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Postharvest conservation of fresh and minimally processed 'Dekopon' tangerine in different temperatures and storage times

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ABSTRACT

This study aimed to evaluate the effect of refrigeration and the storage time of fresh and minimally processed tangerine 'Dekopon' seeking to increase its useful life for marketing. In experiment 1, the harvested fruit were stored in temperatures of 4, 8 and 12 °C and analyzed in 0, 5 and 10 days. In experiment 2, the fruit were minimally processed (the fruit was peeled and the buds highlighted and distributed in trays in three replicates) and storage at temperatures of 4, 8 and 12 °C and analyzed 0, 3, 6, 9 and 12 days. The analysis of the evaluated data were weight loss, pH, total soluble solids (TSS), titratable acidity (TA), ratio TSS:TA, Vitamin C and color parameters. The results for experiment 1 showed that in general, day 0 presented higher values of physicochemical parameters and day 5 at 8 °C presented higher concentration of vitamin C; the fresh juice showed higher brithness at day 10. For experiment 2, in the minimally processed fruit, day 3 demonstrated more retention of physicochemical parameters, except for mass loss and day 12 at 4 °C resulted in a higher content of vitamin C.

KEYWORDS: *Citrus reticulata* Shiranui; postharvest; minimally processed; vitamin C.

INTRODUCTION

Dekopon originated in Japan in the early 1970s, reaching Brazil at 1980 in the South of Minas Gerais. It has been occupying space in the main commercial centers of Brazil, such as CEAGESP (Company of Warehouses and General Warehouses of São Paulo), where the volume sold doubled in the period from 2008 to 2013 (Ferreira, 2014).

In genus Citrus it is grouped a great diversity of species which differ mainly on fruit size, peel coloring and flavor. The tangerines stands out on this genus and several studies highlight its importance on health promotion as a source of vitamins, minerals, fiber and bioactive compounds, such as carotenoids, phenolic acids and flavonoids. The 'Dekopon' (*Citrus reticulata* Shiranuhi mandarin Suppl. J.) is one of tangerine cultivars result from a cross hybridization of 'Ponkan' (*Citrus reticutata* Bla.) and 'Kiyomi tangor' (*Citrus unshiu* Marc. × *Citrus sinensis* Osb.). Its fruit are tender, juicy and very sweet reaches prices above average comparing to other tangerine cultivars on Korea, Japan and Brazil market. It is an excellent dessert as fresh fruit and is also used for marmalades, jams, beverages and vinegar. Its peel improves the taste of many dishes especially baked fish, sashimi and hot pot dishes (UMANO; YUKIO; SHIBAMOTO, 2002; LIM, 2012).

The short harvest period restricts 'Dekopon' fruit supply causing price variation and not meets consumer year-round demand. Therefore, it is necessary to use techniques that enable conservation of fruit by slowing the process of senescence without compromising quality which implies on understanding of biological factors involved in storage process (GONZÁLEZ-MOLINA *et al.,* 2010).

The postharvest technologies has aided the commercial success of citric fruit in worldwide, by management of different techniques such as selection and classification, packaging, storage, processing, quality assessment, transport and control of storage conditions (temperature, humidity and atmospheric composition) and control of postharvest physiological disorder and microbial decay. There is also improvements in methods of packaging, storage and processing but in some cases, improved methods are not used and must be available (YAHIA; ORNELAS-PAZ, 2011).

Researchers have studied the development of techniques that offer products with fresh features to consumers. Minimally processing is a set of simple and applicable practices to most fruit and vegetables (such as washing, cutting and storage), which aims to add value, preserve visual and nutritional quality and offer consumers fresh products with greater convenience (FONSECA *et al.*, 1998).

The objective of this study was to investigate the potential for postharvest conservation through the physicochemical characteristics of fresh and minimally processed 'Dekopon' tangerine exposed to different temperatures and storage times.

MATERIAL AND METHODS

Tangerine fruit of cultivar 'Dekopon' from commercial orchard in Campanha county,south of Minas Gerais, Brazil - latitude 21 ° 49 '54 "south, longitude 45 ° 24' 28" W and an average height of 861 meters humid subtropical climate. The fruit were harvested in August 2013 in the morning and transported to the Post Harvest

Fruit and Vegetable Laboratory of the Department of Food Science of the Federal University of Lavras / MG. These were washed with neutral detergent in running water to remove possible soils, sanitized with sodium hypochlorite 150mg.L^{-1} for 15 minutes, dried on paper towel and then peeled off. Finally they were packed in polyethylene trays with lid (one fruit per tray) and stored in cold chamber. After being sanitized, they were separated into two experiments:

Experiment 1 – Fresh fruit were stored at temperatures of 4, 8 and 12 °C and analysed at 0, 5 and 10 days. The storage time was chosen based on the information provided by the producer who uses 10 days of empirical way to decrease the acidity.

Experiment 2 - Minimally processed fruit (the fruit was peeled and the buds highlighted and distributed in trays in three replicates) were stored at temperatures of 4, 8 and 12 °C and analyzed for 0, 3, 6, 9 and 12 days.

At the end of storage period of each experiments the following analyzes were performed: pH measured using a pHmeter (Quimis, model Q-400A); the total soluble solids (TSS) were determined by the digital refractometer (ATAGO PR-100) with automatic temperature compensation to 25 °C and the results expressed in Brix. Titratable Acidity (TA) - titration with 0.1N sodium hydroxide using phenolphthalein as an indicator in accordance with the AOAC (1997) and results were expressed as percentage of citric acid and it was also calculated the soluble solids: titratable acidity (ratio or TSS:AT).

The physical parameters evaluated were: mass obtained by direct reading in precision scale in kg. The color measurements were performed using a portable colorimeter (Konica Minolta Model CR 400, Singapore). The color measurements were made in the peel and pulp always in the middle region of the fruit, in three replicates (without removing the vesicles and with membranes). For the juice, the fruits were totally crushed, without distinction of points, that is, everything was taken advantage of. The colorimetric parameters were obtained according to the Commission Internationale de l'Eclairage (CIELAB system) and they include the values of L * (brightness), and the coordinates a * (red-green component) and b * (yellow-blue component).

Vitamin C was determined by the colorimetric method using 2,4-dinitrophenylhydrazine, according Strohecker and Henning (1967) and the results were expressed in mg of ascorbic acid kg of fresh weight.

The data were analyzed by ANOVA and Tukey's mean comparison test at a significance level of 5%, followed by a principal component analysis (PCA) using the software R (R Development Core Team, 2013).

RESULTS AND DISCUSSION

The results of physicochemical analysis of fresh tangerine 'Dekopon' are shown in Table 1. In day 5 at 12 °C and 10 at 12 and 8 °C, occurred the greatest fruit mass loss (ML). For the pH, there was no significant difference between the analyzed treatments. Fruit at day 10 (4, 8 and 12 °C) showed a higher titratable acidity (TA), but lower total soluble solids concentration (TSS). For relationship between AT:TSS, day 0 at 4, 8 and 12 °C showed higher values.

Table 1. Content of mass loss (ML), pH, titratable acid (TA), total soluble solids (TSS), ratio of fresh tangerine ‘Dekopon’ with mean and standard deviation (n = 3).

Experiment 1 – Fresh tangerine ‘dekopon’						
Time	Temperature	ML (kg)	pH	TA	TSS	Ratio
Day 0	4 °C	0.0000^{a} ± 0.00	3.38^{a} ± 0.03	1.23^{b} ± 0.05	17.69^{a} ± 0.17	14.36^{a} ± 0.67
	8 ºC	0.0000^{a} ± 0.00	3.38^{a} ± 0.03	1.23^{b} ± 0.05	17.69^{a} ± 0.17	14.36^{a} ± 0.67
	12 °C	0.0000^{a} ± 0.00	3.38^{a} ± 0.03	1.23^{b} ± 0.05	17.69^{a} ± 0.17	14.36^{a} ± 0.67
Day 5	4 °C	0.0009^{b} ± 0.08	3.39^{a} ± 0.04	1.28^{b} ± 0.04	16.57^{a} ± 0.25	12.98^{ab} ± 0.36
	8 ºC	0.0006^{b} ± 0.19	3.28^{a} ± 0.12	1.45^{b} ± 0.13	16.80^{a} ± 0.46	11.61^{b} ± 1.29
	12 °C	0.0017^{c} ± 0.30	3.32^{a} ± 0.08	1.43^{b} ± 0.16	17.02^{a} ± 0.59	12.03^{ab} ± 1.61
Day 10	4 °C	0.0009^{b} ± 0.10	3.33^{a} ± 0.06	2.12^{a} ± 0.04	11.25^{b} ± 0.61	5.32^{c} ± 0.37
	8 ºC	0.0034^{e} ± 0.04	3.39^{a} ± 0.08	2.18^{a} ± 0.00	11.08^{b} ± 1.02	5.08^{c} ± 0.47
	12 °C	0.0022^{d} ± 0.31	3.33^{a} ± 0.02	2.15^{a} ± 0.03	10.93^{b} ± 0.67	5.08^{c} ± 0.36

NOTE: $^{a-d}$ Different superscript letters in the same column indicate statistically significant difference ($p < 0.05$); *Mass Loss (ML), Titratable Acid (TA), Total Soluble Solids (TSS).

The larger mass losses for minimally processed fruit have been found during storage after days 6 at 4 °C and 3 at 4 and 8 °C (Table 2). It has been shown that storage on day 3 at temperatures of 4, 8 and 12 °C had a higher pH than the other treatments. For TA and the relationship between AT:TSS there were no significant differences in the storage time. As for TSS, the day 0 at 4, 8 and 12 °C and the day 9 at 4 °C showed higher concentrations.

Table 2. Content of mass loss (ML), pH, titratable acid (TA), total soluble solids (TSS), ratio of minimally processed tangerine ‘Dekopon’ with mean and standard deviation (three replicates).

Experiment 2 – Minimally processed tangerine ‘dekopon’						
Time	Temperature	ML (kg)	pH	TA	TSS	Ratio
Day 0	4 °C	0.0000^{a} ± 0.00	3.53^{bcd} ± 0.06	1.19^{a} ± 0.05	17.69^{a} ± 0.17	14.82^{a} ± 0.48
	8 ºC	0.0000^{a} ± 0.00	3.53^{bcd} ± 0.06	1.19^{a} ± 0.05	17.69^{a} ± 0.17	14.82^{a} ± 0.48
	12 °C	0.0000^{a} ± 0.00	3.53^{bcd} ± 0.06	1.19^{a} ± 0.05	17.69^{a} ± 0.17	14.82^{a} ± 0.48
Day 3	4 °C	0.0032^{c} ± 0.17	3.67^{abc} ± 0.03	1.39^{a} ± 0.11	16.96^{ab} ± 0.21	12.28^{a} ± 1.17
	8 ºC	0.0085^{d} ± 0.75	3.94^{a} ± 0.13	1.22^{a} ± 0.09	17.61^{a} ± 0.33	14.45^{a} ± 1.25
	12 °C	0.0004^{a} ± 0.16	3.83^{ab} ± 0.13	1.22^{a} ± 0.15	16.79^{ab} ± 0.77	13.82^{a} ± 1.16
Day 6	4 °C	0.0035^{c} ± 1.36	3.60^{abcd} ± 0.26	1.34^{a} ± 0.41	16.76^{ab} ± 0.61	13.25^{a} ± 0.88
	8 ºC	0.0011^{ab} ± 0.23	3.56^{bcd} ± 0.04	1.34^{a} ± 0.18	17.28^{ab} ± 0.37	13.07^{a} ± 1.49
	12 °C	0.0004^{a} ± 0.18	3.49^{bcd} ± 0.06	1.32^{a} ± 0.09	15.99^{b} ± 0.56	12.13^{a} ± 1.06
Day 9	4 °C	0.0003^{a} ± 0.01	3.32^{d} ± 0.10	1.56^{a} ± 0.08	17.93^{a} ± 0.49	11.53^{a} ± 0.94
Day 12	4 °C	0.0020^{bc} ± 0.88	3.47^{cd} ± 0.17	1.47^{a} ± 0.19	16.80^{ab} ± 1.21	11.84^{a} ± 2.31

NOTE: $^{a-d}$ Different superscript letters in the same column indicate statistically significant difference ($p < 0.05$).

The color parameters of the experiment 1 (fresh tangerines) are shown in Table 3. For color L* that indicate brightness, the peel values were higher on days 0 and 5 in all temperatures tested (4, 8, and 12 °C). For pulp, the 5 day at temperatures of 4, 8 and 12 °C showed higher brightness and in the juice was higher in treatment on day 10 at 4, 8 and 12 °C.

Table 3. Color parameters of fresh tangerine ‘dekopon’ with mean and standard deviation (three replicates).

		Experiment 1 – Fresh tangerine ‘Dekopon’								
		Color L*			Color a*			Color b*		
Time	Temperature	Peel	Pulp	Juice	Peel	Pulp	Juice	Peel	Pulp	Juice
Day 0	4 °C	62.41^{a} ± 0.58	72.93^{ab} ± 1.50	47.06^{b} ± 2.71	37.28^{bc} ± 0.92	7.11^{a} ± 0.76	13.02^{bc} ± 1.04	63.62^{cd} ± 0.97	21.13^{a} ± 0.20	44.14^{b} ± 0.86
	8 ºC	62.41^{a} ± 0.58	72.93^{ab} ± 1.50	47.06^{b} ± 2.71	37.28^{bc} ± 0.92	7.11^{a} ± 0.76	13.02^{bc} ± 1.04	63.62^{cd} ± 0.97	21.13^{a} ± 0.20	44.14^{b} ± 0.86
	12 °C	59.83^{a} ± 2.80	72.93^{ab} ± 1.50	47.06^{b} ± 2.7	37.35^{bc} ± 0.61	7.11^{a} ± 0.76	13.02^{bc} ± 1.04	63.44^{cd} ± 1.15	21.13^{a} ± 0.20	44.14^{b} ± 0.86
Day 5	4 °C	60.86^{a} ± 0.77	75.56^{a} ± 1.71	46.33^{b} ± 2.97	39.14^{ab} ± 0.84	6.27^{a} ± 1.18	9.41^{c} ± 2.63	69.50^{a} ± 1.59	19.92^{a} ± 1.39	44.43^{b} ± 5.05
	8 ºC	61.26^{a} ± 1.59	75.21^{a} ± 1.78	47.41^{b} ± 0.41	40.18^{a} ± 0.92	5.45^{a} ± 0.61	9.21^{c} ± 1.26	69.64^{a} ± 2.55	19.31^{a} ± 1.96	43.45^{b} ± 1.43
	12 °C	61.19^{a} ± 0.54	74.63^{a} ± 0.93	47.41^{b} ± 1.26	38.52^{ab} ± 0.11	6.34^{a} ± 0.82	9.91^{c} ± 1.37	66.31^{ac} ± 2.88	20.49^{a} ± 1.29	44.20^{b} ± 1.36
Day 10	4 °C	54.31^{b} ± 0.28	68.04^{bc} ± 1.90	57.84^{a} ± 2.47	34.98^{c} ± 1.22	5.22^{a} ± 1.04	15.86^{ab} ± 1.05	57.12^{b} ± 1.67	18.04^{a} ± 1.68	56.10^{a} ± 1.06
	8 ºC	55.10^{b} ± 0.71	66.63^{bc} ± 1.21	56.98^{a} ± 1.17	35.23^{c} ± 0.71	5.60^{a} ± 0.99	17.72^{a} ± 1.96	58.73^{bd} ± 2.31	19.18^{a} ± 1.23	57.72^{a} ± 3.21
	12 °C	56.04^{b} ± 0.59	67.14^{c} ± 4.26	55.33^{a} ± 0.94	34.72^{c} ± 0.80	5.20^{a} ± 2.38	16.37^{ab} ± 0.23	60.12^{bd} ± 1.59	18.93^{a} ± 2.39	55.22^{a} ± 2.03

NOTE: $^{a\text{-}d}$ Different superscript letters in the same column indicate statistically significant difference ($p < 0.05$).

Regarding the color a* (red-green intensity) and b* color (yellow-blue color intensity), the peel showed greater intensity on day 5 in all tested temperatures (4, 8 and 12 °C). For the pulp, there was no significant difference in the time and storage temperatures in relation to the color parameters a* and b*. As for the juice treatment, the day 10 at 4, 8 and 12 °C showed greater intensity of color a* and b*.

Table 4 shows the color parameters analyzed in the pulp and juice of minimally processed tangerines. Regarding the L* color, the pulp showed higher value during the days 3 and 6 at 12 °C. Already the juice showed the highest values on day 3 at 4 °C. Both in color parameters a* and b*, there was no significant difference between treatments tested for pulp. As for juice, the highest values were found for day 6 at 4°C temperature.

Caro *et al.* (2004) evaluated Citrus fruit of different species and cultivars, (‘‘Red blush’’ grapefruit, ‘‘Palazzelli’’ mandarin-type fruit, ‘‘Minneola’’ tangelo and ‘‘Salustiana’’ and ‘‘Shamouti’’ orange) were minimally processed as segments (for 0, 4, 8 and 12 days) or juices (0, 5, 10 and 15 days) and cold-stored at 4 °C. There were significant variations only in the chemical parameters of segments (not for juices). They observed significant changes of TSS in ‘‘Minneola’’ tangelos (it was higher at 0 and 5 days of storage) and ‘‘Palazzelli’’ mandarin (higher at 4, 8, and 12 days of storage), of pH in ‘‘Minneola’’ tangelos (higher at 4 days of storage) and ‘‘Shamouti’’ oranges (higher at 8 and 12 days of storage), and of TA in ‘‘Salustiana’’ oranges (higher acidity at 8 days of storage). These authors found similar results of TSS and TA when compared to our study for fresh tangerines, but different results of TSS, pH and TA when compared of minimally processed tangerines.

Table 4. Color parameters of minimally processed tangerine 'Dekopon' with mean and standard deviation (three replicates).

Experiment 2 – Minimally processed tangerine 'Dekopon'							
		Color L*		Color a*		Color b*	
Time	Temperature	Pulp	Juice	Pulp	Juice	Pulp	Juice
Day 0	4 °C	72.93^{abc} ± 1.50	47.06^{b} ± 2.71	7.11^{a} ± 0.76	13.02^{ab} ± 1.04	21.12^{a} ± 0.20	44.14^{bc} ± 0.86
	8 ºC	72.93^{abc} ± 1.50	47.06^{b} ± 2.71	7.11^{a} ± 0.76	13.02^{ab} ± 1.04	21.12^{a} ± 0.20	44.14^{bc} ± 0.86
	12 °C	72.93^{abc} ± 1.50	47.06^{b} ± 2.71	7.11^{a} ± 0.76	13.02^{ab} ± 1.04	21.12^{a} ± 0.20	44.14^{bc} ± 0.86
Day 3	4 °C	73.67^{ab} ± 2.40	55.17^{a} ± 2.35	6.95^{a} ± 2.96	11.12^{b} ± 0.98	20.97^{a} ± 3.94	42.73^{c} ± 3.72
	8 ºC	72.88^{abc} ± 0.36	49.39^{b} ± 1.84	7.03^{a} ± 0.52	11.06^{b} ± 2.75	21.40^{a} ± 0.78	42.79^{c} ± 3.83
	12 °C	75.25^{a} ± 4.66	52.20^{ab} ± 1.82	6.50^{a} ± 3.61	12.31^{ab} ± 3.29	19.33^{a} ± 4.34	42.75^{c} ± 2.62
Day 6	4 °C	71.53^{abc} ± 7.95	51.07^{ab} ± 1.21	6.08^{a} ± 2.06	16.29^{a} ± 1.37	18.86^{a} ± 2.20	55.50^{a} ± 1.15
	8 ºC	73.52^{ab} ± 2.53	50.94^{ab} ± 1.34	5.93^{a} ± 2.17	13.43^{ab} ± 1.80	19.89^{a} ± 2.72	50.55^{ab} ± 3.53
	12 °C	76.74^{a} ± 5.70	49.50^{b} ± 1.02	4.63^{a} ± 2.97	10.73^{b} ± 0.97	17.67^{a} ± 2.49	45.43^{bc} ± 2.01
Day 9	4 °C	62.51^{c} ± 4.18	50.99^{ab} ± 1.59	6.84^{a} ± 2.86	14.11^{ab} ± 0.66	19.25^{a} ± 3.43	50.09^{ab} ± 2.48
Day 12	4 °C	63.95^{bc} ± 0.30	40.43^{c} ± 0.39	5.67^{a} ± 0.52	4.87^{c} ± 0.29	17.75^{a} ± 2.45	32.85 ± 0.85^{d}

NOTE: $^{a-d}$ Different superscript letters in the same column indicate statistically significant difference ($p < 0.05$).

Esteve *et al.* (2005) analyzed the physicochemical parameters of various minimally pasteurized refrigerated orange Spanish juices (A, B, C and D) and their changes with storage time (0, 1, 2, 3, 4, 5, and 5 weeks) and temperature (4 and 10 °C). A significant increase in acidity was observed in sample D at 4 °C and at 10 °C after 4 and 3 weeks respectively, and in sample C at 4 °C and 10 °C after 2 weeks of storage. This increase in acidity indicates the start fermentation or spoilage of sample. During six weeks of storage at 4 and 10 °C the variations in pH observed in the juices studied did not become statistically significant. During storage at 4 °C there were slight decreases in L* and variations in a* and b* colors which were not significant in any of three indices. With storage at 10 °C there was a significant increase in L* color from initial value in juices A, C and D, respectively, at end of first or second week. In B, however, no significant variations were observed. At 10 °C there were also significant increases in color a* in juice A, when compared with three weeks of storage, and significant reductions in color b* in juice D, when compared with two weeks of storage. The variations in other parameters and juices at 10 °C were not significant. These data are in accordance with our data for pH, TA, L* and color a* for fresh tangerines.

Brackmann *et al.* (2008) conducted a research to evaluate the effect of temperature and relative humidity (RH) on quality of tangerines 'Montenegrina'. The treatments were the combination of three temperatures (2, 3 and 4 °C) and two relative humidity levels (90 and 96 %). They analyzed the total soluble solids and titratable acidity. The authors concluded that among temperatures and RH evaluated, best storage temperature for tangerine 'Montenegrina' was 3 °C and the RH air was 90 %, being that RH of 96 % increases occurrence of rots. The tangerine "Montenegrin" may be stored for eight weeks without major losses, already after 12 weeks, may be significant losses due to rot.

Rapisarda et al. (2008) investigated the effect of cold storage on physicochemical parameters of five sweet orange genotypes ('Tarocco Messina', ‘Tarocco Meli’, ‘Moro’, ‘Ovale’ and ‘Valencia’) stored at 6±1 °C for 65 days (0, 20, 40 and 65). An increase in TSS during storage occurred in all samples. The TSS and TA ratio increased during storage in all varieties with the exception of ‘Valencia’ orange where a drop was observed on the 65th day of storage. Fruit weight loss after 65 days of storage was less than 5% with respect to initial weight. Titratable acidity remained constant in the early stages of storage, and then decreased in all the varieties, except for ‘Valencia’ orange which increased slightly. This trend is reflected on pH levels which significantly increased at the end of storage, whereas a slight decrease in ‘Valencia’ fruit was observed. Citric acid has been reported to decrease in stored citrus fruit and this decline may be in part due to use of organic acids for energy production and alcoholic fermentation. These results are not in agreement with our study, because the TA increased or did not a significative difference for fresh and minimally processed tangerines, respectively, in the course of storage time.

Agostini *et al.* (2013) researched the influence of the level of minimal processing on the quality of ‘Champagne’ orange stored under refrigeration. The minimally processed oranges were stored at 5 (± 1 ºC) for 8 days and were subjected to physicochemical analyses every two days. During storage, there was a slight increase in Total Soluble Solids (TSS) for the treatments with greater weight loss and reduction in acidity and ascorbic acid. The minimally processed fruit kept their overall fresh visual appearance with a few physicochemical changes up to the 8th day of storage. The data found are not in accordance with our data because the greater mass loss was at day 3, TSS were higher at time 0 and day 4 at 9 °C showed more losses of acid ascorbic for minimally processed tangerines.

Lee, Zhong and Chang (2015) realized a study with a two-year trial to investigate the effects of postharvest storage at 13.5 °C or 25 °C on physiological responses and quality of ‘Ponkan’ (*Citrus reticulata* Blanco) mandarin fruit. They analyzed physicochemical parameters how: color of peel, TSS and TA. They concluded that there were no significant differences in peel color, TSS and TA in the ‘Ponkan’ mandarin fruit postharvest at different temperatures (13.5 °C and 25 °C). These data are in agreement with our study only for TA in minimally processed tangerines.

Figure 1 shows ascorbic acid content of fresh (A) and minimally processed (B) tangerine ‘Dekopon’ under different temperatures and storage time. For fresh tangerines, highest value was found during day 0 at 4, 8 and 12 °C in relation to other tested treatments. Vitamin C is considered the most prone to degradation by exposure to light, heat, presence of oxygen and the pH of the medium, among other conditions (Cunha et al. 2014). Thus, vitamin C content has significant losses throughout storage as observed in this study. The highest losses were found to day 10 at 8 °C. For minimally processed tangerines, on day 12 at 4 °C showed higher concentrations and day 9 at 4 °C the lower concentrations. The content of vitamin C presented quite variations because some fruits had higher concentrations than others, therefore, it should have homogenized the samples before storage.

Caro *et al.* (2004) evaluated the ascorbic acid content of Citrus fruit of different species and cultivars, (‘’Red blush’’ grapefruit, ‘’Palazzelli’’ mandarin-type fruit, ‘’Minneola’’ tangelo and ‘’Salustiana’’ and ‘’Shamouti’’ orange) and were minimally processed as segments (for 0, 4, 8 and 12 days) or juices (0, 5, 10 and 15 days) and cold-stored at 4 °C. For segments, “Salustiana orange” and “Minneola Tangelo” reduced levels of ascorbic acid after 15 days of storage. As for juice, only variety

"Salustiana orange" reduced concentration after 10 and 15 days of storage. The results of ascorbic acid juices are in accordance with our data for minimally processed fruit, because we found that day 12 at 4°C showed highest levels of this compound.

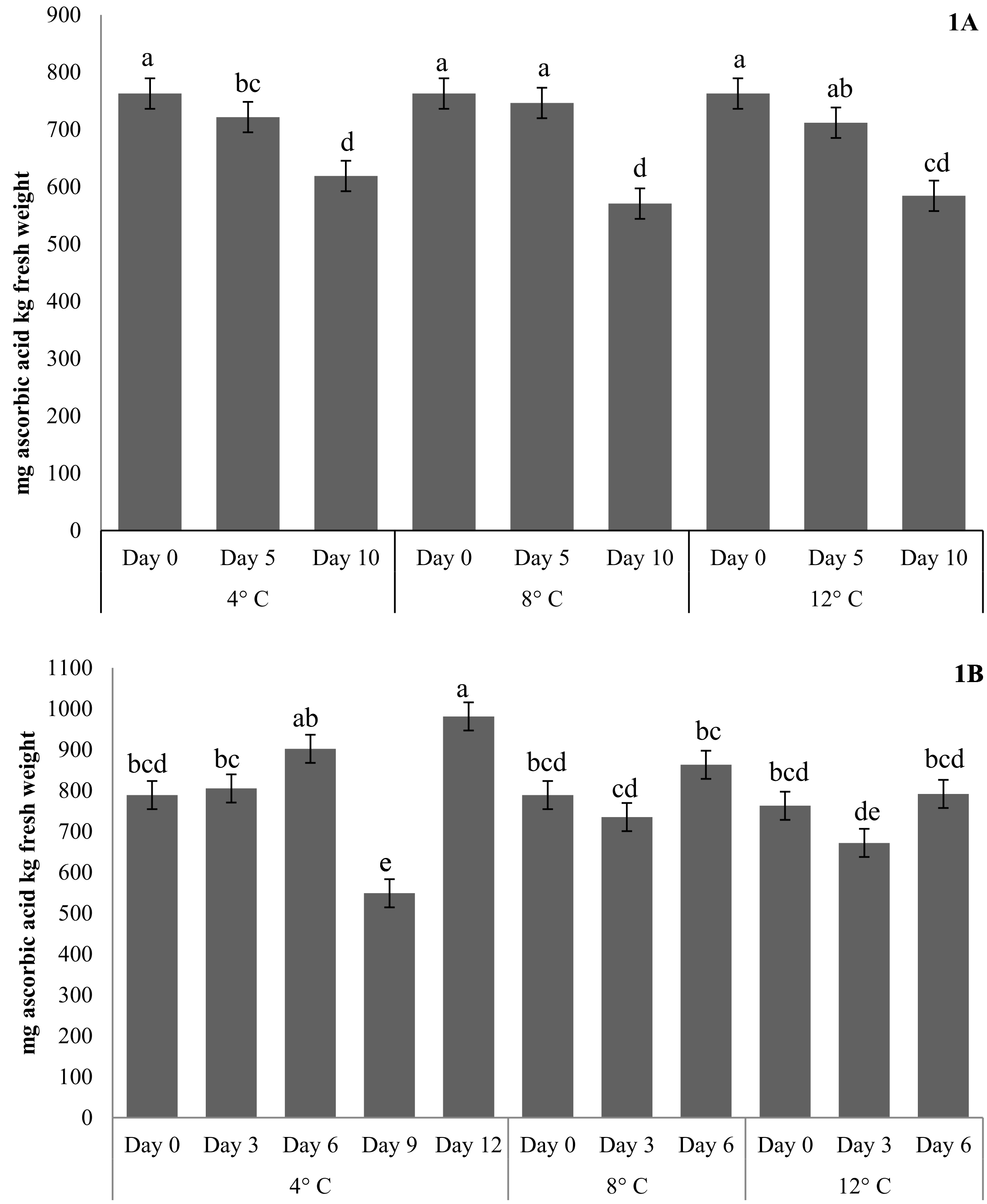

Figure 1 - Ascorbic acid content of fresh (A) and minimally processed (B) tangerine 'Dekopon' under different temperatures and storage time.
NOTE: [a-e] Different superscript letters indicate statistically significant difference ($p < 0.05$).

Esteve *et al.* (2005) analyzed ascorbic acid the content of various minimally pasteurized refrigerated orange Spanish juices (A, B, C and D) and their changes with storage time (0, 1, 2, 3, 4, 5, and 5 weeks) and temperature (4 and 10 °C). They observed that ascorbic acid content of juices decreased as well for 4 °C as 10° C, but faster at 10 °C than at 4 °C.

Burdurlu, Koca and Karadeniz (2006) investigated ascorbic acid degradation in citrus juice concentrates (orange, lemon, grapefruit, tangerine) during an eight week storage at 28, 37 and 45 °C. They concluded that ascorbic acid in citrus juice concentrates decreased with increasing temperature. Orange juice concentrate had lowest reaction rate at 28 °C when compared to other samples. Since ascorbic acid decomposes easily in acid solutions, lemon juice concentrates (pH 1.82) showed the highest ascorbic acid destruction.

Rapisarda et al. (2008) investigated effect of cold storage on ascorbic acid content of five sweet orange genotypes ('Tarocco Messina', 'Tarocco Meli', 'Moro', 'Ovale' and 'Valencia') stored at 6±1 °C for 65 days (0, 20, 40 and 65). Vitamin C content decreased in 'Moro' and 'T. Meli' oranges. In 'Valencia', this component rose after 40 days of storage, whereas in 'T. Messina' and 'Ovale' it increased initially and then declined. But it was not reduced in fruit antioxidant protection.

The fresh tangerines were evaluated within context of eight physicochemical parameters and vitamin C. By analyzing the components (Fig. 2A), data variance was accounted for significant contributions of 76.28 % for the first and 15.14 % for the second principal components. It was observed that day 0 at 4, 8 and 12 °C presented higher values of TSS, ratio, color a* and b* for pulp, color L* for peel; day 10 at 4, 8 and 12 °C showed high levels of TA and color L* for juice; day 10 at 8 °C demonstrated more intensity of colors a* and b* for juice, days 5 at 12 °C and 10 at 8 and 12 °C demonstrated more losses of mass. The day 5 at 4, 8 and 12 °C showed more luminosity (L*) of pulp and day 5 at 8 °C presented higher concentration of vitamin C, color a* and b* for peels.

For a better characterization of the quality parameters of minimally processed tangerines, the main component analysis was used with the results of the physicochemical analyzes of color (L *, a *, b *), total soluble solids, titratable acidity, ratio between total soluble solids and acidity, mass loss and pH, in addition to the determination of the vitamin C content.

From principal component analysis of minimally processed tangerines (Fig. 2B), data variance was accounted for significant contributions of 46.96 % for the first and 21.49 % for the second principal components. Day 3 showed more retention of color L* for juice where it was higher at 4 °C; pH was higher at 8 °C and 12 °C; the highest brightness (L*) of pulp and losses of mass were at 12 °C. Day 0 at 4, 8, and 12 °C showed more intensity of colors a* and b* for pulp; day 6 at 4 °C presented more values of color a* and b* for juice; days 9 at 4 °C and 0 at 4, 8 and 12 °C showed higher levels of TSS and day 12 at 4 °C resulted in a higher content of vitamin C.

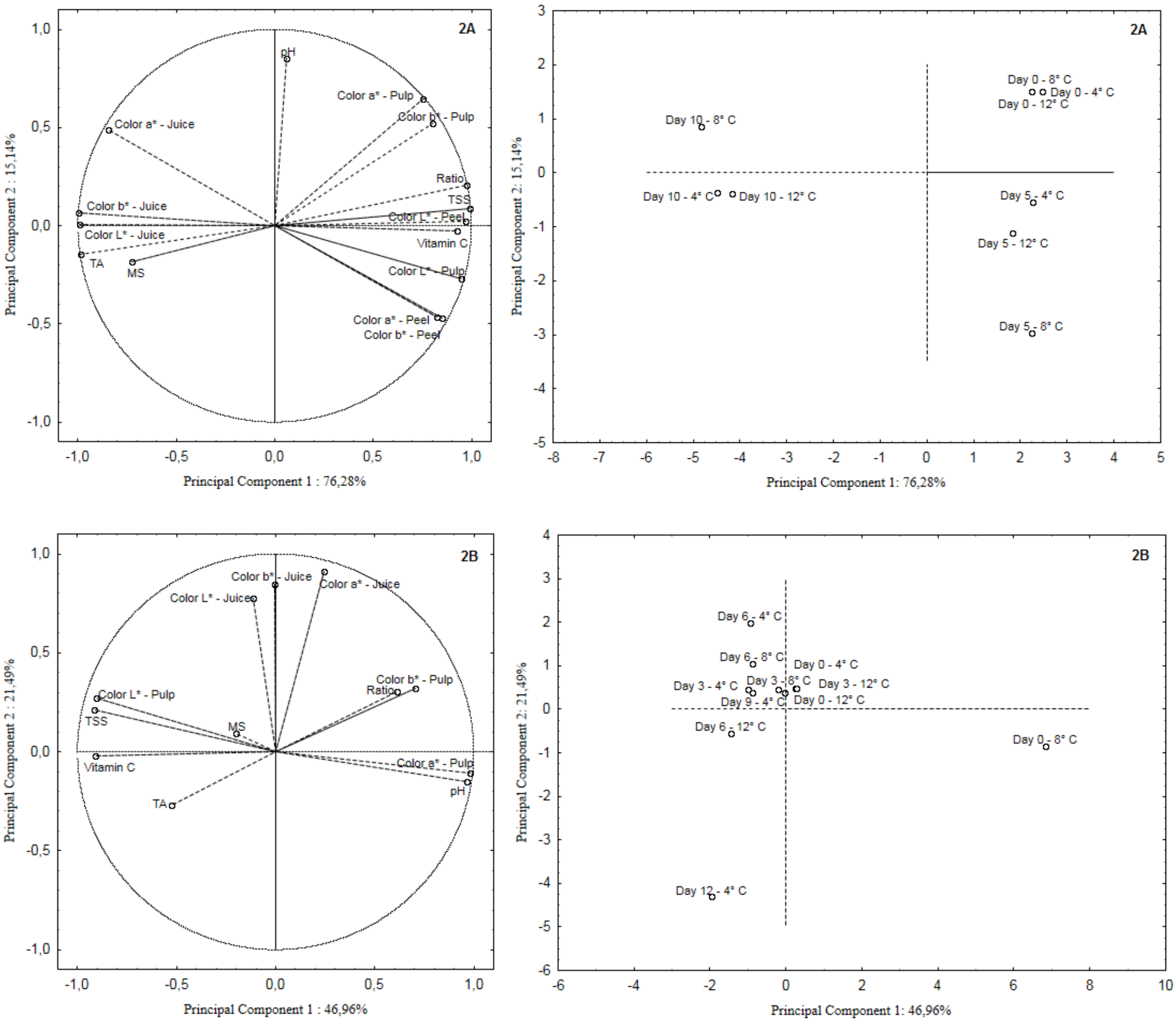

Figure 2 - Principal component analysis of fresh (2A) and minimally processed (2B) tangerine 'Dekopon' under different temperatures and storage time.

CONCLUSIONS

The fresh and minimally processed tangerines 'Dekopon' presented losses in physicochemical quality both in the storage time as in the employed temperature. Regarding color parameters analyzed, fresh juice showed higher levels of color L*, a* and b* according the storage time and day 5 at 8 °C presented higher concentration of vitamin C. As for minimally processed fruit, the time and storage temperatures did not interfere in color parameters a* and b* for the pulp and day 12 at 4 °C resulted in a higher content of vitamin C.

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Conservação pós-colheita de tangerina 'Dekopon' fresca e minimamente processada em diferentes temperaturas e tempos de armazenamento

RESUMO

Este estudo teve como objetivo avaliar o efeito da refrigeração e do tempo de armazenamento em tangerinas frescas e minimamente processadas, buscando aumentar sua vida de prateleira. No experimento 1, os frutos colhidos foram armazenados a temperaturas de 4, 8 e 12 °C e analisados entre 0, 5 e 10 dias. No experimento 2, os frutos foram minimamente processados e armazenados a temperaturas de 4, 8 e 12 °C e analisadas entre 0, 3, 6, 9 e 12 dias. A análise dos dados avaliados foram a perda de peso, pH, sólidos solúveis totais (SST), acidez titulável (AT), relação SST: AT, vitamina C e parâmetros de cor. Os resultados para o experimento 1 mostraram que, em geral, o dia 0 apresentou maiores valores de parâmetros físico-químicos e o dia 5 a 8 °C apresentou maior concentração de vitamina C. Para o experimento 2, na fruta minimamente processada, o dia 3 demonstrou maior retenção de parâmetros físico-químicos , exceto para a perda de massa e 12 dias a 4 °C resultou em um maior teor de vitamina C.

PALAVRAS-CHAVE: *Citrus reticulata* Shiranui; postharvest; minimally processed; vitamin C.

REFERENCES

AGOSTINI, J. S.; SCALON, S. P. Q.; SILVA, K. E.; LIMA, F. F.; GOMES, A. P. E.; LEITE, M.M. Physicochemical and microbiological characteristics of minimally processed 'Champagne' oranges (Citrus reticulata × Citrus sinensis) in different packgings. **Food Science and Technology**, v. 33, n. 1, p. 84-92, 2013.

AOAC International. Official methods of analysis of AOAC international (16th ed.). Gaithersburg, MD, USA: Association of Analytical Communities. 1997.

BRACKMANN, A.; PETERLE, M. E.; PINTO, J. A. V.; WEBER, A.; SAUTTER, C. K.; EISERMANN, A. C. Temperature and relative humidity during cold storage of 'Montenegrina' tangerine. **Ciência Rural**, v. 38, n. 2, p. 340-344, 2008.

BURDURLU, H. S.; KOCA, N.; KARADENIZ, F. Degradation of vitamin C in citrus juice concentrates during storage. **Journal of Food Engineering,** v. 74, p. 211–216, 2006.

CARO, A. D.; PIGA, A.; VACCA, V.; AGABBIO, M. Changes of flavonoids, vitamin C and antioxidant capacity in minimally processed citrus segments and juices during storage. **Food Chemistry**, v. 84, p. 99–105, 2004.

CUNHA, K. D.; SILVA, P. R.; COSTA, A. L. F. S. F.; TEODORO, A. J. Ascorbic acid stability in fresh fruit juice under different forms of storage. **Brazilian Journal of Food Technology**, v. 17, n. 2, p. 139-145, 2014.

ESTEVE, M. J.; FRIGOLA, A.; RODRIGO, C.; RODRIGO, D. Effect of storage period under variable conditions on the chemical and physical composition and colour of Spanish refrigerated orange juices. **Food and Chemical Toxicology,** v. 43, p. 1413–1422, 2005.

FERREIRA, E.A. Panorama da citricultura brasileira. **Informe Agropecuário Belo Horizonte**, v. 35, n. 281, p.7-16, 2014.

FONSECA, S. C.; OLIVEIRA, F. A. R.; BRECHT, J. K.; CHAU, K. V. Development of perforation-mediated modified atmosphere packaging for fresh cut vegetables. **Food Science and Technology International,** v. 4, p. 339-352, 1998.

GONZÁLEZ-MOLINA, E.; DOMÍNGUEZ-PERLES, R. MORENO, D. A. GARCÍA-VIGUERA, C. Review: Natural bioactive compounds of Citrus limon for food and health. **Journal of Pharmaceutical and Biomedical Analysis,** v. 51, p. 327–345, 2010.

LEE, T.; ZHONG, P.; CHANG, P. The effects of preharvest shading and postharvest storage temperatures on the quality of 'Ponkan' (*Citrus reticulata* Blanco) mandarin fruits. **Scientia Horticulturae,** v. 188, p. 57–65, 2015.

LIM, T. K. *Citrus reticulata* 'Shiranui'. **Edible Medicinal and Non-Medicinal Plants**. v. 4, p. 732-738, 2012.

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

UMANO, K.; YUKIO H.; SHIBAMOTO, T. Volatile Chemicals Identified in Extracts from Newly Hybrid Citrus, Dekopon (Shiranuhi mandarin Suppl. J.). **Journal of Agricultural and Food Chemistry,** v. 50, p. 5355−5359, 2002.

YAHIA, E. M.; ORNELAS-PAZ, J. J. Elansari, Fundamental Issues. A volume in Woodhead Publishing Series in Food Science, Technology and Nutrition A. **Postharvest Biology and Technology of Tropical and Subtropical Fruits,** p. 142–193, 2011.

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