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RESEARCH ARTICLE

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POST-HARVEST EVALUATION OF 'DEKOPON' TANGERINS SUBMITTED TO DIFFERENT UV RADIATION TIME C AND REFRIGERATION TEMPERATURES

Luís Henrique Costa Vasconcelos[1*], Flávio Alves da Silva[2], André José de Campos[3], Ana Paula Silva Siqueira[4] and Rebeca Freitas Vasconcelos[5]

[1]Federal Institute of Brasília (IFB). Structural Campus. Brasília/DF, Brazil; [2]Federal University of Goiás (UFG). Campus Samambaia - School of Agronomy. Goiânia/Goiás, Brazil; [3]State University of Goiás (UEG). University Unit of Anápolis. Anápolis/Goiás, Brazil; [4]Federal Goiano Institute (IFGOIANO). Urutaí Campus. Urutaí/Goiás, Brazil; [5]Federal Institute of Tocantins (IFTO). Campus Palmas. Palmas/Tocantis, Brazil

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Corresponding author:
Luís Henrique Costa Vasconcelos

ABSTRACT

Citriculture has a strong economic impact on the Brazilian trade balance, and the study of the 'Dekopon' variety comes as a technological advance meeting the demands of the market. However, this fruit still needs techniques that aim to maintain its post-harvest qualities. Therefore, the objective of this research was to physically and chemically evaluate the 'Dekopon' mandarin fruits by analyzing the influence of the application of different times of type C Ultraviolet Radiation (UVC), associated with different storage temperatures. The fruits were harvested in a commercial orchard and the analyzes developed in laboratory research with the data submitted to analysis of variance ($P < 0.05$), and comparison of means by Scott-Knott at 5% probability. The experiment was carried out in a completely randomized design (DIC), with 3 repetitions in a 4x3x6 factorial scheme, with 4 times of 0, 3, 6 and 9 minutes of UVC radiation; 24, 12 and 6 ºC of refrigeration temperatures at 0, 6, 12, 18, 24 and 30 days of analysis, respectively. The following were evaluated: loss of mass, color, soluble solids, hydrogen potential, titratable acidity, maturation index, geometric characteristics, ascorbic acid, texture and fractions of the fruit. It was concluded that storage at 12ºC made it possible to maintain desirable post-harvest characteristics for a longer period, and the 3-minute radiation time promoted similar performance.

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INTRODUCTION

Tangerines are considered worldwide as the most preferred table fruits by consumers, this, due to their bittersweet flavor, nutritional value, coloring, refreshing qualities and also, because of the ease of being peeled (Silva *et al*., 2014). In the last few years, the post-harvest of fruits and vegetables has aroused great interest from producers and consumers, especially due to the high demand and increased production, and also, to serve the market with regular supply and the incentives offered to exports. This leads to the understanding of the biological factors involved in fruit conservation, in addition to the application or creation of techniques capable of delaying senescence, making the quality of these fruits the main factor (Santos, 2011; Simas *et al*., 2015).

For this purpose, the main technology used for postharvest conservation of fresh citrus fruits is still refrigeration, that is, reducing the temperature, will act to reduce the metabolism of the fruit, and consequently, the shelf life of the vegetables will be prolonged. This preservation process is highly efficient in maintaining the quality of the fruit for a much longer period of time, however, there are precautions for use, such as observing the fruit's resistance to cold storage, noting its tolerance. On average, one third of fresh food is discarded due to inadequate conservation conditions (Tingman *et al*., 2010; Spagnol *et al*., 2018). Another method of great impact is ultraviolet radiation, used in food preservation, being considered a physical treatment method that has an advantage when applied to food. Ultraviolet irradiation (UVC) is used to control deterioration resulting in the disinfection of the fruit surface, stabilizing the rate of microbial growth and delaying the softening and senescence of the fruit (Khademi *et al*., 2013). In this context, the aim of this research was to evaluate the postharvest characteristics of 'Dekopon' mandarin submitted to different times of ultraviolet C radiation and different refrigeration temperatures.

MATERIAL AND METHODS

Origin, harvest and preparation of fruits

The experiment was carried out from May to August 2018, in a commercial orchard in the municipality of Anápolis-GO, located at 16 ° 22'04.0 "S latitude and 48 ° 54'39.7" O longitude (-16.367782, -48.911038). The area of the orchard where the fruits were collected contained approximately 300 trees, homogeneous in size and age (7 years), from which they were selected entirely at random to harvest the fruits suitable for commercialization, respecting the pattern of characteristics of the fruits, in attributes such as color, size, shape, height in relation to the plant, pruning of the plants, thinning of fruits, sanitary emptiness and application of fungicide. The fruits were harvested in the morning, following the harvesting procedures commonly used by the producer, bagging the fruits in Rafia waist bags, depositing the fruits in stoks or PVC boxes, followed by transport in a covered cart to the laboratory for the assembly of experiments, storage and analysis, where they did not undergo any type of sanitization, only superficial cleaning to remove coarse dirt coming from the field, such as foliage, fragments of branches and other coarse particles from the agricultural unit.

The experiments and physical-chemical analyzes were carried out in the Post-harvest Drying and Storage laboratory at the State University of Goiás - UEG, Campus of Exact and Technological Sciences - CCET, in the city of Anápolis - Goiás. Then, the fruits were evaluated for mass, longitudinal and transversal diameter, skin thickness, color, firmness, pH, titratable acidity, soluble solids, ascorbic acid content and fractions of the fruit.

Characterization of the experimente

A prototype of an ultraviolet C radiator (UVC - 254 ηm) was used, consisting of a cylindrical plastic polymer structure and a group of 6 germicidal lamps without a filter, 3 at the top and 3 at the bottom of the irradiator, with 30 watts each, connected in parallel, with the geometry structure 500x500x900mm and galvanized drawn screen, dividing the equipment in upper and lower part, as detailed by Vasconcelos (2015). The experiment was conducted in a completely randomized design (DIC), a double factorial scheme 12x6 (association between refrigeration temperatures and UVC radiation times x days of analysis), where the adopted temperatures were 24, 12 and 6ºC; UVC radiation times were 0, 3, 6 and 9 minutes; evaluated every 6 days (0, 6, 12, 18, 24 and 30 days); and 3 replicates with 2 fruits per plot, to evaluate post-harvest storage. In the laboratory, the fruits were placed inside the device, at a distance of 50 cm, and received irradiation on all faces. After radiation, the fruits were separated at different temperatures and refrigerated and stored in B.O.D. (Biochemical Oxigen Demand), with 85 ± 5% RH, for a period of 30 days. The treatments were divided according to Table 1.

Table 1. Experimental design, UVC radiation times and cold storage temperatures

Treatment	Radiation time (minutes)	Refrigeration (ºC)
T1	0	24
T2	3	24
T3	6	24
T4	9	24
T5	0	12
T6	3	12
T7	6	12
T8	9	12
T9	0	6
T10	3	6
T11	6	6
T12	9	6

Assessments: Post-harvest assessments were divided into 2 groups:

Control Group: physical analysis of fresh weight loss was performed. This group consisted of 3 repetitions, with 2 fruits each, for each treatment, which were numbered and kept intact. The sampling interval was every 6 days, over a period of 30 days. Destructive Group: In this group, analyzes of firmness (stress, strain, final load and surface tension), soluble solids (SS), titratable acidity (AT), maturation index (IM), coloring (L *, a *, b *, ºHue and Chroma), pH, transversal and longitudinal diameters, skin thickness (flavedo and albedo), ascorbic acid content and fractions of the fruit (percentages of juice, skin and bagasse). Three replicates were used, with 2 fruits each, per treatment, on each day of analysis, which were performed every 6 days, over a period of 30 days.

Weight loss: In determining the loss of fresh weight, the fruits were weighed every 6 days, on a precision scale - maximum load of 2000 g and division of 10 mg, Gehaka BG400, error = 0.01g, with 0.001 each unit, considering calculated weight loss. by the difference between the initial mass of the tangerine, contained in the packages, and that obtained in each time interval, the results being expressed in percentage. Calculating the mass loss from equation (1):

$$PM(\%) = \frac{M_i - M_j}{M_i} \, x \, 100 \quad (1)$$

On what:
PM = loss of mass (%);
Mi = initial mass of the fruit (g);
Mj = mass of the fruit in the period after Mi (g).

Firmness: Firmness was determined by using the CT3 texturometer (Brookfield), using a needle probe tip (2.0 mm), with a penetration distance of 20 mm and a penetration speed of 6.9 mm sec-1. The reading was performed on opposite sides of the equatorial section of the fruits, and at 3 random points, and the value obtained to determine firmness, in cN (centiNewton), was defined as the maximum mean force required for a part of the tip penetrate the fruit pulp. The deformation was determined by the tip displacement distance until the fruit peel ruptured, the value obtained being defined for deformation in mm (millimeters). The firmness of the pulp (final load) is the result of the final effort of the tip of the tip when it travels from contact with the shell to the 20 mm drop of the tip and determines the load (or tension) inside the pulp, measured in cN, and the surface tension was determined by the ratio between the stress and the strain, with the value in cN mm^{-1} being obtained.

Titratable acidity and pH: The pH determination was performed using a digital potentiometer (Tecnal, TEC 3P-MP). The device was calibrated with pH 4.0 and 7.0 buffer solution, then the pH was read directly with the electrode immersed in the beaker, containing the pulp juice, according to the methodology proposed by AOAC (2012). Titratable acidity was determined by titration with 0.1 $mol.L^{-1}$ sodium hydroxide solution (NaOH), using 1% phenolphthalein as an indicator, according to AOAC (2012).

Soluble solids and maturation index: The content of soluble solids was determined by reading the samples directly at 20 ° C, in a portable digital refractometer (Reichert, AR 200), according to the method proposed by AOAC (2012), and the results were expressed in ºBrix. The maturation index (IM) was determined by the ratio between soluble solids (SS) and titratable acidity (AT) (IAL, 2008).

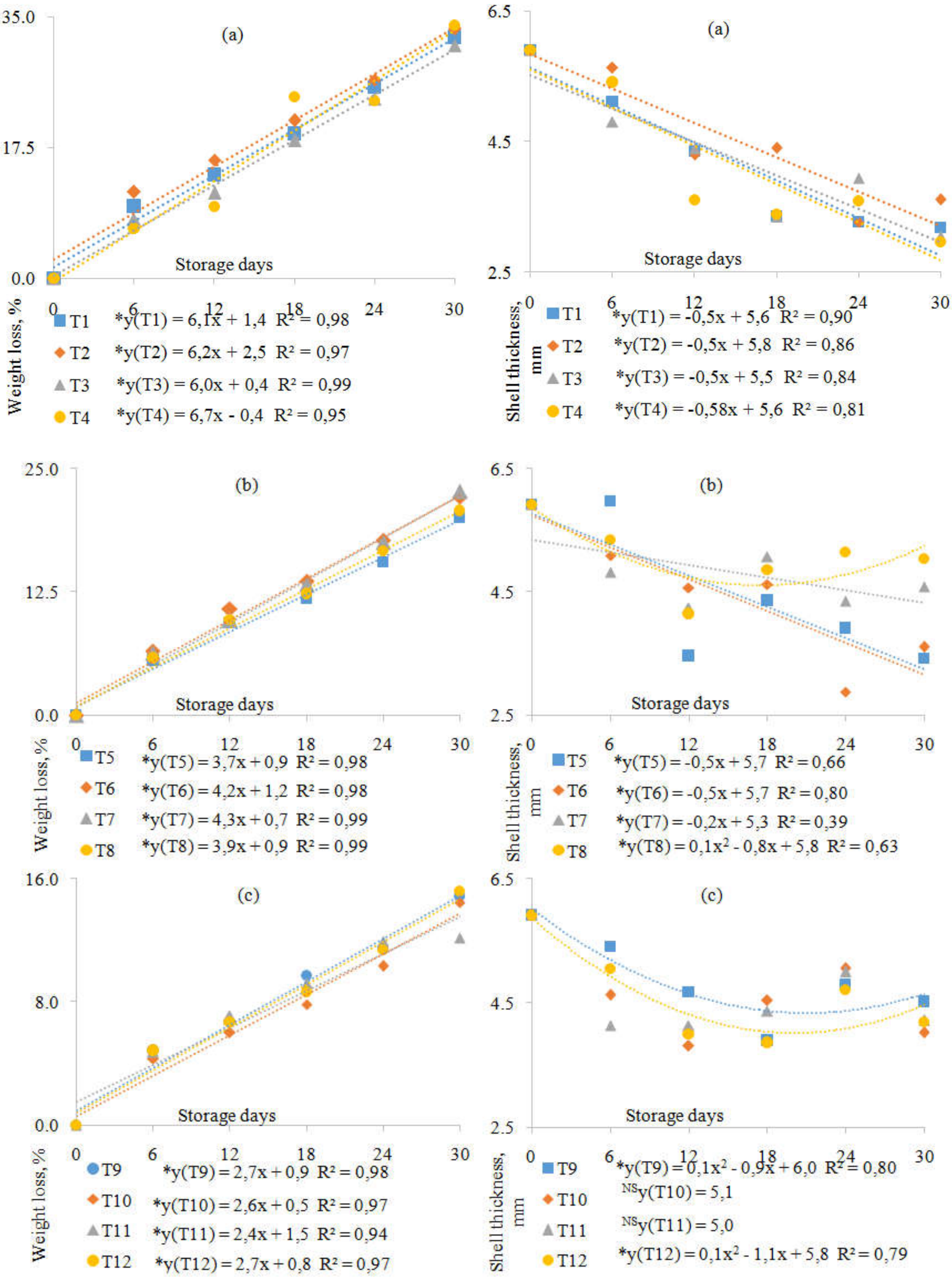

Figure 1. Loss of fresh weight (%), on the left, and peel thickness (mm), on the right, in 'Dekopon' tangerine fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation for different temperatures at 24 ºC (a) , 12 ºC (b) and 6 ºC (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

Coloring: In the coloring, the values L *, a *, b *, Hue and chroma were verified, measured by reflectance, using a portable colorimeter CR-400 from Konica Minolta, where the L * coordinate indicates how dark and how light the product is (zero value black color and value 100 white color), the coordinate a * is related to the intensity of green (-a) to red (+ a) and the coordinate b * is related to the intensity of blue (-b) and yellow (+ B). And the Hue angle (chromatic hue angle) was determined by equation (2), while the chroma (color saturation) was given by equation (3):

$$°H = arc\tan\frac{b^*}{a^*} \quad (2)$$

$$C = \sqrt{(a^{*2} + b^{*2})} \quad (3)$$

On what:

ºH = Hue angle; C = Chroma;

a* = value of a*; b* = value of b*.

Dimensional characteristics of the fruit: The equatorial diameters and longitudinal length of the fruits were measured with the aid of a digital caliper (Mitutoyo Absolute 150mm resolution 0.01mmX.0005"). The longitudinal length was measured from the apex to the end of the fruit stalk, and the equatorial diameter was measured at equatorial line of the fruit.The peel was removed from the peduncle, and the thickness of the peel was measured from the insertion between the middle and upper third of the fruit, between the albedo and the flavedo.The results were expressed in millimeters (mm).

Fruit fractions: The fractions of the fruit were determined from the extraction of the juice from the fruits using the Philips Walita Multiprocessor of food 650 watts of power, and divided into three fractions, pulp, peel and bagasse, considering the pulp, the fruit without the peel, and bagasse, the result of extracting the liquid fraction of the pulp. The results were expressed in percentage, in relation to the whole fruit.

Ascorbic acid content: The ascorbic acid content was determined by the titrometric method described by Benassi and Antunes (1988). Ascorbic acid was extracted with oxalic acid under stirring and, after filtration, it was dosed in the extract, using 2,6-dichlorophenol indophenol 0.02% (Tillmans reagent) and using ascorbic acid as standard. The reading was performed on an Amber burette by consuming 2,6-dichlorophenolindophenol (DCFI) and the results were expressed in mg of ascorbic acid per 100 microliters of juice.

Statistical analysis of the data: The evaluated variables were submitted to polynomial regression analysis according to the post-harvest conservation days. The SISVAR software was used to adjust the regression models by means of an F test at the probability level of 5%, to measure the level of significance of the proposed model.

RESULTS AND DISCUSSION

It is observed through Figure 1, the values of mass loss and shell thickness, that there was significant interaction for mass loss in all treatments. The results show that, for the loss of mass in storage at 24ºC, there were increases over the days in its percentage of lost mass, in all treatments. This behavior varies when compared to lower temperatures. Meanwhile, the peel thickness showed significant interaction in all treatments, except for two, at 6ºC with 3 and 6 minutes of UVC radiation (T10 and T11, respectively). It is observed, for the mass loss, that the difference between the times of UVC radiation is not clear, only the treatment with 6 minutes of radiation (T3) that presents a slight decrease until the last day of analysis, keeping the curve below other treatments. For a temperature of 12ºC, a similar effect was noted, also pointing out that the highest dose was not responsible for the lowest loss of mass, in the same way for Rigolo *et al*. (2009), who infers that the longer time or dose of UVC radiation is not necessarily the most adequate for maintaining post-harvest life, contrary to what was exposed by Neves *et al*. (2002), who obtained better results of mass loss with higher doses. For evaluations at 6ºC, it can be seen that there was a significant difference in treatments T10 and T11 (3 and 6 minutes of irradiation), pointing to lower percentages of mass loss for these treatments. The biggest differences were noted between the different temperatures, for the last day, with treatments at 24ºC showing losses ranging from 31 to 33%, while for fruits stored at 12 and 6 ºC, they were from 20 to 23% and 13 to 15 %, respectively, pointing out that the biggest changes in mass losses were in response to different temperatures. It was also possible to notice that the fruits in the refrigerations of 12 and 6ºC remained with their turgidity until the last evaluations, confirming with Finger & Vieira (2002) where he associates the rate of mass loss with the absence of superficial wrinkling or withering. In general, when evaluated according to time, refrigeration and radiation, they had the same loss behavior, that is, as time goes on, the fruits lose moisture, and the lower the temperature, the lower the senescence, consequently more stable is the maintenance of the post-harvest quality of the fruits. For peel thickness, it was noted that there was a reduction during storage for treatments subjected to 24ºC. The thickness of the bark, on average, started with approximately 5.90 mm and reached up to 3.21 mm, showing more than 45% of the bark reduction. Such a decrease can probably be related to the loss of water from the fruits, which was very evident for these treatments.

At room temperature (24ºC), the treatments had a very specific characteristic, which was the adherence of the peel to the fruit, due to the shortening of the fibers (mesocarp), amplified by the loss of mass and parenchymal cells. The greater the evolution of the storage time, the more difficult it became to remove the peel, and this was different for the other treatments with lower temperatures. Machado *et al*. (2017), working with several citrus accessions, observed that most of them had firm skin adhesion, but did not explain the cause of this effect. Brugnara *et al*. (2012) infer that the tangerine peel that produces the largest fruits, generally has a thick, moderately adherent peel, with a moderately smooth to rough and warty surface, as observed in the 'Dekopon' tangerine. Domingues *et al*. (1999) found tangerine varieties with light, moderate and strong adherence from the peel to the endocarp, and considered only those with light or moderate adherence suitable for trade. In treatments T7 and T8 (at 6ºC with 6 and 9 minutes of UVC radiation, respectively), it was observed that the peels of the fruits maintained their thickness for a longer period in relation to other treatments subjected to the same temperature. This already makes evident the effect of UVC radiation to control the physiological properties having an action on the skin of the fruit. This effect may have been a promoter for regulating mass loss and maintaining other physical and chemical characteristics, brought about by hormone (Stevens *et al*., 1998; Shama & Alderson, 2005). Statistically different from other treatments, revealing the efficiency of the binomial radiation x temperature. The treatments T9 and T12 (stored at 6ºC without radiation and with 9 minutes of radiation, respectively) also showed results close to the fruits stored at

12ºC, however, the main effect is attributed to refrigeration, which provided stabilization after 18 days of storage, allowing to keep the fruit moisture for a longer period. Evaluations on the peel of this fruit are of great importance, as among the few studies carried out with essential oils, there is the study on obtaining the oil from the mandarin peel (Citrus reticulata), carried out by Mishra *et al*. (2005), which showed high average yields, indicating the potential of tangerine to obtain oil. Figure 2 shows the maturation index and soluble solids values. In the soluble solids, there was a low interaction for the soluble solids factor, presenting only significant interaction for three treatments (T1 and T6), however, in general, the other results indicate an increase in the soluble solids content during storage for the greatest part of the treatments. While the relationship between soluble solids and titratable acidity (SS/AT), a significant difference was observed only for treatments stored at 24 ºC with 6 minutes of UVC radiation, and at 6ºC, without radiation and 6 minutes of irradiation (T3, T9 and T11, respectively). For the other values, no significant difference was found. In the soluble solids content, only the treatments for a temperature of 24ºC, without radiation and 3 minutes of UVC radiation at 12ºC, showed a significant

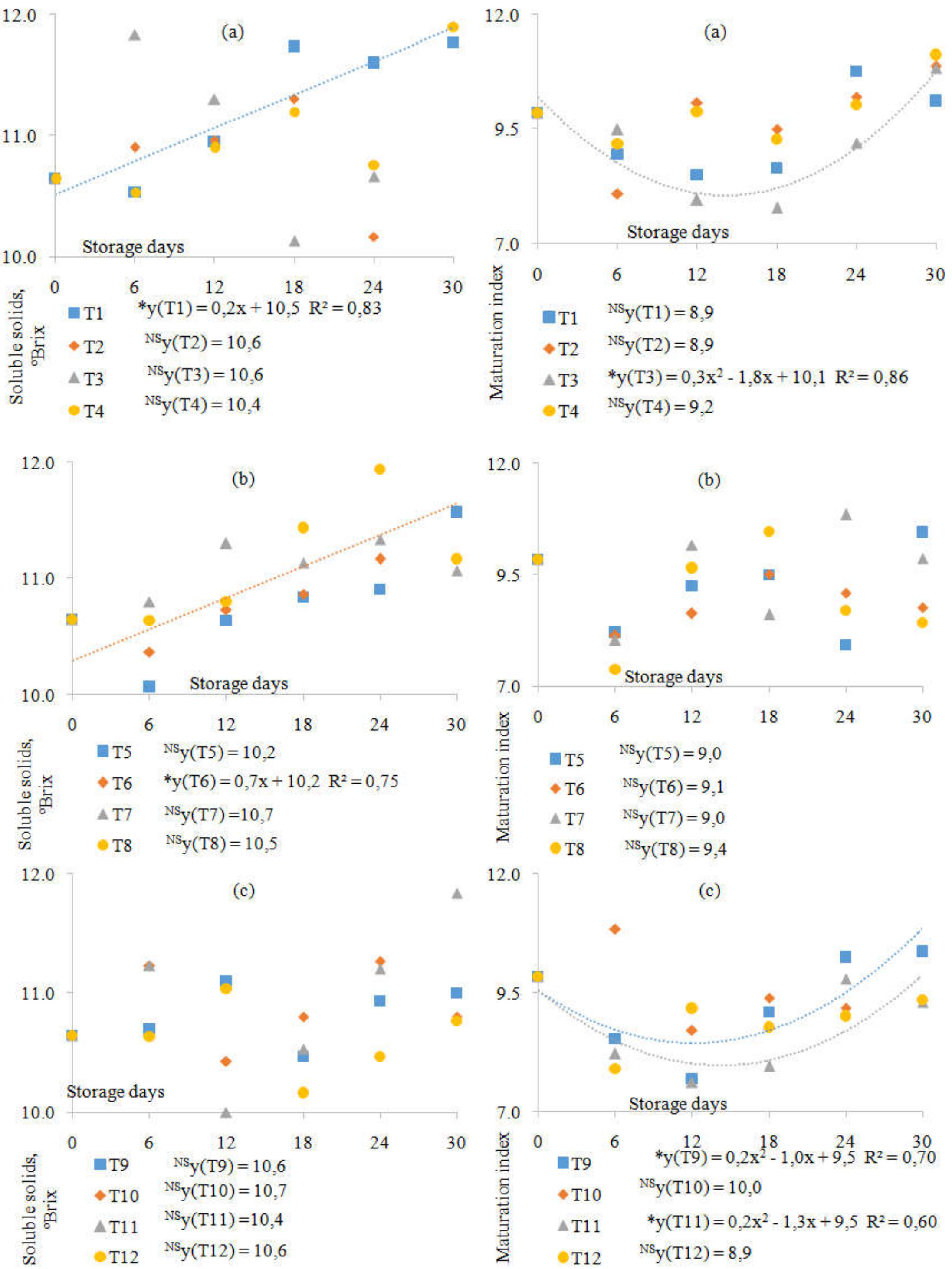

Figure 2. Soluble solids (ºBrix), on the left, and maturation index (SS / AT), on the right, in 'Dekopon' tangerine fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation at different temperatures at 24 ºC (a) , 12 ºC (b) and 6 ºC (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

difference in the soluble solids contents during storage. The other treatments showed no significant difference, but despite this, they point to a slight increase in solids, even though this behavior is not so clear in non-climacteric fruits, where Medina *et al*. (2005), studying the physiology of citrus fruits, infer that the progress of ethylene is slower during the ripening stage, a moment when the transformations that are reflected in the amount of soluble solids are most notable. Note that the temperature control treatment of 24ºC and 12ºC irradiated for 6 minutes increased the content of soluble solids throughout the experiment, which this effect occurs by reducing the mass, and also points out that, even outside the mother plant and being non-climacteric, and with variation in maturation between fruits, it behaved by raising its sugar content, pointing out that at this stage when they generally survive using accumulated substrates, the gain of sensory attributes developed along with increased sweetness. This fact may be due to the degradation of starch, pectin, chlorophyll and synthesis of carotenoids and flavonoids. Stefanello *et al*. (2010), shows that, in non-climacteric fruits, such as tangerine, sugars, the main components of soluble solids, are derived mainly from assimilated substances and not from starch reserves, as occurs in climacteric fruits, where the soluble solids content increases with advancing storage time. Furthermore, this effect may be due to the fruit having a high starch content. This unexpected increase is also evident in other studies such as de Oliveira Júnior *et al*. (2004), analyzing post-harvest changes during storage at an average temperature

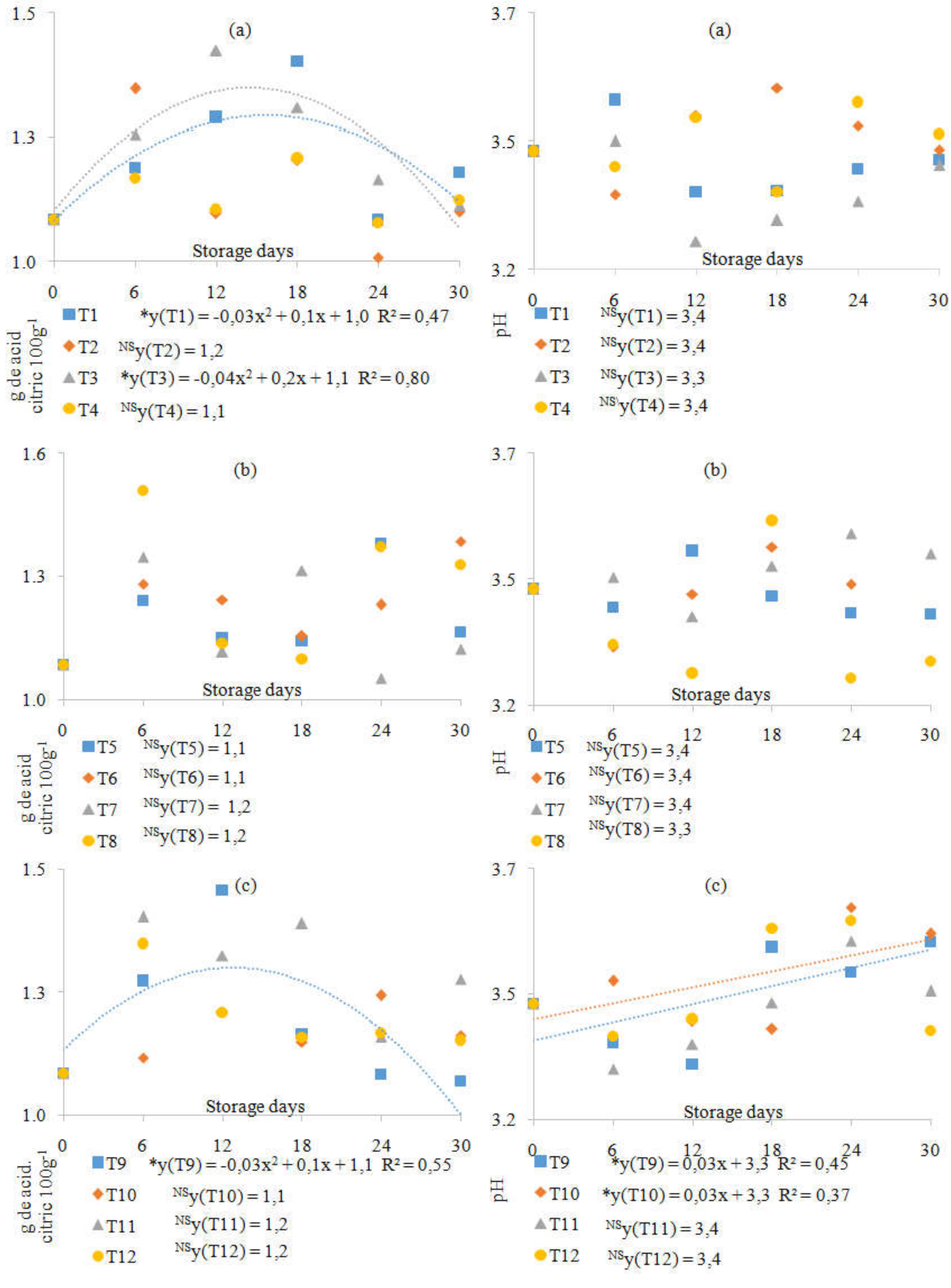

Figure 3.Titratable acidity (g citric acid 100 g-1), on the left, and hydrogenionic potential (pH), on the right, in 'Dekopon' tangerine fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation at different temperatures at 24 ºC (a), 12 ºC (b) and 6 ºC (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

of 22ºC, found an increase in SST content over 20 days for non-climacteric fruits. This difference between refrigeration temperatures and a higher soluble solids content at a temperature of 24ºC in relation to the others of 12 and 6ºC, was also verified by Todisco *et al*. (2012), where fruits stored under refrigeration underwent less changes in the SS than fruits stored at 25ºC for oranges. According to Chitarra & Chitarra (2005), this variation is not common, since citrus fruits present small changes in the sugar content in general, as long as the harvest is carried out during or after the ripening phase. It can also be highlighted where Ferreira *et al*. (2009) state that the sugar content of a fruit is a factor intrinsically related to the genotype, environment and cultural management; providing this behavior to a fruit developed in the cerrado climate. As the behavior of the maturation index is related to SS and TA, and, for these factors, there was a greater increase in soluble solids and low interaction in the titratable acidity, this provided values between 7 and 11, with the minimum acceptable ratio , 6 for oranges and 7 for tangerines (Sartori *et al*., 2002, Duarte *et al*., 2011). It is observed that with 6 minutes of UVC at 24ºC, there was a reduction with a subsequent increase in this index, this change is due to the inversion of the acidity curve that occurred for this treatment, as the fruits presented a behavior very similar to climacteric fruits, Silva *et al*. (2015) observed that this effect is due to the breathing that occurs with fruit ripening. The treatments at 6ºC without radiation and at 6 minutes, where temperatures were the lowest, the same behavior was observed, with little change in relation to the last day that was very close to day zero. It was expected that, by using lower temperatures, it would be possible to keep such values of AT, SS and pH constant during the storage period, however, in these analyzed variables, they presented inversions in the curves, which was not expected from a non -climatteric, being evident that the radiation did not act for these variables delaying the supposed climacteric peak, contrary to the studies of Neves *et al*. (2002), where they stated that there is a positive interaction between UVC irradiation time and refrigeration temperature. Inferring that UVC radiation was efficient in delaying or interrupting the climacteric peak of non-climacteric fruits, pointing out that for the highest doses there was the longest postharvest conservation period.

For the three treatments that showed a significant difference, it is apparent that the fruits until the second week of storage were losing SS and also fresh mass, but after the 18th day, the mass loss remained increasing while the acidity started to invert with the increase SS, corroborating with Camargo *et al*. (2012), where they infer that the increase in the maturation index is associated with loss of mass, favoring an increase in the concentrations of soluble solids. According to Figure 3, it is observed that for titratable acidity and pH of the 'Dekopon' mandarin, in relation to acidity, there was a significant difference only for treatments at 24ºC, without radiation and at 6 minutes, and 6ºC without radiation (T1, T3 and T9, respectively). While, for pH values, a significant difference was observed only for treatments at 6ºC, without radiation and with 3 minutes of UVC radiation (T9 and T10, respectively) for pH values. For the other treatments, no significant difference was observed, indicating only a variation from 3.39 to 3.44 of the pH values throughout the experiment. In acidity, treatments 1 and 3 increased until 12 days of storage and then decreased, reaching, on average, 1.10 g of citric acid.100 g-1. This effect is common in most agricultural products, which show peak acidity with a decrease during storage, corroborating with Silva *et al*. (2017), studying stored oranges. It also points to results similar to Silva *et al*. (2014), who found the same value for Ponkan mandarin, where the acidity presented an average value of 1.14% of citric acid, oscillating between 1.10 and 1.14%. However, it differed from the assessment made by Ibusuki *et al*. (2018), in characterization of 'Dekopon', finding 1.39% in the initial acidity of the fruit. For treatment 9, this peak was before 18 days, with this inversion being more visible at 12 days of storage, obtaining approximately 1.0 g of citric acid.100 g-1. Thus, acidity levels are essential since its reduction is a natural process due to the fruit's maturation process, in which organic acids are metabolized in the respiratory tract and converted into non-acidic molecules (Chitarra & Chitarra, 2005). The acidity behavior for both treatments was similar, even with a significant difference, but it is evident that neither radiation nor refrigeration brought gain or loss for this variable. Unlike Ponkan tangerines irradiated in different doses studied by Sanches *et al*. (2017), where they observed a reduction in acidity during storage, finding initial and final values on average of 0.54 and 0.31 g of citric acid.100 g-1, respectively, showing that the 'Dekopon' tangeria despite being a route from Ponkan, resulted in acidity values higher than twice that of Ponkan tangerines. Great potential for the 'Dekopon' mandarin is perceived, observing the same factors as Gonzatto *et al*. (2015), for consumption in natura, as for industrialization in the form of juice (bright orange color and high acidity) and for resistance to important diseases (cancer-citrus, black spot and brown spot of alternaria). And due to the national limitations regarding this high acidity of the juice, it could be circumvented by planting in areas with a higher air temperature, and by post-harvest storage, however requiring further studies for experimental confirmation.

The pH behavior at 6ºC, without radiation and with 9 minutes of UVC radiation (T9 and T11, respectively) is indicative of deterioration and its increase with the storage time is due to the reduction in acidity due to the ripening of the fruits (Chitarra& Chitarra, 2005). For treatments with the presence of radiation, higher pH values were obtained, which may indirectly infer that for this treatment there was less acidity, while treatments without radiation had lower pH, and in the same way, resulting in more acidic fruits. This variation was also observed by Sanches *et al*. (2017), in Ponkan tangerines under radiation, with values from the beginning to the end of the experiment ranging from 3.79 to 4.12, showing no significant interaction between the evaluated treatments. In agreement with the results of Vale *et al*., (2006) with tangerine '' Ponkan '', where they did not find statistical variation in pH values, and Pinto *et al*. (2006) evaluating the pH of the same fruit in the minimally processed form observed average values between 3.82 and 4.0, without statistical difference. Figure 4 shows the values of the Hue color angle, where it can be noted that in all treatments there was a significant difference with a decrease in the value. However, for the lowest temperature, 6ºC, this drop was less. In the same Figure, it shows the variation of the chroma values where there was a significant difference for all treatments, except for treatments at 24ºC with 3 minutes of radiation, and at 6ºC with 9 minutes of radiation (T2 and T12, respectively).

The Hue color angle, allows to infer that, high values for this type of fruit, refers the color in the direction of the green color, in other words, angle positioned with greater number of degrees, closer to the green the fruit is. However, the color saturation index must also be taken into account. In this respect, observing the treatments at 24ºC the radiation effect was more evident for the highest dose, maintaining a greater color angle, followed by the other treatments, therefore, for this temperature there was an effective behavior of UVC radiation for the time of 9 minutes, and the lower the doses, the greater the color angles for that temperature.

At a temperature of 12ºC, it can be observed that the behavior of the color angle was very close to the treatments at 24ºC, however, in general, the decrease was smaller, following the same proportion where, the highest doses of UVC there was the lowest angle reduction. For treatments submitted to 6ºC, for treatments without radiation, with 3 and 6 minutes (T9, T10 and T11, respectively), it provided a smaller reduction in

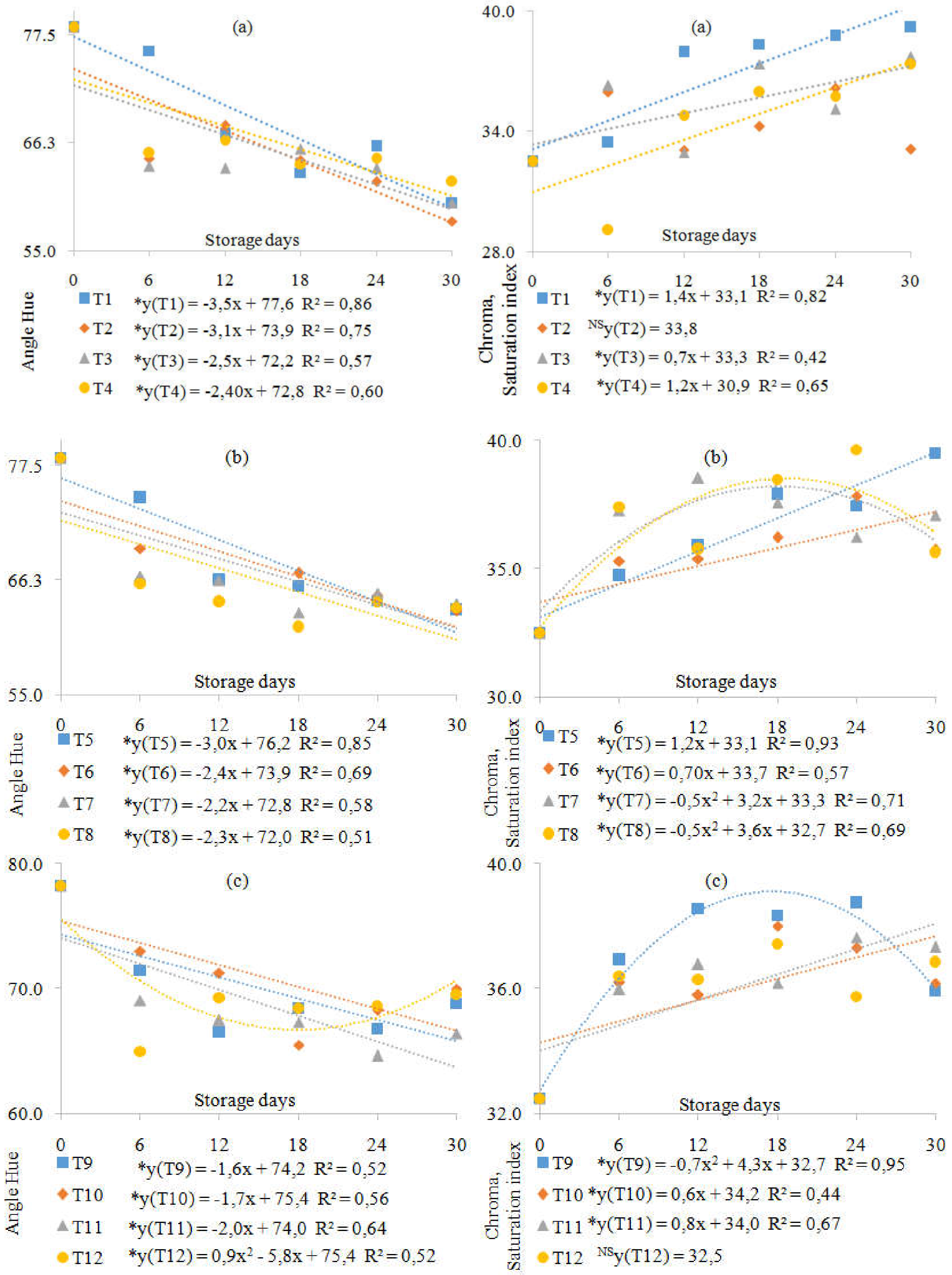

Figure 4. Hue angle (ºH), on the left, and chroma (C *), on the right, in 'Dekopon' mandarin fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation for different temperatures at 24 ºC (a), 12 ºC (b) and 6 ºC (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

the color angle, exceeding the temperature of 12ºC, although, the treatment with the highest radiation dose (T12), helped more effectively in maintaining the chlorophyll pigments and the color angle of the fruit. Pinto *et al*. (2010), reported in their work, that by reducing the temperature during storage, the degradation of chlorophyll in the shell decreases, as a consequence of the lower production of ethylene and the reduction of the combined action of chlorophyllases and oxidative systems. Although fruit respiration has not been studied in this work, it can be inferred that enzymes chlorophyllase and ACC oxidase (1-aminocyclopropane 1-carboxylic acid) appear to be independent of the action of ethylene, as pointed out by Taiz & Zeiger (2004). Another aspect under consideration, shows that during storage, the fruits migrated from yellow to yellow / orange color more vivid. This difference is clearer when compared between temperatures, because at the end of the experiment, the temperature of 24ºC allowed the fruits to exceed up to close to 60ºH, around 65ºH for treatments at 12ºC, and between 65 and 70ºH for the fruits stored at 6ºC, revealing that the temperature acts on the coloring of the 'Dekopon' mandarin fruits during the cold storage, slowing down the progress of the coloring of the fruits. For that, Silva *et al*. (2014) inferred that in citrus, color of the peel is a characteristic that is not dependent on internal maturation, although the consumer normally associates the color green with immature fruits and the orange or yellow coloration with ripe fruits. However, it was observed in this experiment that there was an increase in SS, which can be interpreted with the change in color, which allows us to infer that the color of the skin was an indirect influence in terms of fruit ripening. Tietel *et al*. (2012) reported values close to 60 ° H in 'Mandarin' Or ', thus corroborating the values found in this work. In the work by Silva *et al*. (2014), Hue's values for ‘Dancy’ tangerines corroborate this research. It also corroborates the work of Pacheco *et al*. (2017), analyzing Freemont and Clemenules tangerines, but differs from Ponkan tangerines. And they differ from the data by Oliveira *et al*. (2014), who, analyzing the quality of 'Ponkan' mandarin from different locations, found values between 84 and 86ºH.

The color saturation index - chroma, generally reflects in the aspect of darkening of the fruit, the higher the chroma value the more vivid the color is, and the lower the value, the darker the fruit tends to be, however it is a as it does not act on its own, taking into account other aspects, such as the color angle. Thus, it was seen that for most treatments there was an increase in this parameter, which can infer that the chroma was increasing during storage, and also, the behavior in relation to radiation showed lower values when compared to the control. For treatments at 24ºC, it can be noted that this variable increased during storage, mainly for the control treatment. This increase effect between treatments is believed to be related to the oil present in the fruit already studied by Teruya *et al*. (2015), who observed the presence of essential oil in the pericarp of this fruit, however, there is no evidence that can associate this effect to temperature, since for the various treatments, the averages are very close to each other, varying chroma of 36 to 39. However, for all irradiation control treatments at 24 and 12ºC, they presented higher averages, except for the treatment without radiation at 6ºC, which showed a reduction after 20 days of storage. This effect may be due to the cold injuries that caused this inversion of the curve, since Kluge *et al*. (2006), stated that this effect of temperature can cause changes in the catalase activity of the fruits, oxidizing organic substances (peroxidase). Thus, it is assumed that UVC radiation for the other treatments at 6ºC did not inactivate some antioxidative enzymes involved in the defense mechanism of tangerines, which, only the injury by cold, may have led to the inversion of the curve for the control treatment at 6ºC. The results of this work corroborate with Oliveira *et al*. (2015), who evaluated Ponkan mandarin from different places and analyzed the Chroma of the fruits, finding an average of 34.45 C *. In the works by Silva *et al*. (2014) found values of 63.5 C * on average, in 'Dancy' tangerine. However, this variable differed from the work of Belo (2017), which found 110 C * for 'Dekopon' mandarin.

Figure 5 shows the values of longitudinal length and transverse diameter. For the length, there is a significant interaction for nine treatments with the exception of treatments at 24ºC, irradiated at 6 and 9 minutes, and at 6ºC with 6 minutes of UVC radiation (T3, T4 and T11, respectively). For this variable, the effect of UVC radiation on its times in different treatments was not very evident. While, for the transverse (or equatorial) diameter, there was no significant interaction for treatments at 24ºC at 6 and 9 minutes of exposure to UVC, at 12ºC with 9 minutes of UVC, and finally at 6ºC with 6 minutes of UVC radiation (T3, T4, T8 and T11, respectively). It can be seen that the longitudinal length of the fruits decreased during storage. However, for the control at 24ºC, after 24 days of experiment it showed some stabilization, together showing the same effect, the treatments submitted to 6ºC, except treatment 11, the same behavior was also observed. However, the effect of decrease is related to the loss of fruit mass, and more related to a stabilization of the decrease in fruit, probably due to the effect of treatment at the expense of temperature (Vale *et al*., 2006). The lengths of ‘Dekopon’ tangerine fruits are much higher than the Ponkan tangerine, where on average they are 68.5 mm (Silva *et al*., 2014). Mendonça *et al*. (2006), when evaluating the longitudinal diameter of 'Ponkan' mandarin fruits, observed an average of 68.42 mm. Pio *et al*. (2001) stated that the Brazilian consumer has a preference for larger fruits according to the Tangerines Classification booklet. According to the classification of CEAGESP (2011), for the Ponkan mandarin, 82 mm is a very high value and classified with standard fruit A. The fruits of the treatments at 6ºC were shown throughout the experiment with higher averages, probably due to the effect of temperature in delaying the loss of mass that indirectly, is related to the size and volume of the fruit (Vale *et al*., 2006). For treatments at 24ºC, from the 6th day, there was a sharp reduction in the size of the fruits followed by stabilization, and for treatments at 12ºC, in all treatments, the length of the fruits followed a constant decrease in all storage. Another difference that may be linked to the variability of the fruits, is related to the fruit depending on the position of the plant, and this in relation to the sun. Denoti *et al*. (2009) working with Ponkan tangerine, found that the longitudinal diameter of fruits harvested in the east-west (sun) quadrant, showed significantly higher values (74.42 mm) than those harvested in the shade (67.75 mm), however, not observed a difference for the transverse diameter. The transverse diameter or also called the equatorial diameter, decreased during storage. In most treatments, there was a reduction until around 18 days, with an increase thereafter for this variable. Other treatments, such as T6 and T7 (3 and 6 minutes of UVC at 12ºC, respectively), showed a constant reduction until the last day of storage. It was found that throughout the experiment, the fruits were flattened with geometric characteristics, this in all treatments, however, the lower the temperature, the less this behavior was noticed. However, even though it was noticeable that the fruits geometrically had the longest transverse diameter throughout the experiment, at the same time mass was lost and the transverse diameter / longitudinal length ratio remained constant during the storage days. Visually presenting flat fruits, but more length than width was lost. The transverse width or diameter, can be seen as a characteristic that from a given moment tends to have a spatial limitation, or else, the fruits would start to split showing cracks and cracks in the peels or even have been subjected to compression, and this was not seen in any fruit.

In the work of Detoni *et al*. (2009), applying refrigeration in Ponkan tangerine, observed that the transverse diameter did not show significant differences between treatments. In works by Pacheco *et al*. (2017), analyzing tangerine with potential for the Brazilian market found equatorial diameters from 63.0 to 72.0 mm for Ponkan tangerine. Belo (2017) found an average transversal diameter of 93.47 mm in 'Dekopon' mandarin, a value that corroborates with this experiment. According to Lim (2012), the cross-sectional diameter of the 'Dekopon' tangerine can vary from 65.0 to 90.0 mm, as can be seen with the present work.

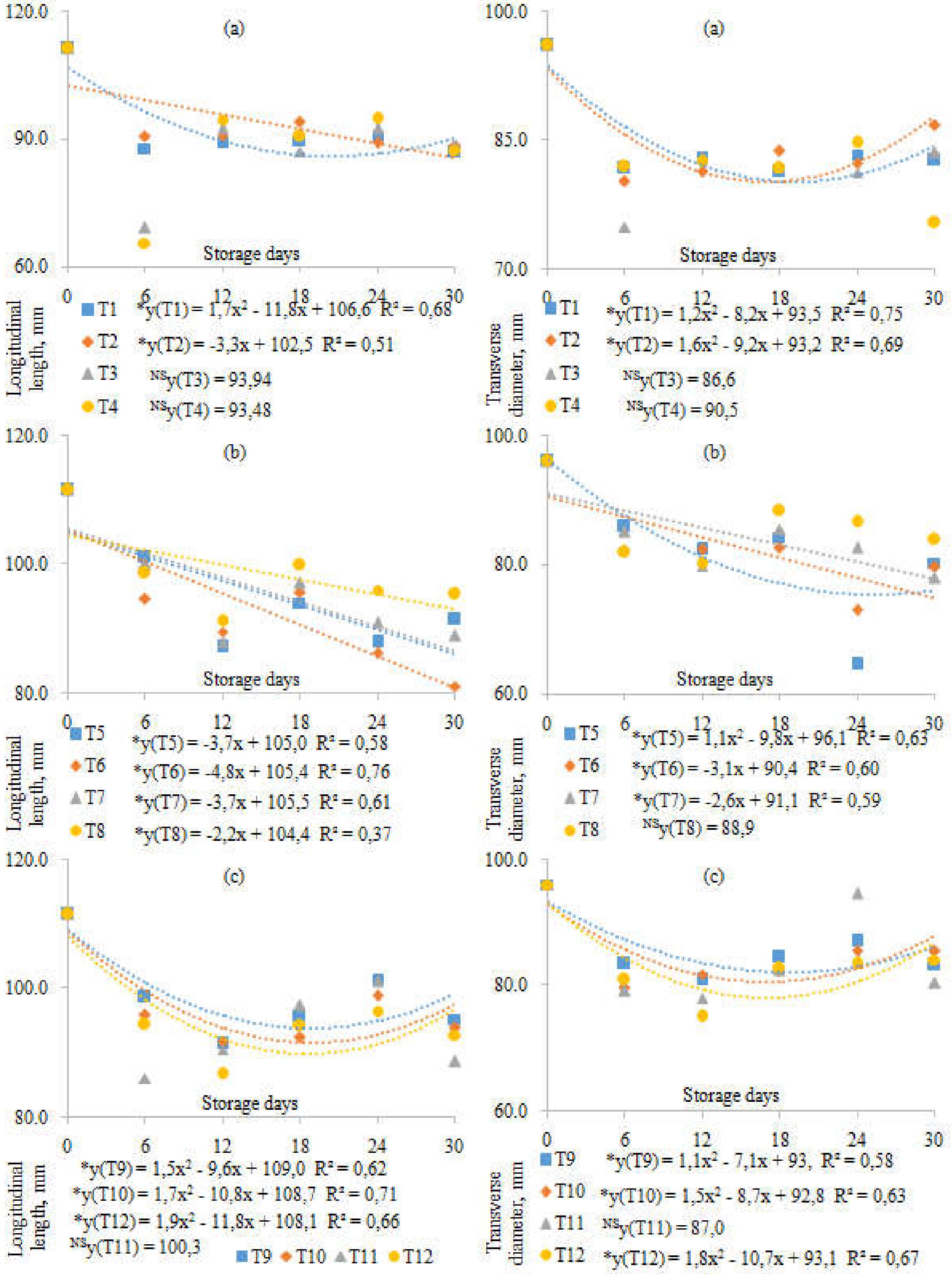

Figure 5. Longitudinal length (mm), on the left, and transverse diameter (mm), on the right, in 'Dekopon' tangerine fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation for different temperatures at 24 °C (a), 12 °C (b) and 6 °C (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

As with the longitudinal length, the effect of UVC radiation on the cross-sectional diameter of the 'Dekopon' tangerine was not evident. Figure 6 shows the values of firmness and deformation of the fruit peel as a function of time of exposure to UVC radiation, temperature and days of storage. For firmness, there was significant interaction for all treatments. While the deformation of the shell, it also showed significant interaction for all treatments, except for the treatment at 12ºC and 9 minutes of radiation (T8). For all treatments, an increase in the firmness value for the fruits was noted. The expected common behavior for most fruits is to present a decrease in this variable, which was not noticed in this study. The greatest firmness was registered for the control treatment, without radiation and at 24ºC. And the smallest straight lines are for treatments at 12ºC at 6 and 9 minutes of radiation and at 6ºC with 3 minutes of UVC radiation (T7, T8 and T10 respectively), therefore for these treatments, it is considered that there was greater influence in relation to constitution of the peel (epicarp and mesocarp) in addition to the combination of refrigeration and radiation, as it provides less resistance to

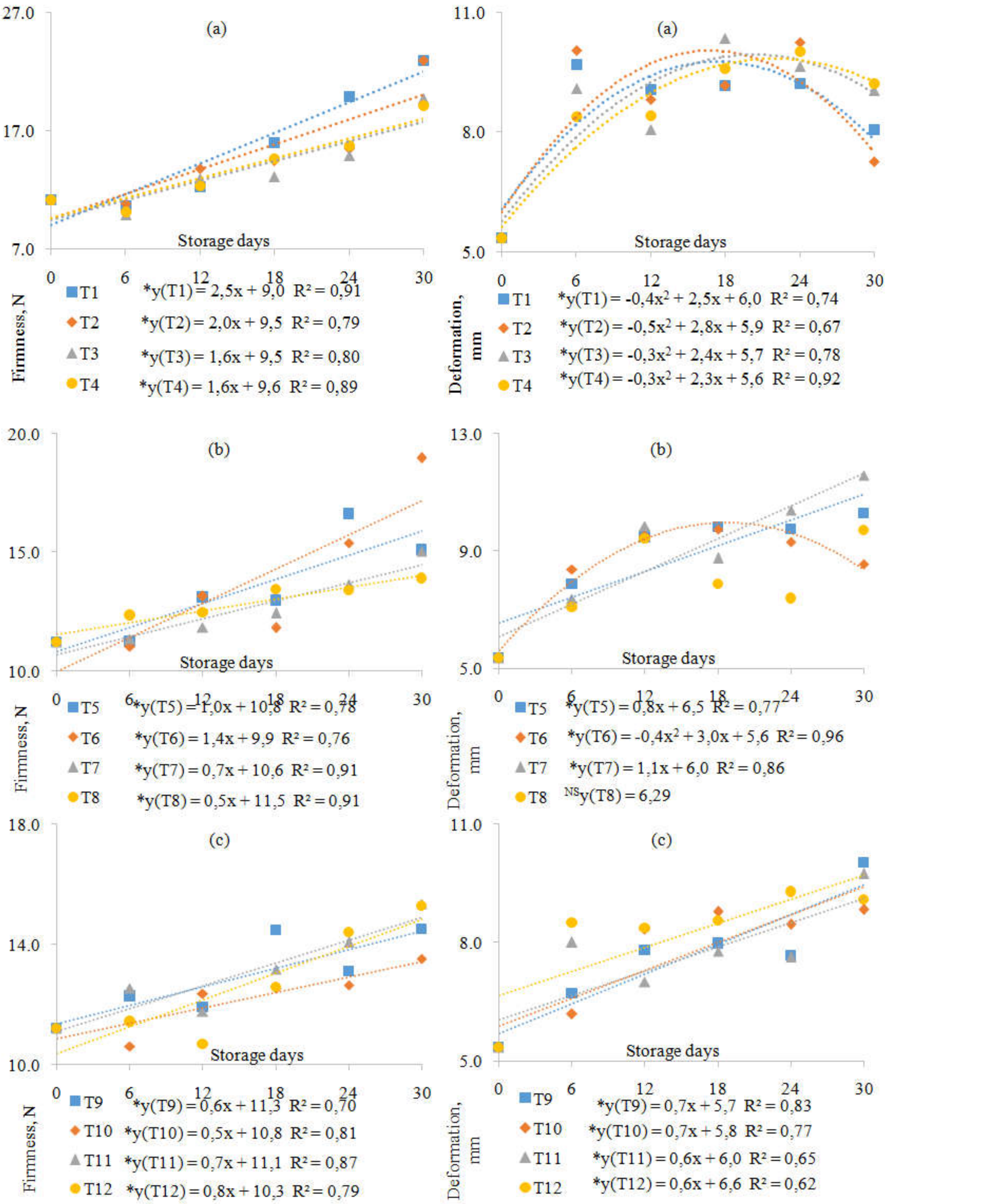

Figure 6. Firmness (N), on the left, and peel deformation (mm), on the right, in 'Dekopon' tangerine fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation for different temperatures at 24 ºC (a), 12 ºC (b) and 6 ºC (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

the penetration of the fruit, making it easier to remove the peel, since this is a major factor for the consumer to satisfactorily evaluate the fruits (Neves *et al*., 2011). In this research, it was observed that as the storage time extended, the fruit peels became thinner and more difficult to detach, mainly in treatments where the radiation and cooling temperature were lower, it was also noticed , that when carrying out the texture tests, the peels apparently took a long time to break, as it is believed that the narrowing of the peel is due to water loss, causing greater flaccidity, and consequently, greater difficulty to break and remove the bark. In other words, this firmness is due to the fruit peel that loses water and increases the stress to break, and with the deformation analysis it is evident that the stiffness of the peel is not related to the pulp. In the research by Pacheco (2015), analyzing Fremont tangerine fruits, the author explains this effect where fruits stored under ambient conditions show an increase in firmness due to changes in the cell wall of fruits that are withered, making it difficult to penetrate the tip of the fruit. measuring device in them. Thus, in contrast to the various studies, lower firmness values refer to fruits that have maintained this physical property for a longer time, associating the maintenance of post-harvest characteristics, where treatments at 12ºC for 6 and 9 minutes, and also the 6ºC with 3 minutes of UVC radiation, provided, for a longer time, the initial firmness of the 'Dekopon' mandarin fruits mainly due to the radiation time adapted to each temperature, thus providing better responses.

Daiuto *et al*. (2013), working with avocados noticed the same effect on irradiated fruits, where there was, in general, an increase in the firmness of the fruits in relation to the initial values. In strawberries submitted to UVC light, Pombo *et al*. (2009) observed that there was an increase in the firmness values providing superior values in relation to other treatments. In the work of Marques *et al*. (2013), the mango fruits associated with UVC and coating, provided greater maintenance of firmness and also of other post-harvest parameters evaluated. According to Mercier and Kúc (1997) and Souza (2015), the action of UVC radiation has an effect as an abiotic stressor capable of activating defense mechanisms of plant tissues, among several mechanisms, one is associated with the maintenance of the plant cell wall. Lu *et al*. (1991) and Tiecher (2010), inferred that, at low dosages, UVC radiation provides delay in senescence and ripening in fruits and vegetables. For the deformation of the peel, the fruits of the treatments at 24ºC showed a quadratic behavior, showing that the deformation increased until the 18 days of the experiment, and then reduced again from this day. This was evident from what can be seen in the physical aspect of the fruits while carrying out the analyzes, because with the advance of the storage time, the skin became thinner and the pulp softer (until some time), mainly, by the advance fruit ripening. However, when the values decreased, the fruits had already reached the deformation limit, and it was clear that the fruits were more rigid, as can be seen by the firmness analysis that increased with the storage time. The same analogy can be applied to the treatment at 12ºC with 3 minutes of radiation (T6). In the fruits of the treatments at 12ºC control and with 6 minutes of UVC radiation, there is a progressive increase in deformation. This behavior points to the softness of the fruit and also the pulp (Figure 14 - b). However, care should be taken to define limits to differentiate the point between softness and wilting in the deformation value of this fruit. The same behavior observed, applies to treatments at 6ºC, however, they reached lower values at the end of the experiment. Giving this action to UVC radiation, as an abiotic stressor activating defense mechanisms of plant tissues, providing changes in the cell wall of plant products (Rivera-Pastrana *et al*., 2014; Souza, 2015).

It is visually estimated that 'Dekopon' tangerine fruits contain fractions with a high amount of carbohydrates. For such carbohydrates there is the starch which, according to Sinha *et al*. (2011), behaves as a storage polysaccharide, while pectin, cellulose and hemicellulose contribute to firmness. Cellulose, in turn, is an important polysaccharide that contributes to the firmness of the cell structure, since it is the main component of the cell wall. With the action of the loss of mass, there is damage to the harvested product, causing the loss of firmness and withering to occur. However, it has not been studied how to differentiate between softness and withering of the 'Dekopon' tangerine fruit, requiring more data and evaluations to limit the deformation of this fruit. However, it is known that in the withering the surface texture is wrinkled, while for turgid fruit it is smooth. The softness that occurs in 'Dekopon' mandarin fruits is related to the enzymatic action that generates disorders in the structure of the peel and pulp, resulting in the softening of the fruits (Thé *et al*., 2009). Studies infer that changes in fruit texture are related to two main enzymatic processes, the action of which is due to polygalacturonase (PG) and pectinamethylesterase (PME) (Anthon *et al*., 2002). Such enzymes act in the depolymerization and solubilization of pectic and hemicellulosic substances that culminate in the softening of the fruits (Vilas Boas, 2002). According to Figure 7, the values of the final tip load or pulp resistance and the surface tension of the skin were evaluated. For the final load values, a significant difference was observed only for half of the treatments, they are: at 24ºC and 12ºC with the exception of the control treatments and with 9 minutes of UVC radiation (T5 and T8, respectively), for the fruits of the treatment at 6ºC no significant difference was noted. While, the surface tension, in two treatments did not present significant difference, at 12ºC and 9 minutes of UVC radiation and at 6ºC and 6 minutes of UVC radiation (T8 and T11, respectively). The others, in general, showed a reduction with an increase from the 12th day.

The final load of treatments subjected to 24ºC was reduced and then, at a given moment, increased until the end of the experiment, showing an inversion in the curve from the 18th day. This effect is due to the loss of mass and consequent loss of water, giving the fruits of this treatment greater rigidity in the pulp with the advance of storage. In this evaluation, it is evident that the UVC radiation acted in the conservation of the physical properties of the fruits, where, with the increase of the exposure time, the inversion of the curve was smaller, and the average values of the final pulp load were lower, resulting in a softer pulp, and probably more juice. This decrease in the firmness of the pulp, makes it softer, as it occurs due to the action of the enzymes PME (pectinamethylesterase) and PG (polygalacturonase) that act at the cell wall level. The activity of these enzymes promotes solubilization of pectic substances in the cell wall and, consequently, the softening of fruits (Kays, 1991). For the treatment at 12ºC and 3 minutes of radiation (T6), the same effect was observed, very similar to the treatment at 24ºC and 9 minutes (T4). However, for the treatment with 6 minutes at the same temperature, it showed a reduction until the end of the experiment, showing that neither radiation nor temperature were effective for this variable. At a temperature of 6ºC, no significant difference was observed, but they presented averages between 51.66 to 89.79 cN, values that are very close to the other treatments. The study of surface tension is designated by the ratio between firmness and deformation, which came to meet a particularity of the experiment, which was the tension gain during storage, since there was a behavior with the decrease and increase in the deformation of the fruits. It was evident that the increase in firmness did not; necessarily, it reflected that the fruits were firmer (or more rigid), and yes, it caused an increase in the deformation, showing that the surface of the fruits was showing resistance to compression, probably due to the loss of water, forming a film of high resistance. Furthermore, the internal firmness of the pulps has decreased, favoring the interpretation of an increase in the surface tension of the fruit peel. It is unclear why the surface tension has increased, since it may be related to the resistance of the skin with lignification of tissues, or by the decrease in tension of penetration to the pulp.

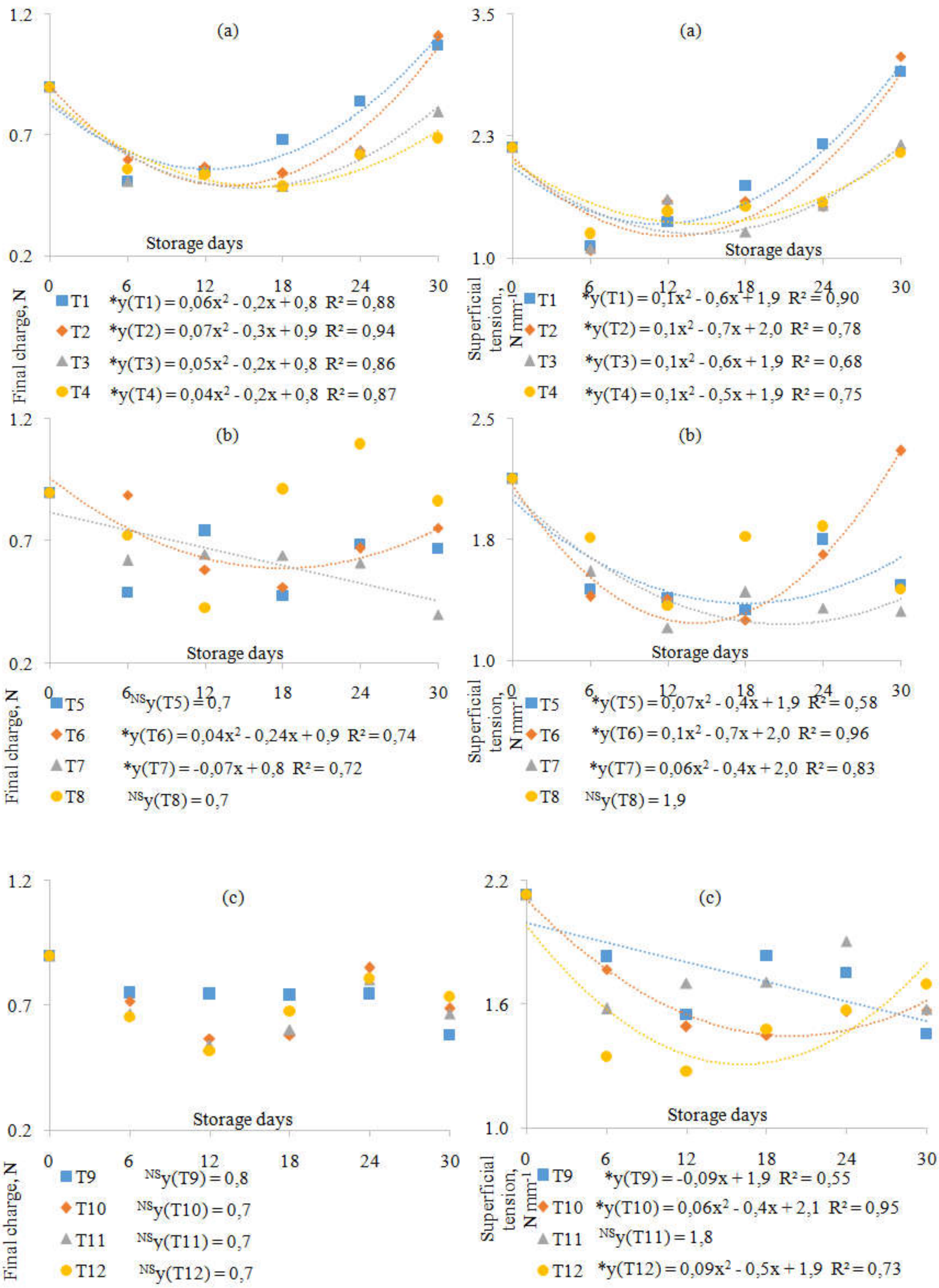

Figure 7. Final load (N), on the left, and surface tension (N mm-1), on the right, in 'Dekopon' tangerine fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation for different temperatures at 24 ºC (a) , 12 ºC (b) and 6 ºC (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

It is known according to Bem (2016), that the temperature rise is considered a striking feature, as it promotes rapid lignification of the cell wall, accelerating the metabolic activity of the cells, thus justifying such results. According to Taiz et al. (2017), lignification transforms the secondary cell wall into a hydrophobic structure, resistant to deconstruction. Note that the surface tension was the opposite of the deformation found in this experiment, for most treatments. And this tension, showed an increase very close to the 18th day, this time when it reversed the resistance of the peel with the resistance of the pulp. The treatments that showed less variation, pointing to the maintenance of this property, were the treatments at 12 ºC control and 6 minutes of UVC radiation (T5 and T7, respectively), as they resulted in curves with less flexion. The levels of ascorbic acid are shown in Figure 8, which showed significant interaction only for four treatments, at 12ºC with 9 minutes of UVC radiation, and at 6ºC without radiation and at 6 and 9 minutes of UVC radiation (T8, T9, T11 and T12 , respectively). In general, it is observed that the levels of ascorbic acid are between 7.19 and 23.13 mg of ascorbic acid 100 mL-1 of juice, a value that reduces during storage. For this, there was no continuous decrease, but isolated peaks of this content, which during storage were decreasing.

Rosa et al. (2007) infer that there are peaks in the ascorbic acid content in different plant products. In the ascorbic acid content of the treatments without significant interaction between them, at the end of the experiment, averages ranging between 8.65 and 16.68 mg of ascorbic acid 100 mL-1 of juice, a reduction of 8.03 mg of ascorbic acid 100 mL-1 of juice in relation to the different treatments, the lowest value for the treatment testifying to both refrigeration and radiation, except at 12 ºC. In the treatment at 12ºC with 9 minutes of radiation, it can be noted that there was an increase in the ascorbic acid content up to 12 days of storage, and then that value continues to decrease until the end of the experiment. The same can be observed for the treatment values at 6ºC. In treatments at 6ºC submitted to radiation, it is noted that there was an effect of UVC waves in the conservation of ascorbic acid levels, compared to treatment without radiation (T9). In the work by Sanches et al. (2017), with Ponkan mandarin submitted to UVC radiation stored under refrigeration, there was a marked reduction in the levels of ascorbic acid during refrigerated and ambient storage, regardless of the use or not of UVC radiation. This reduction without effect of the treatments of the present research, can be as explained by Felício et al. (2006), where they inferred that this is attributed to involvement with antioxidative reactions that take place during fruit ripening due to the direct action of

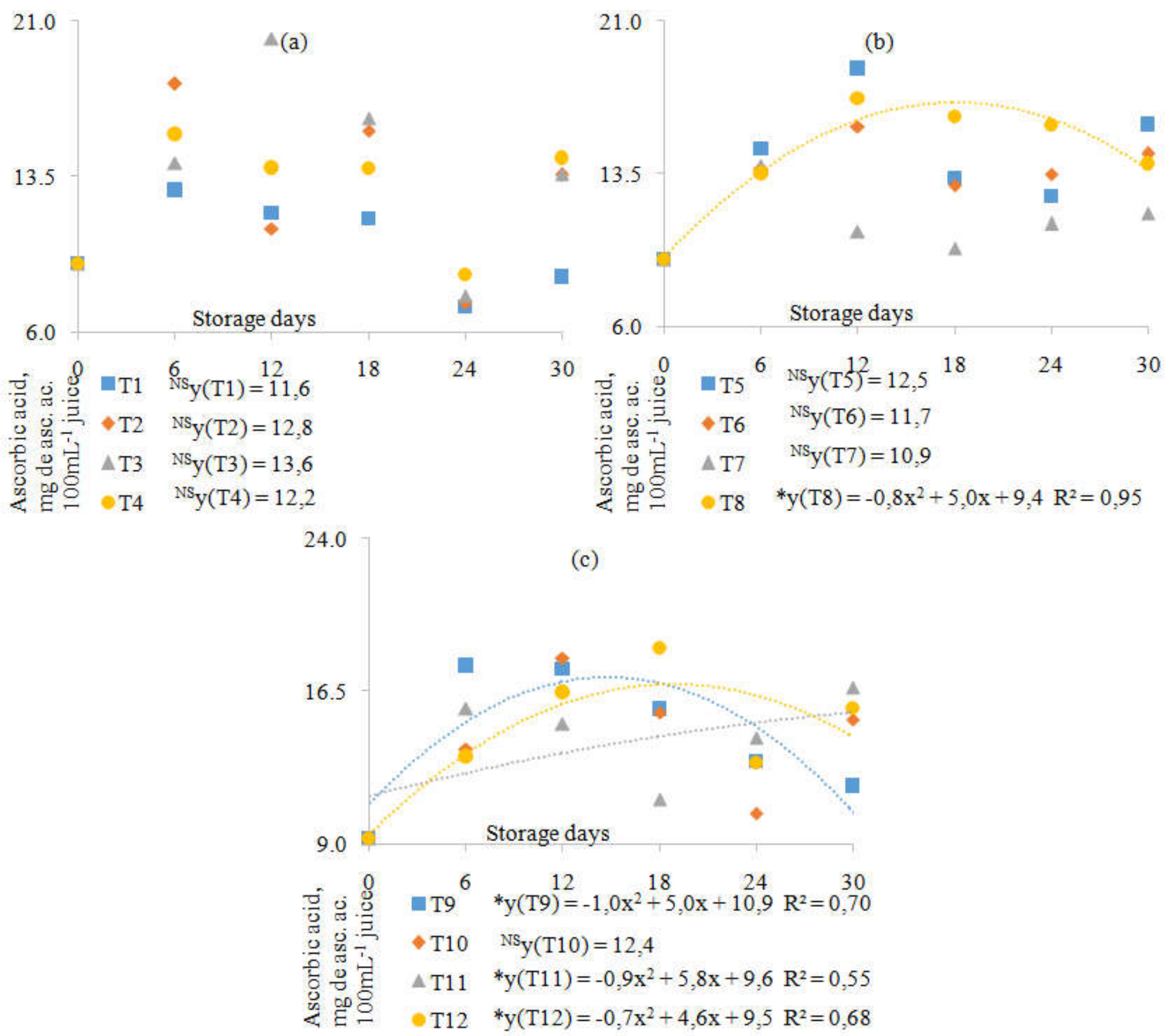

Figure 8. Ascorbic acid (mg of ascorbic acid 100 mL¬-1 of juice) in 'Dekopon' mandarin fruits (Citrus reticulata 'Shiranuhi'), submitted to UVC radiation for different temperatures at 24 °C (a), 12 °C (b) and 6 °C (c), and storage days. Treatments at 24ºC (T1: without UVC light, T2: 3 'light, T3: 6' light, T4: 9 'light); at 12ºC (T5: without light, T6: 3 'light, T7: 6' light, T8: 9 'light); and 6ºC (T9: without light, T10: 3'light, T11: 6 'light, T12: 9' light)

the enzyme ascorbic acid oxidase (ascorbinase) favoring the senescence of the fruits. The oscillations that occur in vitamin C analysis are, in part, due to the variability that exists between fruits, plants and systems. Wu et al. (2004) and Oliveira et al. (2011), observed that this variation that occurs in the levels of ascorbic acid, and that also occur in the same way for carotenoids and phenolic compounds, are attributed to factors such as maturation stage, cultivation techniques, climatic conditions, different varieties of the same fruit and analyzed parts of the fruit. And also according to Couto & Canniatti-Brazaca (2010), the vitamin C content in foods varies according to the region of cultivation, climate, time of harvest, even though it is the same variety. Detoni et al. (2009), observed that fruits located in the east-west (sun) and north-south (shade) side of plants, have a significant difference in the ascorbic acid content, finding 19.28 and 17.51 mg of ascorbic acid 100 mL- 1 for Ponkan mandarin fruits oriented to the sun and shade, respectively. The amounts of ascorbic acid can also be attributed to the size of the fruit and the stage of maturation, since Lima (1997) observed that the content of ascorbic acid is higher in immature fruits, decreasing with maturation, due to the increase in the size of the fruit. . This tendency to decrease the content of this vitamin during ripening can be attributed to the susceptibility of ascorbic acid to oxidative destruction by the enzymes ascorbic acid oxidase, phenolase, cytochrome C oxidase and peroxidase. Ascorbic acid occurs naturally in fruits in the form of L-ascorbic acid, with tangerines containing an average of 20 to 50 mg of ascorbic acid 100 mL-1 of juice. Sanches et al. (2017) found mean vitamin C values of 38.62 mg 100 g-1 pulp in chilled Ponkan mandarin and irradiated with UVC. Couto & Canniatti-Brazaca (2010) found values of ascorbic acid of 32.47 and 21.47 mg 100 mL – 1 juice in Ponkan and Murcott tangerines, respectively, values that are quite distant from those found for 'Dekopon' tangerine in the present study. The vitamin C values of the 'Dekopon' mandarin are closest to Tommy mangoes (16.2 mg 100g-1 fresh matter) found by Oliveira et al. (2011), and also Montenegrina and Rainha tangerines from the work of Monteiro et al. (2009), where they found values of 13.48 and 15.37 mg 100mL-1 juice, respectively. Na Table 2 são exibidos os dados de frações do fruto em frutos de tangerina 'Dekopon'. Nesta variável houve interação significativa para as variáveis de porcentagem de casca e de bagaço, e não houve interação significativa para a porcentagem de suco.

From the beginning of the experiment until the 30th day, the juice percentage values, in general, remained between 50.39 and 50.44%, which is a value considered satisfactory for both fresh consumption and industrial processing (Silva et al., 2014), the peel present in the fruits had a reduction of 7.84%, observing the final average between days, while the percentage of bagasse increased by 7.79%, as can be seen observed between the final averages of the days. What can be noticed is the inversion, in most treatments, between the percentage of peel and bagasse, while one decreased the other increased, respectively. This effect is probably related to the loss of mass of the skin and pulp. The fractions of the fruit of the present study were lower than those of the Ponkan mandarin (60.2%) found by Longkumer & Kabir (2015). However, it was higher in relation to the work by Ennab (2017), with 49.01% of juice, where he observed the effect of nitrogen and GA3 on the growth, yield and quality of fruits of Ponkan tangerine trees. The fractions of the fruit were also higher than those found by Rodrigo et al. (2015), in orange and tangerine Clementine, on average 48%. The 'Ponkan' tangerine fruits of Silva et al. (2014), showed an average juice yield of 46%. It was also higher than the average values of Lee et al. Ponkan mandarin. (2015) (34.2 to 47.6% of juice), by Zubair et al. (2015) (31.1 to 41.9% of juice) and Al-Obeed et al. (2017) (35.13 to 41.4% of juice).

In this study, it was observed that at ambient temperatures there are significant changes in the physical and physical-chemical properties of the 'Dekopon' mandarin, in the same way as analyzed by Obenland et al. (2013), where they inferred that the loss of flavor in tangerines, occurs exclusively, during the part of the storage protocol, where the fruits are submitted to room temperature. There may be some specificity between the varieties of tangerines with this response, which, however, like most, were influenced by the presence of a refrigeration period at 20 ºC in the storage regime. Although storage may be financially difficult for retailers, such results indicate that keeping tangerines refrigerated has benefits for the quality of the product's flavor, especially if consumers are also encouraged to keep tangerines cold before consumption. There is a large-scale accumulation of aromatic volatiles, which occurs rapidly at 20 ºC, and is largely prevented by cold storage, indicating the involvement of compounds in organoleptic properties (Obenland et al., 2013).

Table 2. Percentage of juice, peel and bagasse (%) in 'Dekopon' mandarin fruits (*Citrus reticulata* 'Shiranuhi') submitted to UVC radiation and cold storage

Treatments		% Juice		Δ dias (%)	% BARK		Δ dias (%)	% BAGASSE		Δ days (%)
UVC (minutes)	T (ºC)	Day 0	30 days		Day 0	30 days		Day 0	30 days	
0	24	50,3aA	52,8aA	4,6	28,9aA	17,5bB	-64,8	20,6bA	29,5aB	30,2
3	24	50,3aA	50,4aA	0,03	28,9aA	18,0bB	-60,2	20,6bA	31,5aA	34,5
6	24	50,3aA	50,8aA	0,8	28,9aA	17,6bB	-64,0	20,6bA	31,4aA	34,5
9	24	50,3aA	48,0aA	-4,9	28,9aA	18,7bB	-54,2	20,6bA	33,1aA	37,9
0	12	50,3aA	51,0aA	1,3	28,9aA	20,8bB	-39,1	20,6bA	28,1aB	26,6
3	12	50,3aA	51,8aA	2,8	28,9aA	20,0bB	-44,7	20,6bA	28,0aB	26,6
6	12	50,3aA	53,0aA	5,0	28,9aA	22,4bA	-28,9	20,6aA	24,4aC	15,6
9	12	50,3aA	50,4aA	0,2	28,9aA	26,6aA	-8,7	20,6aA	22,8aC	9,7
0	6	50,3aA	51,7aA	2,5	28,9aA	23,0bA	-25,6	20,6bA	25,2aC	18,2
3	6	50,3aA	48,8aA	-3,0	28,9aA	22,9bA	-26,0	20,6bA	28,1aB	26,6
6	6	50,3aA	46,7aA	-7,8	28,9aA	24,0bA	-20,5	20,6bA	29,2aB	29,4
9	6	50,3aA	49,3aA	-2,1	28,9aA	21,5bA	-34,7	20,6bA	29,1aB	29,3
Averages		50,3	50,4	0,10	28,9	21,1	-37,0	20,6	28,4	27,4

Note: Means followed by the same, lower case in the line and upper case in the column, between the variables only, do not differ statistically from each other by the Scott-Knott test at 5% probability (P> 0.05).

Final considerations

It is concluded that the association of UVC radiation and refrigeration acted effectively in the post-harvest conservation of 'Dekopon' mandarin, allowing the maintenance of physical and physical-chemical properties, for a longer shelf life, with a temperature of 12 ºC to more indicated, and for the different times of UVC radiation, it can be concluded that the exposure time of 3 minutes made it possible to maintain the desirable characteristics of postharvest of the fruits during the evaluation period in 30 days, mainly, regarding refers to the variables of fresh weight loss, color, metric parameters, ascorbic acid and texture.

REFERENCES

Al-Obeed RS,Ahmed MA,Kassem HA,Al-Sif AM. 2017. Improvement of "Kinnow" mandarin fruit productivity and quality by urea, boron and zinc foliar spray. *Journal of Plant Nutrition, United Kingdom,* 41(5): 609-618.

Anthon GE, Sekine Y, Watanabe N (2002). Thermal inactivation of pectin methylesterase, polylagacturonase, and perosidase in tomate juice. *Journal of Agricultural and Food Chemistry, Munique,* 50(1): 6153-6159.

Belo APM (2017). Caracterização sensorial e físico-química de tangerinas produzidas em goiás. 2017. 107 f. Tese (Doutorado em Agronomia)–Escola de Agronomia, Universidade Federal de Goiás, Goiânia.

Bem FAM (2016). Curva de desidratação e composição químico-bromatológica do feno de jitirana peluda (*Merremia aegyptia* L. Urban). 2016. 18f. Trabalho de Conclusão de Curso (Graduação em Ciências Agrárias)–Universidade Estadual da Paraíba, Catolé do Rocha.

Benassi MT, Antunes AJ (1988). A comparison of meta-phosphoric and oxalic acids as extracts solutions for the determination of vitamin C in vegetables. Arquivos de Biologia e Tecnologia, Curitiba, 31(1):507-513.

Brugnara EC, WeilerRL, Schwarz SF (2012). Avaliação morfológica e agronômica de híbridos de tangerinas Montenegrina e King. *Citrus Research & Technology, Cordeirópolis,* 33(1):11-18.

Camargo RB,TeraoD,Peixoto AR,Ono EO,Cavalcanti LS,Costa RM da (2012). Atmosfera modificada na conservação da qualidade de uva 'Thompson Seedless' e na redução da podridão de Aspergillus. Summa phytopathol, Botucatu, 38(3).

Companhia de Entrepostos e Armazéns Gerias de São Paulo – CEAGESO (2011). Normas de classificação de Citros de mesa, CEAGESPE -São-Paulo, 12p.

Couto MAL,Canniatti-Brazaca SG (2010). Quantificação de vitamina C e capacidade antioxidante de variedades cítricas. Ciência e Tecnologia de Alimentos, Campinas, 30(1): 15-19.

Daiuto ER,Vieites RP,Tremocoldi MA. Carvalho LR. de; Fumes, JGF (2013). Pós-colheita do abacate 'Hass' submetido a radiação UVC. Revista colombiana de ciências hortícolas, Bogotá, 7(2): 149-160.

Detoni AM,Herzog NFM,OhlandT,Kotz T,Clemente E (2009). Influência do sol nas características fisicas e químicas da tangerina 'Ponkan' cultivada no oeste do Paraná. Ciência e agrotecnologia, Lavras, 33(2): 624-628.

Domingues ET,Souza VC,Sakuragui CM,Pompeu Junior J,Pio RM,Teófilo Sobrinho J,Souza JP (1999). Caracterização morfológica de tangerinas de banco ativo de germoplasma de citros do Centro de Citricultura Sylvio Moreira/IAC. Scientia Agrícola, Piracicaba, 56(1): 197-206.

Duarte TF,Bron IU,Ribeiro RV,Machado EC,Mazzafera P,Shimizu MM (2011). Efeito da carga pendente na qualidade de frutos de laranjeira 'Valência'. Revista Brasileira de Fruticultura, Jaboticabal, 33(3): 823-829.

Ennab, HÁ (2017). Effect of nitrogen and GA3 on growth, yield and fruit quality of chinese mandarin trees Menoufia. Journal of Plant Production, Cham, 2(1): 117 – 128.

Ferreira RM de A,Aroucha EMM,Souza PA de,Queiros RF de,Pontes Filho FST (2009). Ponto de colheita da acerola visando à produção industrial de polpa. Revista Verde, Mossoró, 4(2): 13 - 16.

Finger FL,Vieira G (2002). Controle da perda pós-colheita de água em produtos hortícolas. Viçosa: Universidade Federal de Viçosa, 29 p.

Gonzatto MP,Schwarz SF,Oliveira RP de,Bender RJ,Souza PVD de (2017). 'Ursbrs Hada': tangoreiro de maturação tardia e duplo propósito. Revista Brasileira de Fruticultura, Jaboticabal, 37(2).

IAL (2008). Instituto Adolfo Lutz. Normas Analíticas do Instituto Adolfo Lutz: Métodos Químicos e Físicos Para Análise de Alimentos. 3 ed. São Paulo: IAL.

IbusukiD,Fujiwara M,Yokoo Y (2018). Liquid composition including citrus pericarp essential oil. Patent application publication. Number 2018/0064141a1.

Kays SJ (1991). Postharvest physiology of perishable plant products. New York: Van Nostrand Reinhold, 532p.

Khademi OZ,ZamaniE,Poor A,Kalantari S (2013). Effect of UVC radiation on postharvest physiology of persimmon fruit (*Diospyros kaki* Thunb.) cv. 'Karaj' during storage at cold temperature. International Food Research Journal, Serdang, 20(1): 247-253.

Lee T,Zhong P,Chang P (2016). The effects of preharvest shading and postharvest storagetemperatures on the quality of 'Ponkan' (*Citrus reticulata* Blanco) mandarin fruits. Scientia Horticulturae, Viterbo, 188(1): 57–65.

Lim TK (2012). Edible Medicinal And Non-Medicinal Plants. 4. ed. Cham Netherlands: Fruits, 1023 p.

Lima LC de O (1997). Tecido esponjoso em manga 'Tommy Atkins': transformações químicas e bioquímicas no mesocarpo durante o armazenamento. 1997. 151 f. Tese (Doutorado em Ciência dos Alimentos)–Universidade Federal de Lavras, Lavras.

Longkumer M, Kabir J (2015). Correlation and path analysis of physico-chemical characters of mandarin genotypes of nagaland. Research Journal of Agricultural and Environmental Sciences, Bologna, 2(2).

Lu JY,Stevens C,Khan VA, Kabwe M (1991). The effect of ultraviolet irradiation on shelf-life and ripening of peaches and apples. Food Quality, Campinas, 14(1): 299-305.

Machado JAM, Mota MCG da S,Machado C de F,Ledo CA da S,Passos OS (2017). Caracterização de acessos de citros a partir do uso de descritores qualitativos e quantitativos relacionados ao fruto. In: 11ª Jornada Científica – Embrapa mandioca efruticultura.

Marques KM, Miguel ACA,Durigan MFB,Galati VC,Durigan JF (2013). Associação da radiação ultravioleta e de revestimentos na conservação de mangas 'Palmer' previamente armazenadas sob condição promotora de injúria. In: Simpósio brasileiro de pós-colheita de frutas, hortaliças e flores, 2013, Ribeirão Preto. Anais... Ribeirão Preto.

Medina CL,Rena AB,Siqueira DL,Machado EC (2005). Fisiologia dos citros. Journal Citros, Campinas, 1(1): 148-183.

Mendonça V,Ramos JD,Rufini JCM,Araújo Neto SE de,Rossi EP (2006). Qualidade de frutos de tangerineira Ponkan após poda de recuperação. Ciência e Agrotecnologia, Lavras, 30(2): 271-276.

Mercier J, KÚC J (1997). Elicitation of 6-methoxymellein in carrot leaves by Cercospora carotae. Journal of the Science of Food and Agriculture, Chichester, 73(1): 60-62.

Ministério da Agricultura, Pecuária e Abastecimento – MAPA Secretaria de Defesa Agropecuária – SDA. Manual de Métodos de Análises de Bebidas e Vinagres Disponível em:http://www.agricultura.gov.br/arq_editor/file/Aniamal/Laborat%C3%B3rios/Metodos%20IQA/BEV/Nao%20Alc/NAO%20ALCOOLICOS%20%2022%20ACIDO%20ASCORBICO.pdf. Acesso em: 06 set. 2018.

MishraD,Shukla AK,Dixit AK,Singh K (2005). Aqueous enzymatic extraction of oil from mandarin peels. Journal of Oleo Science, Nagasaki, 54(6): 355-359.

Neves LC,Manzione RL,Vieites RL (2002). Radiação gama na conservação póscolheita da nectarina (*Prunus persica* var. nucipersica) frigoconservada. Revista Brasileira de Fruticultura, Jaboticabal, 24(3): 676-679.

Neves MF,Trombin VG,Milan P,Lopes FF,Cressoni F,Kalaki R (2011). O retrato da citricultura brasileira. São Paulo: Centro de pesquisa e projetos em marketing e estratégia, 138 p.

ObenlandD,Collin S,Sievert J,Arpaia ML (2013). Mandarin flavor and aroma volatile composition are strongly influenced by holding temperature. Postharvest Biology and Technology, Amsterdam, 82(1): 6-14.

Oliveira Júnior EN,Santos CD,Abreu CMP,Corrêa AD,Santos JZL (2004). Postharvest changes of "fruta-de-lobo" (*Solanum lycocarpum* St. Hil.) during the ripening process: physical-chemical, chemical and enzymatic analysis. Revista Brasileira de Fruticultura, Jaboticabal, 26(1): 410-413.

OliveiraDda S,Aquino PP,Ribeiro SMR,Proença RP da C,Pinheiro-Sant'ana HM (2011). Vitamina C, carotenoides, fenólicos totais e atividade antioxidante de goiaba, manga e mamão procedentes da Ceasa do Estado de Minas Gerais. Acta Scientiarum and Health Sciences, Maringá, 33(1): 89-98.

Pacheco C de A (2015). Aspectos histológicos, físico-químicos, sensoriais e fitotécnicos da tangerina Fremont. 201 99 f. Tese (Doutorado agricultura tropical e subtropical)–Instituto Agronômico de Campinas, Campinas.

Pacheco C de A,Azevedo FA de,Barros VNP de,Cristofani-Yaly M,Verruma-Bernardi MR (2017). Fremont - IAC 543: tangerine with potential for the brazilian market. Revista Brasileira de Fruticultura, Jaboticabal, 39(especial).

Pinto DM,Vilas Boas EV de B,Damiani C (2006). Qualidade de tangerina ''Ponkan'' minimamente processada e armazenada a 5°C. Ciência Agrotécnica, Lavras, 31(4): 1131- 1135.

Pinto PM,Jacomino AP,Cavalini FC,Cunha Junior LC,Inoue KN (2009). Estádios de maturação de goiabas 'Kumagai' e 'Pedro Sato' para o processamento mínimo. Ciência Rural, Santa Maria, online.

Pio RM,Keigo M,Figueiredo JO de (2001). Características do fruto da variedade Span Americana (*Citrus reticulata* Blanco): uma tangerina do tipo 'Poncã' de maturação precoce. Revista Brasileira de Fruticultura, Jaboticabal, 23(2): 325-329.

Pombo MAD,Martinez MC, Civello GA, Pedro M (2009). UVC irradiation delays strawberry fruit softening and modifies the expression of genes involved in cell wall degradation. Postharvest Biology and Technology, Amsterdam, 51(1): 141-148.

RigoloG,Benato EA,CiaP,Anjos VDA,Sarantopoulos CL,Berto MI,Castro MF de,KaihatuC (2009). Radiação ultravioleta (UVC) e atmosfera modificada na conservação de uva cv. centennial seedless. Instituto Agronômico de São Paulo – IAC.

Rivera-Pastrana DM,Gardea AA,Yahia EM,Martínez-Téllez MA,González-Aguilar GA (2014). Effect of UVC irradiation and low temperature storage on bioactive compounds, antioxidant enzymes and radical scavenging activity of papaya fruit. Journal Food Science Technology, Cham, 51(12): 3821–3829.

Rodrigo MJ,CillaA,BarberáR,Zacarías L (2015). Carotenoid bioaccessibility in pulp and fresh juice from carotenoid-rich sweet oranges and mandarins. Food & Function, São Paulo, 6(6): 1950-1959.

Rosa JS da,Godoy RL de O,Oiano Neto J,Campos R da S,Matta, VM da,Freire CA,Silva AS,Souza RS de (2007). Development of a method for vitamin C analysis in food using high performance liquid chromatography and ion exclusion. Ciência e Tecnologia de Alimentos, Campinas, 27(4): 837-846.

Sanches AG,Silva MB da,Moreira EGS,Cosme SS,Cordeiro CAM (2017). Radiação UVC na longevidade pós-colheita de tangerinas sob refrigeração. Revista Agrarian, Dourados, 10(36): 129-135.

Santos LO (2011). Armazenamento refrigerado, atmosfera controlada e desverdecimento de tangerinas. 2011. 143 f. Tese (Doutorado em agronomia) - Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal.

Sartori IA,Koller OC,Schwarz SF,Bender RJ,Schäfer G (2002). Maturação de frutos de seis cultivares de laranjas-doces na depressão central do Rio Grande do Sul. Revista Brasileira de Fruticultura, Jaboticabal, 24(2): 364-369.

ShamaG,Alderson P (2005). UV hormesis in fruits: a concept ripe for commercialization. Trends in Food SCience and Technology, Loughborough, 16(1): 128-136.

Silva APG da,Silva S de M,Schunemann APP,Dantas AL,Dantas RL,Silva JA da,Mendonça RMN (2014). Índices de identidade e qualidade de tangerina 'Ponkan' produzida no estado da Paraíba. Revista Agropecuária Técnica, João Pesoa, 35(1): 143-149.

Silva LRA da,Silva GMC,Silva WB,Souza CLM de,Oliveira JG de (2015). Atividade respiratória em mitocôndrias isoladas da polpa do mamão uenf/caliman 01 e tainung 01 na conservação do fruto em pós-colheita. Revista Brasileira de Fruticultura, Jaboticabal, 37(2).

Silva PS,NavroskiR,Arruda AL,Richter AF,Barreto CF,Macedo TA de,Malgarim MB (2017). Filmes comestíveis na conservação de laranjas 'Salustiana'. Revista da 14ª Jornada de Pós-Graduação e Pesquisa, Bagé, 14(14).

Simas DLR,Amorim SHBM de,Oliveira JM de,Alviano DS,Silva AJR da (2015). Caracterização dos óleos essenciais de frutas cítricas. Citrus Research & Technology, Cordeirópolis, 36(1): 15-26.

Sinha NK,Hui YH,Evranuz E,Siddiq M,AhmedJ (2011). Handbook of vegetables and vegetable. Washington: Blackwell Publishing Ltd, 788 p.

Souza AER de (2015). Fisiologia e proteômica enriquecida de parede celular em cana-de-açúcar (Saccharum spp.) sob estresse por radiação ultravioleta B e seca. 251 f. Tese (Doutorado em genética)–Centro de Ciências Biológicas, Universidade Federal de Pernambuco, Recife.

Spagnol WA,Silveira Junior V,Pereira E,Guimarães Filho N (2018). Monitoring the cold chain: new technologies and recent advances. Brazilian Journal of Food Technology, Campinas, 21(13).

Stefanello S,Schuelter AR,Scapim CA,Finger FL,Pereira GM,Bonato CM,Rocha AC. de S,Silva JM (2010). Amadurecimento de frutos de cubiu (*Solanum sessiliflorum* Dunal) tratados com Etefon. Acta Amazônica, Manaus, 40(3): 415-434.

Stevens C,Khan VA,LuJY,Wilson CL,Pusey PL,KabweMK,Igwegbe ECK,Chalutz E,Droby S (1998). The germicidal and hormetic effects of UVC light on reducing brown rot disease and yeast microflora of peaches. Crop Protection, Guildford, 17(1): 75-84.

Taiz L, Zaiger E, Moller IM,Murphy A (2017). Fisiologia e desenvolvimento vegetal. 6. ed. Porto Alegre: Artmed, 888 p.

Taiz, L, Zeiger, E (2004). Fisiologia vegetal. 3. ed. Porto Alegre: Artmed, 719 p.

Teruya T,Teruya Y,Sugiyama S,Woo J (2015). method for manufacturing composition containing nobiletin and tangeretin derived from citrus fruits, and composition containing nobiletin and tangeretin obtained thereby. Patent Application Publication. United States. Pub. No, US 2015/0283196A1.

Thé PMP, NUNES R de P, CARVALHO VD de (2009). Efeitos de tratamentos pós-colheita sobre fatores que influenciam na textura de abacaxis cv. Smooth Cayenne. Revista Ceres, Viçosa, 56(6): 705-712.

Tiecher, A (2010). Efeito da radiação UVC na expressão gênica e nas respostas bioquímico-fisiológicas em frutos de tomate (Solanum lycopersicum Mill.). 2010. 70 f. Dissertação (Mestrado em ciências)–Faculdade de Agronomia Eliseu Maciel, Universidade Federal de Pelotas, Pelotas.

Tietel Z,Fallik E,Lewinsohn E,Porat R (2012). Importance of storage temperatures in maintaining flavor and quality of mandarins. Postharvest Biology and Technology, Amsterdam, 64(1): 175-182.

Tingman W,Jian Z,Xiaoshuan Z (2010). Fish product quality evaluation based on temperature monitoring in cold chain. African Journal of Biotechnology, África, 9(37): 6146-6151.

Todisco KM, Clemente E, Rosa CILF (2012). Conservação e qualidade pós-colheita de laranjas “folha murcha” armazenadas em duas temperaturas. Revista em Agronegócios e Meio Ambiente, Maringá, 5(3): 579-591.

Vale AAS, Santos SD dos, Abreu CMP de, Corrêa AD, Santos JÁ (2006). Alterações químicas, físicas e físico-químicas da tangerina 'ponkan' (*Citrus reticulata* Blanco) durante o armazenamento refrigerado. Ciência e Agrotecnologia, Lavras, 30(4): 778-786.

Vasconcelos LHC (2015). Radiação ultravioleta C e embalagens na conservação pós-colheita de cajá-manga. 2015. 90 f. Dissertação (Mestrado em engenharia agrícola)– Campus de Ciências Exatas e Tecnológicas, Universidade Estadual de Goiás, Anápolis.

Vilas Boas EV de B (2002). Tecnologia de processamento mínimo de banana, mamão e kiwi. In: 1º Seminário internacional de pós-colheita e processamento mínimo de frutas e hortaliças, 7., 2002. Piracicaba. Anais... Escola Superior de Agronomia “Luiz de Queiroz”.

Zubair M,Balal RM,Aqueel MA,Shahid MA,Akhtar G,AkramA,Khan MW,Sadiq MA (2015). Nutritional assessment of kinnow mandarin fruit (*Citrus reticulata* blanco), infected by few sucking insect-pests of Citrus. Pakistan Journal of Nutrition, Dubai, 14(8): 487-491.

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