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Postharvest longevity of Fremont IAC 543 mandarin

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Abstract: The planting of new types of table citrus is an interesting alternative for citrus growers in the state of Paraná, as this domestic market continues to grow and needs innovation. Thus, the aim of this study was to evaluate the acceptance and storage of a new hybrid for the region of Londrina / PR, Fremont IAC 543 mandarin (*Citrus clementina* hort. ex Tan x C. *reticulata* Blanco). Treatments were: storage of fruits with and without wax coating at room temperature [21 ± 2 °C and relative humidity (RH) = 60 ± 5%] for up to 36 days. Sensory (acceptance test and purchase intention) and physicochemical analyses [weight, juice yield, acidity, soluble solids and soluble solids/titratable acidity (ratio)] were performed before and after storage. Physicochemical data were submitted to analysis of variance and regression, while sensory analysis results were explored through descriptive statistics and principal components analysis using the R statistical software. It could be concluded that Fremont IAC 543 mandarin can be stored with wax coating and at room temperature without losing its quality characteristics for a period of up to 18 days.

Index terms: *Citrus* spp., Storage, Sensory analysis, Quality

Longevidade pós-colheita de tangerina Fremont IAC 543

Resumo: O plantio de novos tipos de citros de mesa é uma alternativa interessante para os citricultores do Estado do Paraná, pois esse mercado interno continua em crescimento e necessita de inovação. Assim, o objetivo deste trabalho foi avaliar a aceitação e o armazenamento de um novo híbrido para a região de Londrina-PR, a tangerina Fremont IAC 543 (*Citrus clementina* hort. ex Tan x *C. reticulata* Blanco). Os tratamentos foram: armazenamento dos frutos com e sem revestimento de cera em temperatura ambiente [21 ± 2 °C e umidade relativa (UR) = 60 ± 5%] por até 36 dias. Análises sensoriais (teste de aceitação e intenção de compra) e físico-químicas [peso, rendimento do suco, acidez, sólidos solúveis e sólidos solúveis/acidez titu-

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lável (relação)] foram realizadas antes e após o armazenamento. Os dados físico-químicos foram submetidos à análise de variância e de regressão, enquanto os resultados da análise sensorial foram explorados por meio de estatística descritiva e da análise de componentes principais utilizando o software estatístico R. Pôde-se concluir que a tangerina Fremont IAC 543 pode ser armazenada com revestimento de cera e em temperatura ambiente sem perder suas características de qualidade por um período de até 18 dias.

Termos para indexação: *Citrus* spp, armazenamento, análise sensorial, qualidade.

Introduction

Brazil occupies the seventh position in the ranking of world production of mandarins, and the state of São Paulo has the highest production, mainly of Ponkan mandarin (*Citrus reticulata* Blanco) and Murcott tangor [*C. reticulata* Blanco x *Citrus sinensis* (L.) Osbeck], which together correspond to 79% of the cultivated area in the state. The state of Paraná is the third largest Brazilian producer, whose production is basically composed of Ponkan mandarin, grown in the Vale do Ribeira region (FAO, 2021; IBGE, 2021).

The production of mandarins in citrus-growing regions has always been a good option for producers seeking to diversify the destination of their production; however, it is essential to evaluate new cultivars within the mandarin production chain, minimizing the vulnerability of extensive plantations of restricted cultivars, such as Ponkan and Rangpur mandarins and Murcott tangor, providing the sector with improved cultivars in terms of economic, phytosanitary and qualitative aspects (STUART et al., 2009; AZEVEDO et al., 2010; PACHECO et al., 2012) .

Within this diversity of cultivars belonging to the group of mandarins, the Fremont IAC 543 cultivar stands out, a hybrid resulting from the crossing between Clementina and Ponkan mandarins (*Citrus clementina* hort. ex Tan x *Citrus reticulata* Blanco), introduced in Brazil in 1991 through the 'Sylvio Moreira' APTA Citrus Center /IAC, from Florida/USA (PIO et al., 2006), whose characteristics range from resistance to the *Alternaria alternata* fungus, which causes the alternaria brown spot (ABS) disease, the main fungal disease that affects mandarins (PACHECO et al., 2012). The plant has reduced plant size (semi-dwarf); average weight of 103 grams; juice yield of approximately 45%; ratio of approximately 11.7; and option to extend the harvest period without losing its organoleptic and quality characteristics (PACHECO et al., 2019).

Aiming at better decision-making, mainly in the management of harvest and postharvest of mandarins, as well as in their market positioning, the physicochemical characterization of fruits, with or without wax coatings, together with sensory analysis are essential tools and need, in some way, to be accessible to producers (STONE; SIDEL, 2004; ROSSI; TORKOMIAN, 2015; PACHECO et al., 2017), so that they will be able to manage their orchard more assertively, since most producers do not have advanced postharvest storage techniques (cold storage).

Thus, there is still lack of in-depth studies on the effect of room temperature on the quality of citrus fruits, and more detailed studies in this aspect should be carried out, since specific data can be an analysis tool in decision-making by citrus growers, since this situation is experienced by many small and medium producers who do not have advanced technologies for postharvest mandarin conservation.

Concomitantly, the use of a wax coating (based on carnauba, cassava starch, beeswax, starch film, gelatin) comes to improve the postharvest fruit conservation, as in addition to improving the appearance of fruits, it acts in reducing weight loss (moisture); has antifungal action; decreases physiological peel disorders; and attenuates tissue collapse close to the petiole, providing a 30% to 50% reduction in the water loss rate of fruits under commercial conditions (PEREIRA et al., 2014; HASSAN et al., 2014, BARBARÁ et al. , 2020).

The aim of this work was to evaluate the postharvest longevity of the Fremont IAC 543 mandarin cultivar through the storage of fruits at room temperature, with and without wax coating.

Material and methods

Plant material and experimental design

Mandarin fruits of the Fremont IAC 543 variety grafted onto Rangpur lime IAC 863 (*C. limonia* Osbeck) were used, collected from an experiment installed in 2009, in a 6 m x 3 m spacing, at Sítio Lagoa Bonita, municipality of Mogi-Mirim, São Paulo State, Brazil,, at coordinates 22º 25’ S and 46o 57’ W and 617 meters a.s.l.. The climate is of Cfa type, humid subtropical climate with hot and muggy summer, according to the Koppen’s classification (SETZER, 1966). The soil at the study site is a Red Yellow Latosol (EMBRAPA, 2018).

The test was carried out at the Laboratory of Plant Sciences, Center for Agricultural Sciences, State University of Londrina, Parana State, Brazil, where Fremont IAC 543 mandarin fruits were sanitized with wool flannel and then received application of commercial wax (Aruá wax, BR 12 line), one milliliter per fruit, applied with the aid of a pipette (HTL pipette model comfort monocanal). Subsequently, fruits were exposed to temperature of 17 ± 2 °C and relative humidity (RH) of 50 ± 5%, for two days, for drying, thus reproducing the activities carried out in processing units (packing house).

Subsequently, fruits with and without wax coating were submitted to storage at room temperature [21 ± 2 ° C and relative humidity (RH) = 60 ± 5%], and evaluated in 13 moments, with interval of three days between evaluations, which were started after the coating of fruits treated with wax, thus totaling 38 days after fruit harvesting: T0 (0 DAH), T1 (3 DAH), T2 (6 DAH), T3 (9 DAH), T4 (12 DAH), T5 (15 DAH), T6 (18 DAH), T7 (21 DAH), T8 (24 DAH), T9 (27 DAH), T10 (30 DAH), T11 (33 DAH), T12 (36 DAH). The experiment was in randomized blocks, designed in split plots, with three replicates of each treatment and total of 10 fruits per replicate.

Assessments

Physicochemical analysis of fruit and juice

At time zero (T0, fruits without wax) and every three days, samples of fruits with and without wax coating were collected to quantify: a) weight loss, determined by the difference between initial weight and that obtained each day of analysis, expressed as percentage (%); b) longitudinal (Ǿ L) and cross-sectional (Ǿ T) diameters, in centimeters, by reading on a Starrett digital caliper, model 727; c) juice yield, determined after crushing fruits in juice processor (Walitta) and calculated using the juice weight /fruit weight ratio and expressed as percentage; d) acidity (g 100 g^{-1} in N% solution), obtained by titration with standardized 0.3125N NaOH solution, using phenolphthalein as indicator, and the acidity concentration expressed as percentage; e) soluble solids (ºBrix), determined by direct reading in refractometer (B&S model RFM 330); f) ratio, calculated using the soluble solids (SS)/titratable acidity (TA) ratio, which indicates the ripening stage of citrus fruits; g) fruit peel and pulp color determined by the instrumental method at four points of each sample, using digital colorimeter (Minolta CR-400), with determination of L* (luminosity), a* (color variation from green to red) and b* values (color variation from blue to yellow) (PAPADAKIS et al., 2000). Using the a* and b* values, the hue angle was calculated: $(ºh = \tan - 1(b*/a*))$ (i), which defines the color tone, and chroma: $\left(C^* = \sqrt{(a^*)^2 + (b^*)^2}\right)$ (ii), which defines the color intensity (MCGUIRE, 1992) and; h) vitamin C, vitamin C extraction was carried out using 5 mL of juice, to which 50 mL of 0.5 g.100 mL^{-1} oxalic acid were added. Titration of the amount of vitamin C (ascorbic acid) in samples was performed using the 2,6-diclobenzeneindophenol indicator (JACOBS, 1958; LEME Jr.; MALAVOLTA, 1950). All data were submitted to analysis of variance and regression.

Sensory analysis

Concomitant with physicochemical evaluations, fresh Fremont IAC 543 mandarin fruits, with and without wax coating stored at room temperature, were submitted to sensory analysis throughout the storage period, served at room temperature in disposable white and properly identified napkins. Such tests were performed by a group of 10 individuals, belonging to the Study Group on Tropical and Subtropical Fruit Growing (GEFRUTS), State University of Londrina, with different age groups and social classes.

Data were collected through individual forms, using a nine-point hedonic scale, ranging from “I extremely liked it” (9) to “I extremely disliked it” (1), used to evaluate samples in relation to overall impression, color, texture, aroma and flavor. The same form contained questions about what evaluators most liked or disliked in the sample, according to methodology used by Behrens et al. (1999). There was also a structured five-point scale for purchase intent, ranging from “I certainly would buy” (5) to “I certainly would not buy” (1). For this research, ethical approval was granted by the Human Research Ethics Committee of the Federal University of São Carlos (UFSCar), Protocol No. 2305.0.000135-11. All participants in this study signed the Informed Consent Form before participating in sensory analysis (Resolution 196/96 - National Health Council).

Data analysis

Results were explored using descriptive statistics and principal components analysis, which were processed using the R software (R CORE TEAM, 2022).

Results and discussion

Physicochemical quality of fruit and juice

Fremont IAC 543 mandarin fruits used in the analyses were within their optimal maturation point, in June, with adequate acidity (0.77), soluble solids (11.38 °Brix) and ratio (14.78) values, making them suitable for commercialization and consumption (Table 1), according to the table citrus classification standards (CEAGESP, 2011). As for color characteristics, according to Pathare et al. (2013), it was observed that the Fremont IAC 543 mandarin has intense orange color, evidenced by the Hue angle of 44 and by the proximity of coordinate a (32.09) and b (30.96) values, with high purity (chroma = 44.72) and color saturation (luminosity = 46.62). Thus, these fruits are pleasant to the consumer’s taste, as they present good balance between sweet and sour (FRATA, 2006); have potential for dual aptitude, as the ratio is close to the range considered ideal for industrial processing (11-14) and within the ideal range for fresh consumption (8-15), as reported by Sartori et al. (2002); and can be purchased by consumers of this citrus group, as their peel color is considered attractive by the consumer market (PIO et al. 2001; MAZZUZ, 1996). As for physical aspects, Fremont IAC 543 mandarin fruits (Table 1) differed from Ponkan mandarin fruits (PIO et al., 2005) in size, being physically smaller and lighter; however, they presented higher juice yield (44% versus 43% of Ponkan mandarin). Regarding the Clementina variety, Fremont IAC 543 mandarin showed very similar characteristics, such as early maturation at mid-season, intense orange peel color and fruit shape, ØL/ØT ratio close to one (SAUNT, 1990), which, according to Pio et a. (2001), expresses better acceptance by the consumer market.

Throughout the storage time, there was an increase in fruit weight loss (Figure 1A); however, weight loss was greater when fruits were stored at room temperature and without wax coating. On the 15th day of storage, the weight of fruits with wax coating was close to 110 g, while the weight of fruits without wax coating was close to 100 g. This occurs due to the water eliminated in the transpiration process caused by the difference in vapor pressure between the fruit and the air in the environment (SOUSA et al., 2000). Therefore, fruits that received carnauba wax coating were protected by this lipophilic substance which, due to its low polarity, attenuates the respiratory

Table 1 - Mean values and standard deviation of weight (W), longitudinal diameter (Θ L), cross-sectional diameter (Θ T), juice yield (JY), titratable acidity (TA), soluble solids (SS), ratio (R) and color (Hue, Luminosity - L, a, b, Chroma - C) of Fremont mandarin IAC 543 fruits (Laboratory of Plant Sciences, UEL, June 2018).

Variety	W (g)	Θ L (cm)	Θ T (cm)	JY (%)	TA (%)	SS (°Brix)	R	Hue (°)	L	a	b	C
Fremont IAC 543	113.07	5.38	5.95	44	0.77	11.38	14.78	44	46.62	32.09	30.96	44.72
Standard deviation	±3.5	±2.8	±1.9	±2.4	±0.06	±1.3	±2.06	±2.2	±3.7	±2.8	±3.1	±2.9

Average of 60 fruits harvested in June/2018, followed by their respective standard deviations.

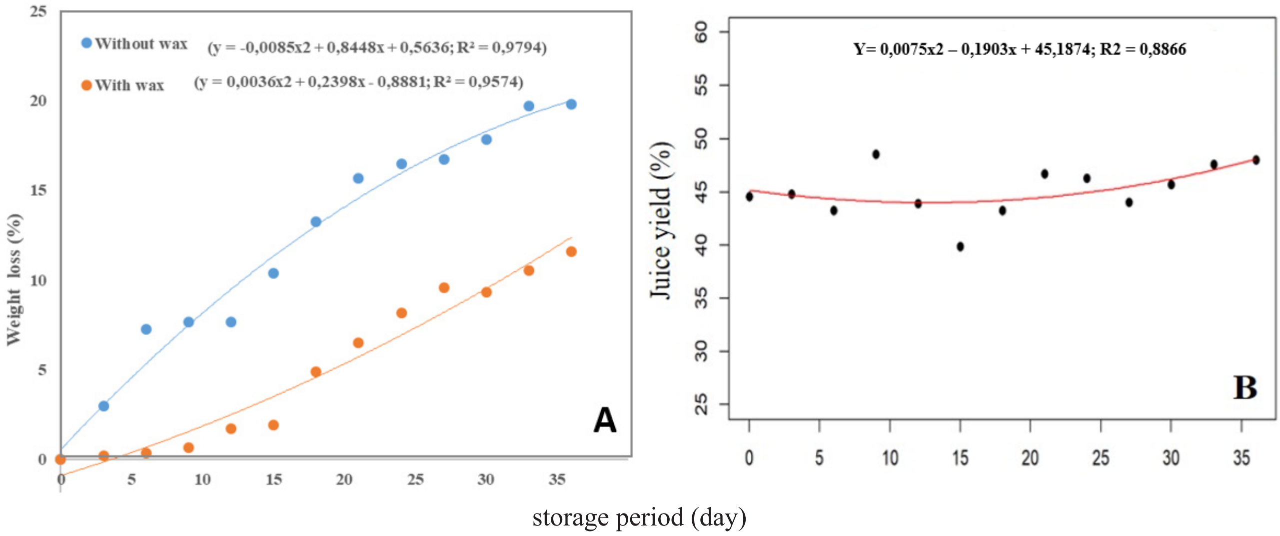

Figure 1 - Weight loss (A) and juice yield (B) of Fremont IAC 543 mandarin fruits, with and without wax coating, throughout the storage period, at room temperature.

exchanges of fruits, reducing their metabolic processes (PEREIRA et al., 2014; SILVA et al. 2009; BLUM et al. 2008).

The weight loss percentage of Fremont IAC 543 fruits stored at room temperature with wax coating was lower than the weight loss percentage of fruits without wax coating (Figure 1A). On the 15th day of storage, the weight loss rate of fruits with wax coating was approximately five times lower than that of fruits without wax coating; after this period, there was an increase in the weight loss rate of fruits treated with wax, but in smaller proportion when compared to the increase in the weight loss rate of fruits without wax coating. Losses of around 5% of fruit mass occurred between 3 and 6 days after harvesting, in the treatment without wax and at 18 and 21 DAH when the fruits were waxed, evidencing the importance of this post-harvest treatment. On the other hand, Fremont tangerine fruits are very firm and even at the end of storage, regardless of the treatment, the fruits did not deform, being suitable for commercialization. In other words, the increase in the weight loss rate of fruits treated with wax reached 11.6%, on the 36th day of storage, against 19.8% of fruits without wax coating. Malgarim et al. (2007) and Jomori et al. (2003) studied the effect of wax coatings on the conservation of Nules clementina and Tahiti acid lime, respectively, and also verified reduction in the weight loss of fruits coated with wax. Barbara et al. (2020) found greater firmness of fruits with wax coating when they remained for 18 days at 22 °C. For Pereira et al. (2014), the wax coating provides atmosphere modification, preventing moisture loss. Cantillano et al. (2011) evaluated the effect of carnauba wax coating on Ponkan mandarin and reported homogeneity in the fruit flavedo coverage, forming a physical barrier against water loss, in addition to preventing the penetration of pathogens via natural openings.

The juice yield values (%) fluctuated over the storage period, at room temperature, but tended to values between 43 and 47% (Figure 1 B), not differing from values of

44.8 and 44.6% found by Pacheco et al. (2017) and Pio et al. (2006), respectively. Malgarim et al. (2007) studied the storage of 'Navelina' oranges with wax coating and also observed increase in juice yield over the storage period. This result can be explained by the fact that the water loss in citrus fruits is mostly restricted to the epidermis, allowing low juice yield oscillation inside fruits during storage (ECHEVERRIA e ISMAIL, 1990), since the reduction in the peel weight occurs at faster rate than the reduction in the pulp weight, resulting in greater juice yield over time.

Regarding titratable acidity, interaction between time and coating was observed (Figure 2 A). Decrease in the acidity content was observed in fruits with and without wax coating until, approximately, the 18th day of storage. This behavior is due to the fact that organic acids, present in citrus fruits, are metabolized as respiration substrates (MARCILLA et al., 2009) and, after harvesting and throughout the storage period, the concentration of these acids tends to decline, not only as a consequence of the respiratory process, as previously mentioned, but also due to their use as carbon skeletons for the

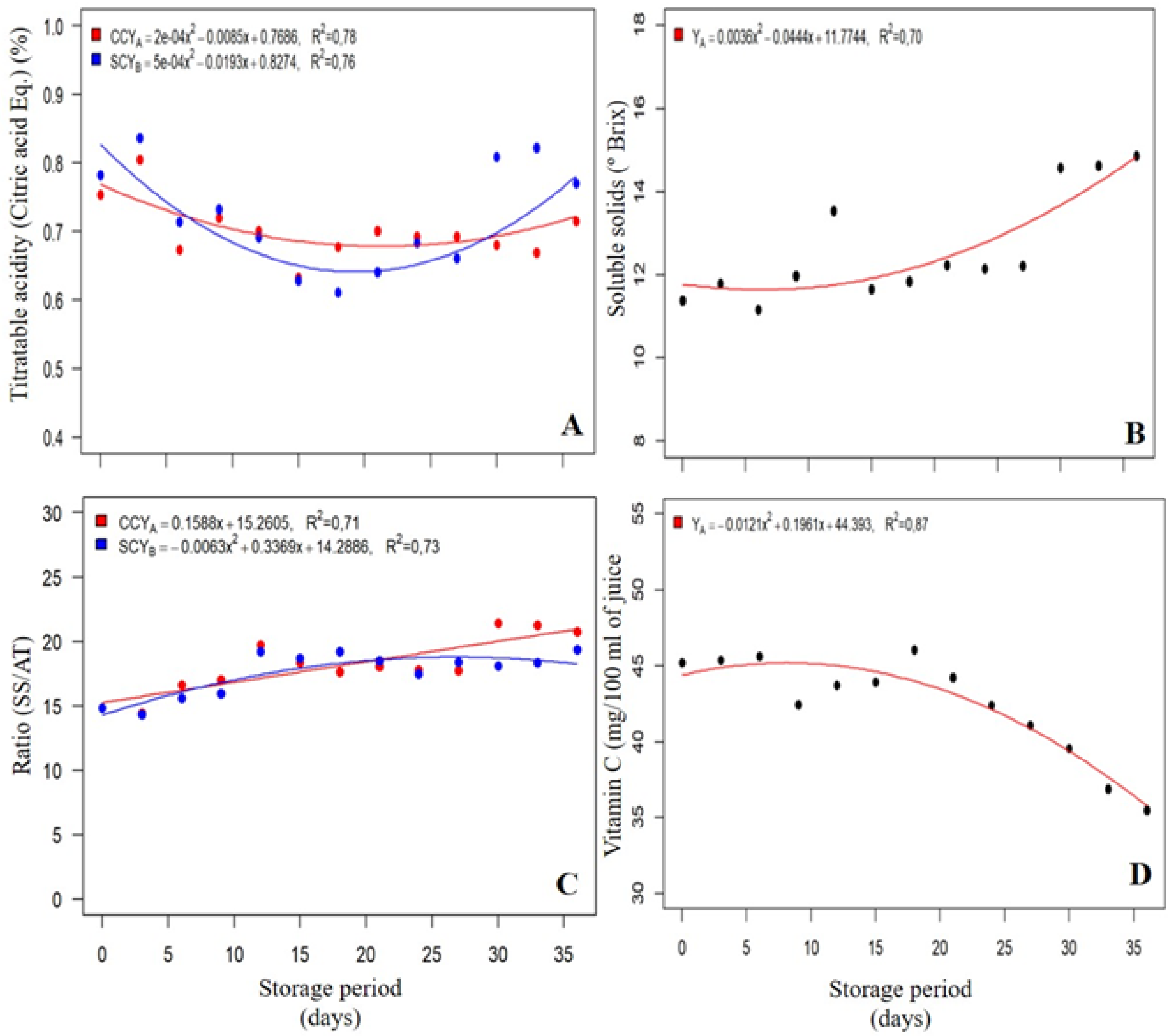

Figure 2 - Titratable acidity (A), Soluble solids (B), Ratio (C) and Vitamin C content of Fremont IAC 543 mandarin fruits, with and without wax coating throughout the storage period at room temperature. (W: With wax; WW: Without wax).

synthesis of new compounds (KAYS, 1991; OBENLAND et al., 2011).

From the 21st and 33rd days of storage, increase in titratable acidity was observed for fruits without and with wax coating, respectively. This increase is related to fruit senescence which, with CO_2 accumulation from respiratory processes, over time, tends to stimulate alternative metabolism pathways such as fermentation, contributing to increase acidity inside fruits, which occurs more quickly in uncoated fruits, since in these, the respiratory rate is more accentuated, as well as the concentration of organic acids due to the accentuated weight loss of such fruits (SANCHES et al., 2016; NELSON et al. , 2014).

The soluble solids content (°Brix) increased over the storage time, with significant increase from the 30th day onwards, reaching values above 14°Brix (Figure 2 B), with initial value of 11.4. The increase in the soluble solids content may be a consequence of their concentration due to the weight loss, resulting in fruit dehydration. Similar results were found by Marcilla et al. (2009) and Obenland et al. (2011), who observed, in their respective studies, increase in the concentration of soluble solids in Nules clementina and Murcott tangor, respectively. The increase in the SS content after fruit harvesting is a result of biological activities such as the conversion of organic acids into intermediate glycolytics and these into hexoses or the release of soluble sugars through starch hydrolysis (ECHEVERRIA; ISMAIL, 1990).

The SS/TA ratio significantly increased during the storage period of fruits at room temperature, and mandarins coated with wax reached the highest ratio on the 30th day of storage (21.43), while those without wax coating reached the highest ratios between the 18th (19.23) and 36th (19.37) days and, from the 21st day of storage, although with fluctuations, the SS/TA ratio stabilized (Figure 2 C). LIMA et al. (1999) also observed this behavior when studying the postharvest quality of Ponkan mandarin fruits when stored at room temperature. Therefore, such results are explained by the increase in the SS content throughout the storage period, which directly reflects the increase in the SS/TA ratio, responsible for the flavor of fruits.

The vitamin C content of fruits was not affected by the use or not of wax coating, but the influence of the storage period was detected, which led to a decrease in vitamin C contents over time (Figure 2 D). The initial vitamin C content was 45.23 $mg100g^{-1}$ of juice, in accordance with the Brazilian Table of Food Composition - TACO (2011), whose average vitamin C content for mandarin juice is 41.8 mg $100g^{-1}$ of juice. However, on the 36th day of storage, reduction of approximately 21.5% in the vitamin C content was observed, reaching value of 35.48 $mg100g^{-1}$ of juice, which are close to those reported by Ting e Attaway (1971), who found vitamin C content ranging from 20 to 50 $mg100g^{-1}$ of fresh mandarin juice. Vitamin C values remained stable until the 18th day of storage, after which there was a marked decrease in this value. Some studies also report reduction in Vitamin C contents in stored citrus fruits, in the case of Lima et al. (1999), who stored Ponkan mandarin; Kluge et al. (2007), who stored Valencia orange and Cantillano et al. (2009), who stored Salustian orange. The reduction in vitamin C content occurs due to the oxidation of ascorbic acid by a series of chemical and biochemical mechanisms, involving degradation enzymes (ascorbic acid oxidase, peroxidase, polyphenol oxidase and cytochrome oxidase) throughout fruit senescence (GARDNER et al., 2000; CHITARRA; CHITARRA 1998).

Regarding color parameters, for the luminosity factor (L), the peel of fruits showed different behavior between fruits with and without wax coating throughout the storage period at room temperature (Figure 3 A). In general, there was a decrease in L values throughout the storage period of fruits, indicating increase in black color, that is, peel darkening over time. Such darkening was more accentuated for fruits without wax coating, which already on the 6th day of storage, showed decrease in L values, unlike fruits with wax coating, whose factor remained relatively stable until the 27th day of storage. Enzymatic darkening is a metabolic process that contributes to the change in fruit color, mainly caused by the action of the enzyme polyphenol oxidase (PPO), in which fruit senescence accelerates the pace of this process (VILAS BOAS, 2002; PORTE; MAIA, 2001). Internally, the same fruit darkening tendency was observed, shown by the continuous decrease in L values over the storage period (Figure 3 B). The initial value of 46.48 dropped to 42.91 on the 36th day of storage, a 7.7% reduction. It is noteworthy that the internal darkening of fruits occurs during the oxidation of ascorbic acid, producing compounds with carbonyl radicals that react with the amino group and, by polymerization, produce dark pigments responsible for juice darkening, the so-called browning (MORAES, 2006; SHAW; MOSHONAS, 1991).

For color saturation, the chroma color factor (C), both in the peel and in the inner part of fruits, no interaction was observed between the use of wax coating and time; however, time influenced the behavior of the variable under study (Figure 3 C, D). The chro-

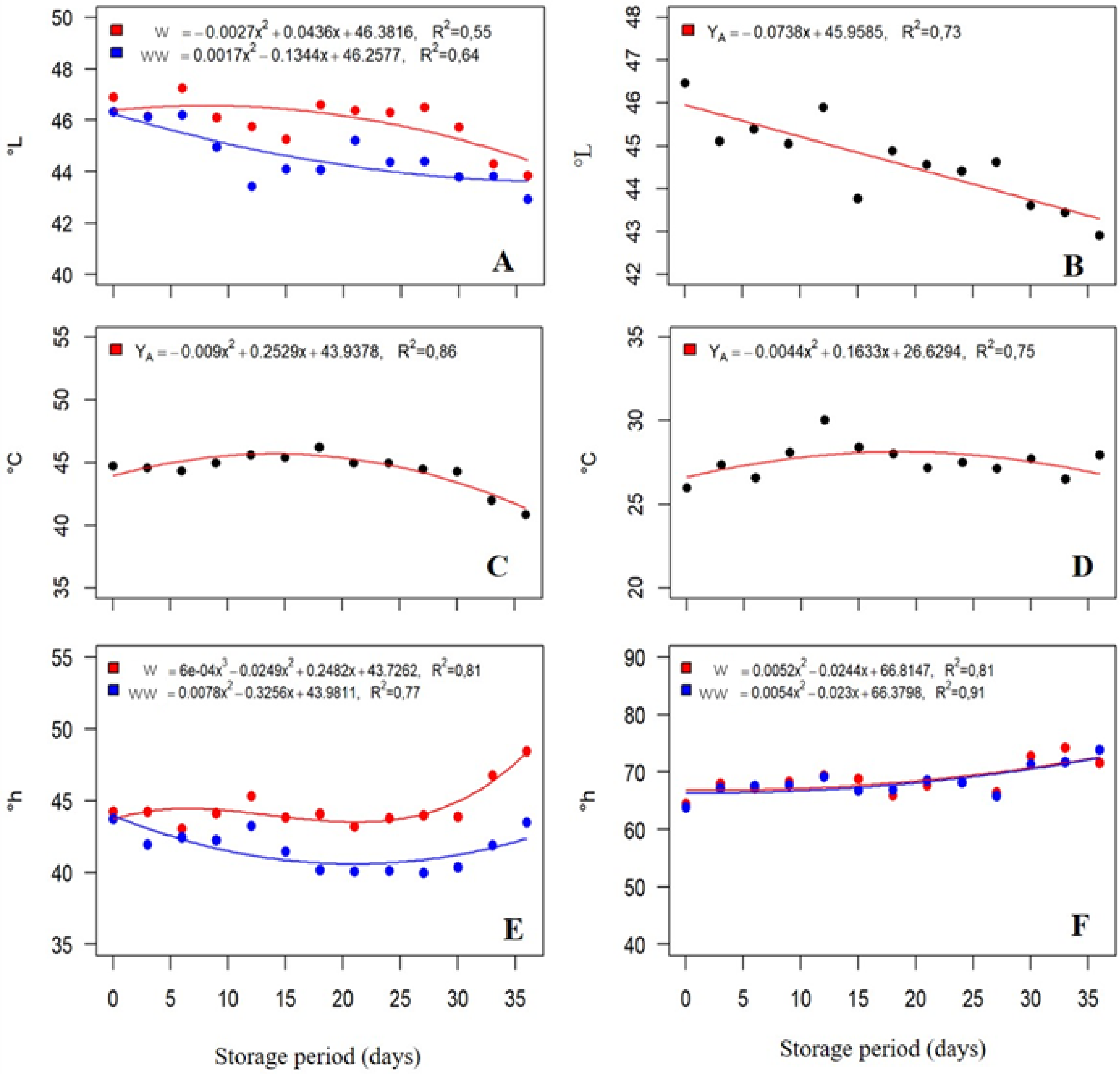

Figure 3 - Luminosity factor (L) of the peel (A) and inner part (B), chromaticity factor – C, of the peel (C) and inner part (C) and color angle (°h) of the peel (E) and inner part (F) of Fremont IAC 543 mandarin fruits throughout the storage period at room temperature. (W: With wax; WW: Without wax).

ma color factor of the fruit peel, from the 21st day of storage on, showed decrease in its values from 46.2° to 40.9° on the 36th day of storage, a result explained by the fact of exposure to oxidative agents is more pronounced in fruit peel, thus accelerating the degradation of these compounds (PINTO et al., 2007). Boonyakiat et al. (2012) studied the storage of Ponkan mandarin and found a change in the fruit peel color from green to yellow, and a decrease in chroma values, inferring that such changes occurred due to the oxidative degradation observed in fruits. Factor C for the inner part of fruits showed a trend to increase its values, which can be correlated with fruit dehydration, since there is concentration of pigments (lutein, zeaxanthin, β-cryptoxanthin and β-carotene) responsible for the characteristic yellow-orange pulp color (DUTRA et al., 2012; CANO et al., 2008). Salomão et al. (2014) in their studies on the physical characterization of fruits of 19 Fremont mandarin clones found results similar to those reported in the present work, whose values ranged from 24 to 35°. Such behaviors are justified by the reduction of factor L, as previously reported, since the increase in fruit darkening directly reflects on its saturation, resulting in decrease in color intensity.

Regarding the hue angle (h°), interaction effect was observed between time and the use or not of wax coating, both for the internal color, pulp, and for the external color, peel. For the peel hue, it was observed, that fruits not coated with wax had lower hue values than those coated with wax, a difference that increased over the storage period (Figure 3 E, F), reaching approximately 5 ° on the 36th day of storage, showing, therefore, that fruits without wax coating remained more reddish than fruits with wax coating. Small fluctuations were observed in the hue angle values (h°) of fruits without wax coating, showing a slight decrease, except for an increase from the 33rd day of storage, that is, slight intensification of the orange color of the peel of fruits without wax was observed, due to an increase in the proportion of red color in relation to the yellow color, a change related to the degradation of chlorophyll and revelation of carotenoids (JACOMINO et al., 2008; CHITARRA; CHITARRA, 2005).

For fruits coated with wax, increase in the hue angle was observed over the storage period, which was more accentuated from the 30th day, which provides an increase in the proportion of yellow color in these fruits, justified by the protection provided by the wax against the oxidation of carotenoids responsible for the peel color. The increase in the yellow color of fruits coated with wax and stored at room temperature may be related to the delay in the degradation of chlorophyll and/or synthesis of carotenoids (lutein) and flavonoids (AMARIZ et al., 2010). The internal color angle of fruits, although with interaction between time and use or not of wax, increased along the storage period, at room temperature, with similar values between fruits with and without wax coating, 64.5º and 63.8º at the beginning of the analysis and 71.7º and 73.9º at the 36th day of storage, respectively. This variation points to an increase in the yellow color during the storage period, justified by the concentration of pigments in the fruit pulp juice vesicles (MORAES et al., 2002).

Sensory analysis of fruits

Concomitantly, these fruits were sensorially evaluated during the storage period, thus carrying out the principal component analysis (PCA), in which the sensory characteristics of the sample were evidenced together, showing great agreement with results previously obtained (Figure 4). Through PCA, it was possible to rewrite the sample coordinates in a more convenient axis system for data analysis, that is, the original variables generated, through their linear combinations, the principal components, in which principal component 1 (PC1 = 60.0%) has more statistical information than principal component 2 (PC2 = 19.2%), reducing the dimensionality of the representative points of the sample, because, although the statistical information present in the original variables is the same as in the principal components, more than 70% of this information was obtained in only two of the first principal components (CRUZ; REGAZZI, 2001).

The appearance vector is the most influential attribute due to its greater length and alignment to the PC1 axis. However, there is little association of this aspect with the flavor vector, due to the different direction and variation, which allows inferring that the appearance of fruits is not directly related to the flavor attribute. The same can be observed with the aroma attribute, which is not directly related to appearance, but is associated with flavor, when the positioning of vectors is observed. In contrast, it was observed that the firmness attribute was more associated with appearance than with aroma and flavor.

This result is due to the grouping of wax-coated fruits in this region of the graph (Figure 4), which correlates with lower weight loss for wax-coated fruits, as previously reported, contributing to the stability of the good acceptance of these fruits in the firmness attribute, since the maintenance of the turgidity of fruits due to less dehydration contributes to this event. Surmacka-Szczesniak (2002), Brackmann et al. (2008) and Dantas et al. (2017) also associated appearance and firmness vectors, warning to the fact that the wax coating provides turgidity and shine to the peel of fruits, making them more attractive to consumers, while texture denotes freshness to the product, being a quality attribute that contributes to fruit purchase. By the close position of overall impression and purchase

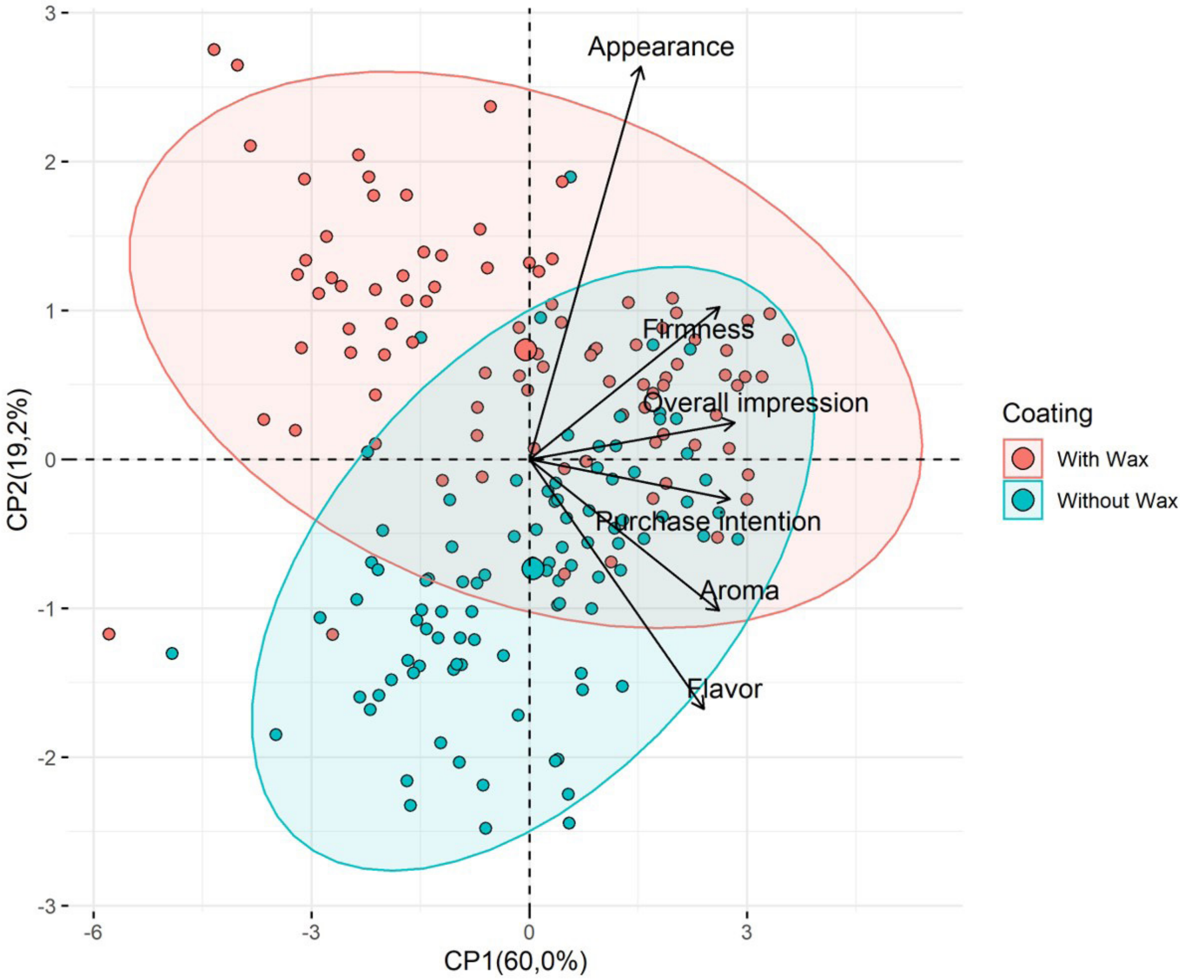

Figure 4 - Principal component analysis between factors (Fremont IAC 543 mandarin fruits with and without wax) and analyzed variables (appearance, firmness, overall impression, purchase intention, aroma and flavor).

intention vectors (Figure 4), it was verified that there is high correlation between them, allowing inferring that the overall impression has strong appeal when deciding whether or not to purchase fruits.

It was also observed that a few days of storage favor these attributes, but with the advancement of storage and given the previously reported physicochemical changes, the acceptance of fruits stored at room temperature by consumers tends to decrease from the 21st day onwards (Figure 5). The little association of wax-coated fruits with the flavor aspect can be attributed to the organoleptic changes caused by the use of the wax coating which, despite the positive effect during the storage of citrus fruits, depending on the concentration, can harm the odor and flavor characteristics (JOMORI et al., 2003). In their studies, Malgarim et al. (2007) found increase in the perception of off-flavor in Nules clementina fruits stored using different coatings, while Luvielmo and Lamas (2012), reported that high wax coating concentrations can be harmful to fruits by creating anaerobiosis conditions, inducing undesirable alterations in the flavor and odor attributes of such fruits, since they make them susceptible to oxidation. Finally, the initial storage period of fruits, until the 21st day, was the one that kept mandarins with satisfactory sensory characteristics according to evaluators, except for attribute appearance associated with fruit firmness, which presented, for fruits without wax coating, a drop in acceptance on the 9th day of storage, while for fruits with wax coating, such drop was only detected after the 24th day of storage.

Conclusion

Fremont IAC 543 mandarin can be stored, with wax coating and at room temperature, without losing its quality characteristics for a period of up to 18 days and for only 9 days without wax coating at room temperature.

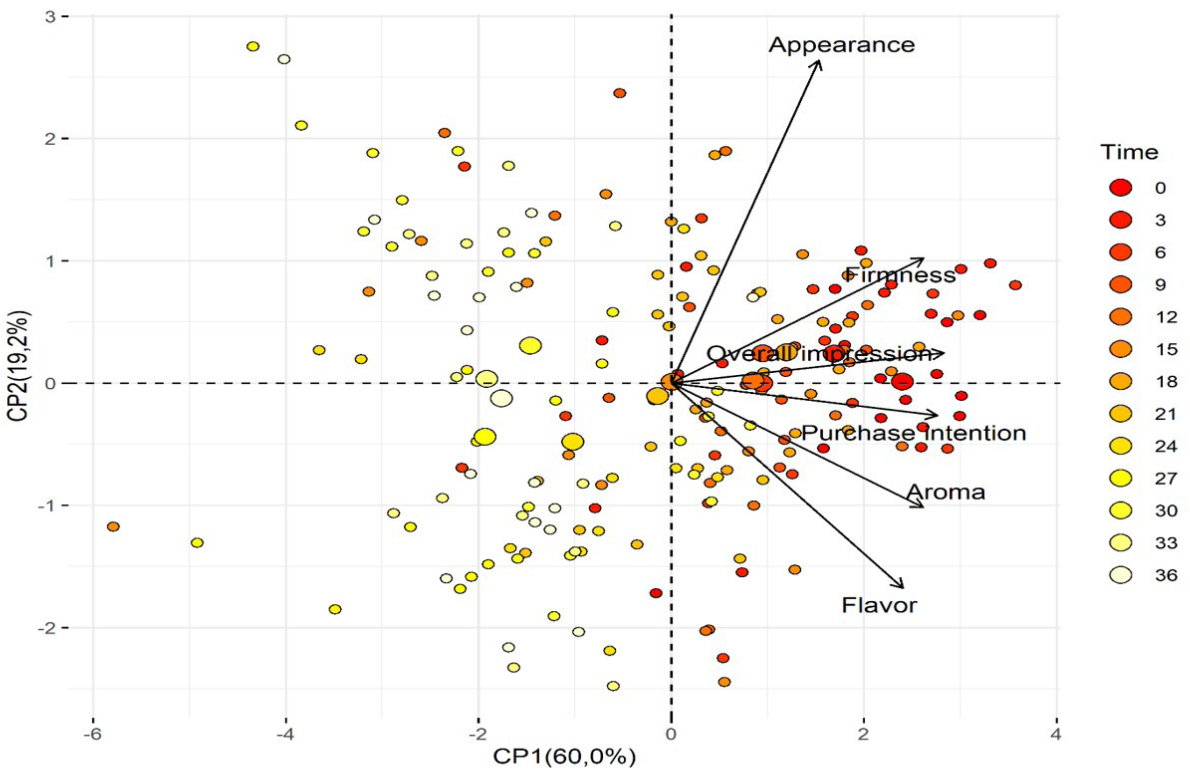

Figure 5 - Principal component analysis between factor (time) and analyzed variables (appearance, firmness, overall impression, purchase intention, aroma and flavor).

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