05$) on length, equatorial diameter, length / equatorial diameter ratio, volume, weight, aryl, peel, pulp and seed yield, thickness, pH, total soluble solids and vitamin C. The results showed that passion fruits can be harvested at different maturation stages without affecting such physical characteristics.

The lengths of passion fruits with 1/3 yellow peel, 2/3 yellow peel and yellow peel were 82.65 mm, 88.13 mm and 88.04 mm, respectively. Cavichioli et al. (2011) observed passion fruits averaging 101.0 mm in length, higher than values determined for the different maturation stages of passion fruits in this work. However, the length of passion fruits resulted in average value similar to that analyzed by Alves et al. (2012), with average of 85.35 mm.

The equatorial diameter of passion fruits was 78.37, 79.19 and 79.15 mm for fruits at maturation stages of 1/3 yellow peel, 2/3 yellow peel, and yellow peel, respectively. Cavichioli et al. (2011) analyzed passion fruit with diameter of 79.5 mm, similar to value found in this work. Dissimilarly, Araújo et al. (2008) obtained values lower than those found for fruits analyzed in this study, 76.64 mm.

Although no significant differences ($p > 0.05$) were observed for the length / equatorial diameter ratio, the results demonstrated that passion fruits with 2/3 yellow peel showed larger size, followed by 1/3 yellow peel and

Table 1. Mean length (L), equatorial diameter (ED), length / equatorial diameter ratio (L. ED^{-1}), volume, weight, aryl, peel, pulp and seed yield, peel thickness, pH, total soluble solids (TSS), titratable acidity (TA), maturation index (MI) and vitamin C values passion fruits (*Passiflora edulis* Sims) at three maturation stages.

Parameter	Peel color			VC (%)
	1/3 yellow (n = 31)	2/3 yellow (n = 30)	Yellow (n = 30)	
Length (mm)	82.65[a]	88.13[a]	88.04[a]	13.07
ED	78.37[a]	79.19[a]	79.15[a]	11.19
L. ED^{-1}	1.06[a]	1.12[a]	1.11[a]	10.35
Volume (ml)	300.58[a]	330.37[a]	328.37[a]	30.99
Weight (g)	182.38[a]	191.00[a]	195.39[a]	32.71
Aryl yield (%)	5.26[a]	4.73[a]	4.56[a]	34.69
Peel yield (%)	43.25[a]	45.62[a]	42.63[a]	19.75
Pulp yield (%)	33.97[a]	33.86[a]	37.05[a]	18.89
Seed yield (%)	17.51[a]	15.78[a]	15.75[a]	26.61
Peel thickness (mm)	5.88[a]	5.84[a]	5.66[a]	23.13
pH	2.65[a]	2.72[a]	2.67[a]	5.38
TSS (°Brix)	14.77[a]	14.81[a]	15.02[a]	13.23
ATT (%)	0.81[a]	0.67[b]	0.63[b]	27.33
MI	19.72[b]	22.36[ab]	24.69[a]	22.43
Vitamin C (mg ascorbic acid.100 g^{-1})	25.98[a]	24.22[a]	26.55[a]	27.70

Different lowercase letters in line differ significantly by the Tukey test at 5% probability.

yellow fruits. This fact was confirmed with passion fruit volumes, which obtained the same sequence of results, fruits with 2/3 yellow peel with higher volume and fruits with 1/3 yellow peel and yellow fruits with lower volume.

Passion fruits evaluated in this study showed lower weight (182.38, 191.00 and 195.39 g, at maturation stages 1, 2 and 3, respectively). Cavichioli et al. (2011), reported a mean weight of 218.44 g. Values close to those found in this study were observed by Alves et al. (2012), with mean weight of 194.83 g for ripe passion fruits.

The aryl yield of passion fruits was 5.26, 4.73 and 4.56% at maturation stages 1, 2 and 3. A different result was obtained by Oliveira et al. (2011), who observed that the aryl development occurs concomitantly with the fruit development, and ripe fruits had an average of 9.39% aryl yield, whereas for fruits at intermediate maturation stage, aryl yield was 8.30%.

Passion fruit peel showed yield of 43.25, 45.62 and 42.63% for 1/3 yellow peel, 2/3 yellow peel and yellow fruits, respectively. These values were lower than those found by Coelho et al. (2011) (53.00%) and Reolon et al. (2009), with average of 69.40, 73.70 and 63.30% for green, yellow-green and yellow fruits. However, aimed at the highest peel yield (52.07%), results corroborate those by Ferreira et al. (2010), who reported that peel thickness is a relevant factor for fruit classification, being inversely proportional to juice yield.

The pulp yield was lower than that observed by Farias et al. (2007), with average of 44.43%. Values similar to those of this study were reported by Silva et al. (2008), with average values of 31.44 to 41.28% of pulp yield. Santos et al. (2009) reported that the quantification of juice mass per seed had the disadvantage of adhering juice in the sieve used in the extraction, causing measurement errors. The lower pulp yield observed in this study may be related to the maturation stage of fruits, because harvest was performed with fruits at different maturation stages, which can be observed by the high proportion of passion fruit peel.

In this study, seed yield was higher than that observed by Oliveira et al. (2011), who found that the proportion of total residue was higher in ripe fruits with smaller size and seed yield was lower for larger fruits, but did not vary with shape, with average of 4.23% of seeds. Coelho et al. (2011) found that the amount of seeds with aryls was not influenced by fruit size, and fruits with averages of 251.54 and 123.26 g, resulted in 11.5% yield of this residue.

Passion fruit peel thickness was 5.88 mm for fruits with 1/3 yellow peel, 5.84 mm for fruits with 2/3 yellow peel and 5.66 mm for yellow fruits. Values lower than those found in this work were observed by Santos et al. (2009), with average peel thickness between 3.24 and 3.54 mm. However, Freire et al. (2010) and Cavalcante et al. (2007) evaluated average peel thickness values of 7.11 and 6.0 to 7.0 mm, respectively, which were higher than those found in this study.

The pH of the passion fruit was 2.65, 2.72 and 2.67 for fruits with 1/3 yellow peel, 2/3 yellow peel and yellow fruits, respectively. Medeiros et al. (2009) reported values higher than those found in this study, between 3.11 and 3.17, as well as Uchoa et al. (2008) 4.17. However,

Table 2. Mean L, a *, b *, Chroma, and Hue Angle (H °) values of passion fruit peel(*Passifloraedulis* Sims) at three maturation stages.

Parameters	Peel color			VC (%)
	1/3 yellow peel (n = 240)	2/3 yellow peel (n = 240)	Yellow peel (n = 240)	
L	49.64[c]	55.80[b]	65.09[a]	9.69
a*	-5.91[c]	-2.12[b]	0.83[a]	-136.33
b*	30.76[c]	44.67[a]	39.86[b]	18.70
Chroma (C*)	31.40[c]	44.91[a]	40.06[b]	18.17
H°	-1.37[c]	-0.64[b]	0.53[a]	-229.29

Different lowercase letters in the line differ significantly by the Tukey test at 5% probability.

Silva et al. (2005) found values similar to those of this study, ranging from 2.5 to 2.7.

The total soluble solids content was consistent with the results of Silva et al. (2005), who reported that during the maturation of passion fruits, there is an increased amount of TSS, with values ranging from 10.2°Brix to 16.8°Brix. However, in the mature stage, Uchoa et al. (2008) reported values of 20.56 °Brix for passion fruit pulp.

t was observed that titratable acidity was higher in green fruits, 0.81%, Silva et al. (2005) showed the values for titrable acidity of the 4.99 to 5.53 %; Pinheiro et al. (2006) found the range values 0.45-1.26 g.100g^{-1} citric acid; when compared to fruits with advanced maturation stage, 2/3 yellow, 0.67% and yellow,0.63%.

Passion fruit analyzed by Raimundo et al. (2009) and Cavichioli et al. (2011) showed much lower values for the TSS / TTA ratio, varying between 3.07 and 4.40 and 3.4, respectively. The difference in these values can be associated with the maturation stage of fruits and the mode of preparation of passion fruit pulp samples.

Passion fruits showed Vitamin C contents of 25.98 mg of ascorbic acid.100 g $^{-1}$ for fruits with 1/3 yellow peel, 24.22 mg of ascorbic acid.100 g $^{-1}$ for fruits with 2/3 yellow peel and 26.55 mg ascorbic acid.100 g $^{-1}$ for yellow fruits. Farias et al. (2007) found higher vitamin C values, 38 mg ascorbic acid.100g $^{-1}$ for. Uchoa et al. (2008) found values lower than those obtained in this work, 11.76 mg ascorbic acid.100 g $^{-1}$.

In the study by Farias et al. (2007), the average total soluble solids content was 11.02°Brix, titratable acidity of 5.28%,and vitamin C of 35.77 mg 100 g^{-1}, which is higher than the average value observed in this study.

The results of the physicochemical analyses are within Standards of Identity and Quality (SIQ) for passion fruit pulp with minimum acidity level of 2.5 g of citric acid /100 g, pH between 2.7 and 3.8 and minimum total soluble solids content of 11° Brix (Brasil, 2000).

Maturation stages of passion fruit peel significantly influenced ($p < 0.05$) the L*, a*, b*, Chroma and H ° results (Table 2). Lightness (L) was higher in fruits with yellow peel, followed by fruits with 2/3 and 1/3 of yellow peel. The average a* values indicated decreased green color with increasing maturation stage of passion fruits, which was expected; however, the highest intensity of yellow color (b*) was verified in fruits with 2/3 yellow peel, followed by yellow fruits and fruits with 1/3 yellow peel.

Coelho et al. (2011) found that lightness and parameter b* of passion fruit peel occur progressively and linearly with fruit maturation. The evolution of lightness was observed in this study; however, the development of parameter b* does not occur homogeneously and had lower values for yellow fruit compared to fruits with 2/3 yellow peel. According to Silva et al. (2008), the yellow color distribution on the entire fruit surface occurs irregularly from the base to the peduncle and defines the upper region near the peduncle to characterize the typical coloring of each maturation stage of the fruit, a fact that explains the difference in the values of variable b* reported in this work, which were presented as an average of several points of the fruit. Vianna- Silva et al. (2008) reported that greater sun exposure on the fruit top causes differences in parameters b* and a*.

The chroma values were higher than 31.40, which indicated that the amount of pigment in passion fruit peel is considerable. However, it was observed that yellow fruits showed lower chroma values than fruits with 2/3 yellow peel. This difference can be explained by the decomposition of pigments during maturation. In addition, color is completely saturated when the Hue Angle indicates no presence of white and black coloring (Barbosa, 2010).

According to CIELAB, the Hue angle (Mcguire, 1992) defines red color as 0°, yellow as 90° green as 180° as blue as 270°, and data confirmed that passion fruits had red-yellowish color according to the maturation stage.

Instrumental parameters pulp color of passion fruits are shown in Table 3. The L* values of passion fruit pulp decreased ($p < 0.05$) with increasing maturation stage of fruits, indicating greater lightness in fruits with 1/3 green peel. For the chromaticity coordinate a*, fruits with 1/3 yellow peel showed mean values similar to yellow fruits, and greater than fruits with 2/3 yellow peel. The yellow color intensity of pulps was higher in the intermediate maturation stage, when compared to other maturation stages.

Fruits with 2/3 yellow peel also showed more intense

Table 3. Mean L, a *, b *, Chroma, and Hue Angle (H °) values of passion fruit pulp (*Passiflora edulis* Sims) at the three maturation stages.

Parameters	Peel color			VC (%)
	1/3 yellow peel (n = 600)	2/3 yellow peel (n = 432)	Yellow peel (n = 584)	
L*	34.78[a]	33.88[b]	33.07[c]	10.43
a*	9.11[a]	8.42[b]	8.71[ab]	45.06
b*	19.93[b]	28.99[a]	19.24[b]	46.30
Chroma (C*)	22.35[b]	30.60[a]	21.52[b]	41.34
H°	1.11[b]	1.25[a]	1.07[c]	17.97

Different lowercase letters in the line differ significantly by the Tukey test at 5% probability.

pulp color, and for yellow fruits and fruits with 1/3 yellow peel, the results were similar (p> 0.05). Medeiros et al. (2009) also found predominance of yellow color for passion fruit pulp.

Chroma values of passion fruits were 22.35 for fruits with 1/3 yellow peel and 21.52 for yellow fruits, with significant difference (p <0.05) from fruits with 2/3 yellow peel, with an average of 30.60. Flores et al. (2011) observed chroma values between 13.67 and 27.85 for passion fruit pulp. Therefore, fruits with 2/3 yellow peel showed higher amounts of pigment than yellow fruits, which is due to the loss of pigment with fruit maturation.

The H ° results indicate greater average value for fruits with 2/3 yellow peel, followed by fruits with 2/3 yellow peel and yellow fruits and in general, the values obtained indicate pulp color ranging from yellow to red with greater H ° intensity for fruits at intermediate maturation stage.

DISCUSSION

Negreiros et al. (2007) found that the selection of fruits with larger equatorial diameter allowed obtaining heavier fruits with higher pulp yield. For Morgado et al. (2010), the selection of heavy passion fruits can be made directly in the field by measuring fruit length. However, Oliveira et al. (2011) reported that the juice yield increased with the maturation stage, but was not influenced by shape and size.

According to Reolon et al. (2009) the use of passion fruit peel as raw material with functional properties becomes relevant when fruits are harvested with green peel or starting yellowing without major damage to juice yield. The use of passion fruit peel in food products contributes to increase their fiber content since passion fruit peel is rich in soluble fiber, with large amounts of pectin, which is beneficial to the organism (Guertzenstein and Sabaa-Srur, 1999; Yapo and Koffi, 2006).

An alternative for food industries is the processing of passion fruit peel for use in food formulations, due to the high proportion of peel with high nutritional properties. Byproducts obtained from tropical fruits contain high levels of bioactive compounds (vitamins, minerals, polyphenolic antioxidants and dietary fiber), which may have positive health effects and contribute for the prevention of cardiovascular diseases, cancer and diabetes (Ayala-Zavala et al., 2011; Viuda-Martos et al., 2010). Passion fruit seeds are of pharmacological and nutritional interest because they are rich in polyunsaturated fatty acids such as ω-3 and ω-6 (Zeraik et al., 2010). Cavichioli et al. (2008) reported that passion fruits with thinner peel have greater amount of pulp, which is interesting for the food industry.

Chitarra and Chitarra (2005) reported that acidity decreases in fruits at final maturation stage and beginning of the senescence stage due to the use of organic acids in biochemical processes of respiration. The maturation index increased with increasing yellow color in the peel of passion fruits and showed significant differences among them (p <0.05). Based on results, passion fruits with 2/3 yellow peel are less acidic and have higher maturation stage.

Jiménez et al. (2011) reported that passion fruit undergo an increase in pH, soluble solids content and a decrease in titratable acidity during ripening. According to those authors, the increase in soluble solids content is a result of starch hydrolysis to sugars that relates to the Carbohydrates in fruit ripening. Since the acidity relates to the use of organic acids during respiration of the fruit (Jiménez et al., 2011).

However, even with fruit ripening passion fruit, Oliveira et al. (2014) state that this is a result which is characterized by high acidity. Also related to the acid content in fruits, Silva et al. (2005) state that the ratio of soluble solids content with the titratable acid content is interesting to analyze the maturation index and during ripening such content tends to increase as a result of the fall of acidity.

According to Azzolini et al. (2004) and Gongatti Neto et al. (1996), the maturation index can be analyzed by the TSS values of fruits, which indicates the presence of substances dissolved in the pulp, with prevalence of sugars. However, for Manfroi et al. (2004), the maturation index should be analyzed with caution, since decrease of acidity and increase of sugars do not always occur in equal proportions.

By combining the pulp color and titratable acidity results, passion fruits would be able to be harvested and consumed after reaching maturation stages 2 and 3, which according to Coelho et al. (2010) would be the optimal point to harvest passion fruits of the winter harvest when fruits present 30.7% of peel surface with yellowish coloration and juice quality parameters suitable for consumption in the fresh form, thus corroborating with the present study.

Conclusion

The results indicated that passion fruits presented high peel yield, regardless of maturation stage, but fruits with lower titratable acidity must be harvested at more advanced maturation stages, which would be more suitable for industrial processing. The pH, titratable acidity and total soluble solids of passion fruit pulp were consistent with the minimum values established by Brazilian legislation. Lightness of peel and pulp were inversely proportional, and with increased maturation stages, pulp decreased lightness. Color parameters can be used to evaluate peel and pulp color of passion fruits with more suitable results for maturation stages 2 and 3.

Conflict of Interest

The authors have not declared any conflict of interest.

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REFERENCES

Abreu SPM, Peixto JR, Junqueira NTV, Sousa MAF (2009). Physical-chemical characteristics of five genotypes of yellow passion fruit cultived in brasília. Rev. Bras. Frutic. 31(2):487-941. http://dx.doi.org/10.1590/S0100-29452009000200024

Alves RR, Salomão LCC, Siqueira DL, Cecon PR, Silva DFP (2012). Relations among physical and chemical characteristics of sweet passion fruit cultivated in Viçosa, MG. Rev. Bras. Frutic. 34(2):619-623. http://dx.doi.org/10.1590/S0100-29452012000200038

AOAC (2005). Official Methods of Analysis of AOAC International. 18th ed.

Araújo FPDE, Silva NDA, Queiroz MDE (2008). Genetic divergence among Passiflora cincinnata mast accessions based on morphoagronomic descriptors. Rev. Bras. Frutic. 30(3):723-730. http://dx.doi.org/10.1590/S0100-29452008000300027

Ayala-Zavala JF, Vega-Vega V, Rosas-Domínguez C, Palafox-Carlos H, Villa-Rodriguez JA, Siddiqui W (2011). Agro-industrial potential of exotic fruit by products as a source of food additives. Food Res. Int. 44(7):1866-1874. http://dx.doi.org/10.1016/j.foodres.2011.02.021

Azzolini M, Jacomino AP, Bron IU (2004).Indices to evaluate postharvest quality of guavas under different maturation stages. Pesq. Agrop. Bras. 39(2):139-145. http://dx.doi.org/10.1590/S0100-204X2004000200006

Barbosa SJ (2010). Qualidade de suco em pó de mistura de frutas obtido por spray drying. 107f. Dissertação (mestrado em produção vegetal) – Universidade de Montes Claros, Montes Carlos.

Brasil (2000). Ministério da agricultura do abastecimento. Instrução Normativa nº 01/00, de 07/01/00. Regulamento técnico geral para fixação dos padrões de identidade e qualidade para polpa de fruta. Diário Oficial da República Federativa do Brasil, Brasília, DF, Seção I:54-58.

Cavalcante LF, Santos GD, Oliveira FA, Cavalcante IHL, Gondim SC, Cavalcante MZB (2007). Growth and production of yellow passion fruit in a soil of low fertility treated with liquid biofertilizers. Rev. Bras. Cienc. Agr. 2(1):15-19.

Cavichioli JC, Corêa LDeS, Boliano AC, Santos PC (2011). Physical and chemical characteristics of yellow passion fruit grafted on three rootstocks. Rev. Bras. Frutic. 33(3):905-914. http://dx.doi.org/10.1590/S0100-29452011000300026

Cavichioli JC, Ruggiero C, Volpe CA (2008). Physical and chemical characteristics of yellow passion fruit submitted to the artificial lighting, irrigation and shade. Rev. Bras. Frutic. 30(3):649-656. http://dx.doi.org/10.1590/S0100-29452008000300015

Chitarra MIF, Chitarra AB (2005). Pós-colheita de frutos e hortaliças: fisiologia e manuseio. 2. ed. rev. e ampl. Lavras: UFLA.

Coelho AA, Cenci SA, Resende ED (2011). Yields and wastes of yellow passion fruit juice as a result of fruit size and different storage harvesting spots. Rev. Bras. Prod. Agroind. 13(1):55-63. http://www.deag.ufcg.edu.br/rbpa/rev131/Art1318.pdf

Farias JF, Silva LJB, Araújo Neto SE, Mendonça V (2007). Quality of yellow passion fruit marketed in Rio Branco, Acre. Rev. Caatinga 20(3):196-202. ISSN 0100-316X

Ferreira DF (2011). Sisvar: a computer statistical analysis system. Ciênc. Agrotec. 35(6):1039-1042.

Ferreira FM, Neves LG, Bruckner CH, Viana AP, Cruz CD, Barelli MAA (2010). Development of super-traits for selection of families of yellow passion fruit. Acta Sci. 2(32):247-254. http://dx.doi.org/10.4025/actasciagron.v32i2.3328

Flores PS, Silva DFPda, Bruckner CH, Oliveira SPde, Salomão LCC (2011). Physico-chemical characterization of fruits of passion fruit obtained from gamma irradiation. Cienc. Rural.41(11):1903-1906. http://dx.doi.org/10.1590/S0103-84782011001100009

Freire JLDEO, Cavalcante LF, Rebequi AM, Dias TJ, Nunes JC, Cavalcante IHL (2010). Qualitative attributes of yellow passion fruits produced with saline water, biofertilizer and mulching. Rev. Bras. Cienc. Agrar. 5(1):102-110. http://dx.doi.org/10.5039/agraria.v5i1a674

Gongatti Neto A, Ardito EFG, Garcia EEC, Bleinroth EW, Freire FCO, Menezes RE (1996). Acerola exportação: procedimento de colheita e pós-colheita: EMBRAPA – SPJ. p.(Série Publicação Técnica FRUPEX. 30:21.

Guertzenstein SMJ, Sabaa-Srur AUO (1999). Uso da casca de maracujá (Passiflora edulis f. flavicarpa, Deg) cv amarelo como fonte de fibra na alimentação de ratos (Rattus norvegicus) nomais e diabéticos. Anais do III Simpósio Latino Americano de Ciência de Alimentos. Campinas, Brasil. 116 pp.

Jiménez AM. Sierra CA, Rodríguez-Pulido FJ, González-Miret ML, Heredia FJ, Osorio C. (2011). Physicochemical characterisation of gulupa (Passiflora edulis Sims. fo edulis) fruit from Colombia during the ripening. Food Res. Intern. 44(7):1912–1918. http://dx.doi.org/10.1016/j.foodres.2010.11.007

López-Vargas JH, Fernández-Lopez J, Pérez-Álvarez JA, Viuda-Martos M (2013). Chemical, physico-chemical, technological, antibacterial and antioxidant properties of dietary fiber powder obtained from yellow passion fruit (Passiflora edulis var. flavicarpa) co-products. Food Res Internat. 51(2):756-763. http://dx.doi.org/10.1016/j.foodres.2013.01.055

Manfroi L, Miele A, Rizzon LA, Barradas CIN, Souza PVD (2004). Ripeng volutin fCabernt Facgrpes onducte inhlyre stm. Cienc. Agrotec. 28(2):306-313. http://dx.doi.org/10.1590/S1413-70542004000200009

Marchi R, Monteiro M, Benato EA, Silva CAR. (2000). Using skin color as quality of yellow passion fruit indicator (Passiflora edulis Sims. F. Flavicarpa.) for the industrialization. Ciênc. Tec. Alim. 20(3):381-387. http://dx.doi.org/10.1590/S0101-20612000000300017

McGuire RG (1992). Reporting of objective color measurements. Hort. Sci. 27(12):1254-1255.

Medeiros SAF, Yamanishi OK, Peixoto JR, Pires MC, Junqueira NTV, Ribeiro JGBL (2009). Physico-chemical characteristics of purple and acid-passion-fruit genotypes grown in Brasília. Rev. Bras. Frutic. 31(2):492-499. http://dx.doi.org/10.1590/S0100-29452009000200025

Morgado MAD, Santos CEMdos, Linhales H, Bruckner CH (2010). Phenotypic correlations in physicochemical characteristics of Passion fruits. Acta Agronômica. 59(4):457 461.

Negreiros JRda, Álvares VdeS, Bruckner CH, Morgado MAD, Cruz CD (2007). Relations among physical fruit traits and pulp content in yellow passion fruit. Rev. Bras. Frutic. 29(3):546-549. http://dx.doi.org/10.1590/S0100-29452007000300026

Oliveira EMSDE, Regis SA, Resende EDDE (2011).Characterization of yellow passion fruit pulp wastes. Cienc. Rural.41(4):725-730. http://dx.doi.org/10.1590/S0103-84782011005000031

Oliveira GA, Bureau S, Renard CMGC, Pereira-Netto ABE, Castilhos F (2014). Comparison of NIRS approach for prediction of internal quality traits in three fruit species. Food Chemi. 143(1):223–230. http://dx.doi.org/10.1016/j.foodchem.2013.07.122

Paucar-Menacho LM, Silva AHda, Barreto PAdeA, Mazal G, Fakhouri FM, Steel CJ, Collares-Queiroz FP (2008). Development of functional fresh food adding soy protein isolate and polidextrose using paprika as coloring agent. Cienc. Tec. Alim. 28(4):767-778. http://dx.doi.org/10.1590/S0101-20612008000400002

Pinheiro AM, Fernandes AG, Fai AEC, Prado GMdo, Sousa PHMde, Maia GA (2006). Chemical, physico-chemical and microbological evaluation of single strenght fruit juices: pineapple, cashew apple and passion. Ciênc. Tecnol. Aliment. 26(1):98-103. http://dx.doi.org/10.1590/S0101-20612006000100017

Raimundo K, Magri RS, Simionato EMRS, Sampaio AC (2009). Physical-chemical evaluation of the frozen passion fruit pulp traded in the Bauru region. Rev. Bras. Frutic. 31(2):539-543. http://dx.doi.org/10.1590/S0100-29452009000200031

Reolon CA, Braga GC, Salibre AB (2009). Características físico-químicas da casca do maracujá amarelo em diferentes estádios de maturação. Boletim do centro de pesquisa e processamento de alimentos (CEPPA). 27(2):305-312.

Santos CEMDOS, Bruckner CH, Cruz CD, Siqueira DLDE, Pimentel LD (2009). Passion fruit physical traits in function of the genotypes and fruit weight. Rev. Bras. Frutic. 31(4):1102-1119. http://dx.doi.org/10.1590/S0100-29452009000400025

Silva TV, Resende ED, Viana AP, Pereira SMF, Carlos LA, Vitorazi L (2008). Determination of the peel color scale and juice yield of yellow passion fruits in defferent harvest seasons. Rev. Bras. Frutic. 30(4):880-884. http://dx.doi.org/10.1590/S0100-29452008000400007

Silva TV, Resende EDde, Viana AP, Rosa RCC, Pereira SMdeF, Carlos LdeA, Vitorazi L (2005). Influence of the ripening stages on quality of the yellow passion fruit juice. Rev. Bras. Frutic. 27(3):472-475. http://dx.doi.org/10.1590/S0100-29452005000300031

Uchoa AMA, Costa JMCda, Maia GA, Silva EMCS, Carvalho AdeFFU, Meira TR (2008). Physicochemical parameters and crude and dietary fiber content of edible powders from tropical fruit residues. Segurança alimentar e nutricional. 15(2):58-65.

Viuda-Martos M, López-Marcos MC, Fernández-López J, Sendra E, López-Vargas JH, Pérez-Alvarez JA (2010). Role of fibre in cardiovascular diseases: a review. Compr. Rev. Food Sci. Food Safety. 9(2):240-258. http://dx.doi.org/10.1111/j.1541-4337.2009.00102.x

Yapo BD, Koffi KLK (2006). Yellow passion fruit rind a potential source of low-methoxyl pectin. J. Agric. Food Chem. 54(7):2738-2744.