

Duration of hydrothermal treatment and peeling of 'Murcott' tangor

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ABSTRACT: Hydrothermal treatment facilitates the peeling of 'Pera' sweet orange fruit and does not alter its quality. The aim of this work was to adapt the technology of peeling for the use of hydrothermal treatment in 'Murcott' tangor and to evaluate its influence in the CO₂ production and the physicochemical, microbiologic and sensorial characteristics of fruits. The peeling time, the yield of marketable fruits and the internal temperature of fruits during the treatment were also evaluated. The hydrothermal treatment consisted of placing the fruits in a water-bath at 50 °C for 5, 10, 15, 20, 25 and 30 min. Fruits were peeled by first opening a gap in the peduncle region with a knife and then manually removing the flavedo and albedo. Fruits were stored at 5 °C for six days. Hydrothermal treatment caused changes in the fruits' CO₂ production for only the first few hours after processing. Internal fruit temperature after 30 min of treatment reached 35 °C. There were no changes in the physicochemical and microbiologic characteristics of the fruits. The treatment did not change the flavor, improved the fruits' appearance, decreased the peeling time of the treated fruits by 57 % and increased the yield of marketable fruits. In conclusion, the hydrothermal treatment accomplished from 5 to 30 min at 50 °C can be used as part of the peeling process for 'Murcott' tangor.

Keywords: fresh-cut, heating, quality, appearance, easy peeling

Introduction

Tangerines rank second in economic importance among other citrus fruits. Among the tangerines the 'Ponca' and the 'Murcott' varieties stand out (Pio et al., 2005). 'Murcott' tangor which is also known as Honey Tangerine is a hybrid between sweet orange (*Citrus sinensis*) and tangerine (*Citrus reticulada*). The fruit has high commercial value because it is juicy, sweet and a little acidic flavor (Figueiredo, 1991). However, the residual odor transferred to the consumer hands, when they are peeled, limits their consumption. 'Murcott' tangor has a thin and adhered peel to the juice portion, being difficult to peel. Therefore, it has a great potential of being marketed as a fresh-cut product convenient to assist to the consumer's demands (Damiani et al., 2008).

Hydrothermal treatment at 50 °C for 8-30 min was found to be effective in maintaining the quality of the 'Pera' sweet Orange fruit (Arruda et al., 2008; Pinheiro et al., 2009). This technique can be extended to other citrus fruits difficult to peel such as 'Murcott' tangor. The aim of this work was to adapt the technology of peeling for the use of the hydrothermal treatment in 'Murcott' tangor and to evaluate its influence in this fruit quality.

Materials and Methods

Fruits with uniform size were used, weighting around 300 ± 50 g and with a shine skin. 'Murcott' tangors were used with a soluble solids/titratable acidity ratio around 16. 'Murcott' tangor were washed, sanitized with chlorinated water (200 mg of active chlorine L⁻¹) for 10 min and cooled at 5 °C for 12 h. Then, fruits were submitted to hydrothermal treatment and peeled. This treatment consisted of putting the fruits in heated water at around 50 °C, for 0 (control) 5, 10, 15, 20, 25 and 30 min. Fruits

were then peeled by first opening cut the peduncle region with a knife and after that, manually removing the flavedo and albedo. Fruits were put in expanded polystyrene trays, covered with polyvinyl chloride film of 17 µm of thickness and stored at 5 ± 1 °C and 80 ± 5 % of relative humidity for six days.

CO₂ production of both fresh-cut fruits submitted and those not submitted to hydrothermal treatment as well as for whole fruit with peel. Fruits were put in hermetic containers of glass that were kept closed for 30 min. Air samples measuring 1 mL were collected inside the containers with a Hamilton® Gastight syringe. Samples were injected into a ThermoScientific gas chromatographer, (Trace 2000GC), equipped with a flame ionization detector (250 °C), an injector (100 °C), a Porapak N column of 4 m (100 °C) and a methanator (350 °C). CO₂ production was determined considering the container's volume, the fruit mass, the period of time the container remained closed and the initial concentration of CO₂ inside of containers. The experimental design was entirely casualized with six replicates of one fruit for each treatment. Measurements were carried out every 2 h for 10 h after peeling and every 24 h for six days.

Internal fruit temperature was evaluated at 2 cm depth in relation to the epicarp during the hydrothermal treatment to determine the curve of heating of the fruit. For the measurement, type-T thermocouples were inserted (copper-constantan) in the equatorial region of the cooled fruits. Fruits were immersed in a water-bath at 50 °C for 30 min. Temperature data were recorded with a data acquisition system (Micrologger CR7, Campbell Scientific, Inc., Logan USA). Eight replicates were conducted of one fruit. Water temperature was also monitored. Fruit were characterized for peel thickness, whose replicates' average was 3.2 mm, and degree of humidity, whose average was 85.3 %.

Physicochemical analyses were carried out on the day of processing and on the 6th day of storage at 5 °C. The external

color was determined by a Minolta colorimeter (CR-300). Two measurement media were considered for each fruit. Results were expressed in Lightness (L). Soluble solids, titratable acidity and ascorbic acid content were determined according to the methodology described by Carvalho et al. (1990). The experimental design was entirely casualized with four replicates of two fruits each treatment.

Microbiologic analyses were carried out on the day of processing and on the 6th day of storage at 5 °C. Analyses included total count of aciduric microorganism (yeasts, molds and aciduric bacteria), total count of lactic bacteria and the most probable number (MPN) of total coliforms and thermo-tolerant coliforms according to Silva et al. (2007). Acidified Potato Dextrose Agar was used to count the levels of contamination from aciduric microorganisms using spread-plate technique. Plates were incubated to 25 °C for five days. The number of lactic bacteria was quantified by using pour plate technique. Orange Serum Agar was used. Plates were incubated to 30 °C for 48-72 h. Most probable number (MPN) of total coliforms and thermo-tolerant coliforms were determined by using *multiple-tube* method.

Sensorial analyze was carried out for attributes flavor and appearance on the first and sixth days of storage at 5 °C. The fruits treated for 30 min were compared as a control in three tests. For flavor, the triangle test was made, which is used to determine whether a noticeable difference exists between two products by comparing three samples, with two of them being identical. Then, 30 untrained judges were asked to identify the different sample (Ferreira et al., 2000). For the appearance, a paired-preference test to evaluate the choice of a sample over another was applied (Ferreira et al., 2000), as was a visual quality test. For the last test, the following score was used: 5 – excellent; 4 – good; 3 – fair; 2 – bad; 1 – very bad.

For measuring the effect of treatment on peeling time, five people peeled ten fruits that had undergone treatment, totaling 350 fruits. The average of the time spent peeling each fruit and the yield of marketable fruits were evaluated. Fruits showing injuries (breaking of the segments' membranes with juice leakage) of 1 cm² or more, or showing more than three injuries smaller than 1 cm² were considered unsuitable for commercialization. The design

used randomized blocks, with each person considered a block. The sequence of the treatments in each block was randomized.

The results obtained in each experiment were submitted to variance analysis and averages compared by Tukey's test (5 %). Regarding the sensorial analysis, the statistical analysis accomplished with the triangle test was based on number of correct judgments compared with the number of total judgments (30 judges). The minimum number of judges with correct answers needed to establish a difference between samples is 15 at a 5 % significance level (O'Mahony, 1986). For paired-preference test, the statistical analysis was based on the number of judgments of the suitable sample as a favorite. In the case of 30 judges, the minimum number of correct judgments in favor of a certain sample that is needed to establish a significant difference at 5 % is 21 (Meilgaard et al., 1991). For the visual quality test, the results were submitted to the variance analysis and the averages were compared using Tukey's test (5 %).

Results and Discussion

CO₂ production of 'Murcott' tangors that had gone through hydrothermal treatment increased with time. However, this effect was limited to the first hours following the treatment. The CO₂ production of treated fruits equaled that of the untreated fruits in the eighth hour following the processing (Figure 1A) ($p > 0.05$). Similar results were found by Pinheiro et al. (2009), who verified that the CO₂ production of treated 'Pera' sweet oranges (50 °C for 10 to 30 min), equaled that of untreated fruits on the fourth hour following processing. A day after processing, fresh-cut 'Murcott' tangors had already presented the same CO₂ production as that presented by whole fruits with peel (Figure 1B) ($p > 0.05$). The stress effect of processing did not remain during the fruits' storage.

Internal fruit temperature increased ($p \leq 0.01$) during hydrothermal treatment up to 35 °C at a depth of 2 cm. There was greater increase of the temperature in the first minutes of treatment, which became less intense over time (Figure 2). The internal temperature of the 'Pera' sweet oranges treated (50 °C for 10 to 30 min) reached 35 °C approximately, at a depth of 2 cm (Pinheiro et al., 2009). Internal temperature of peaches

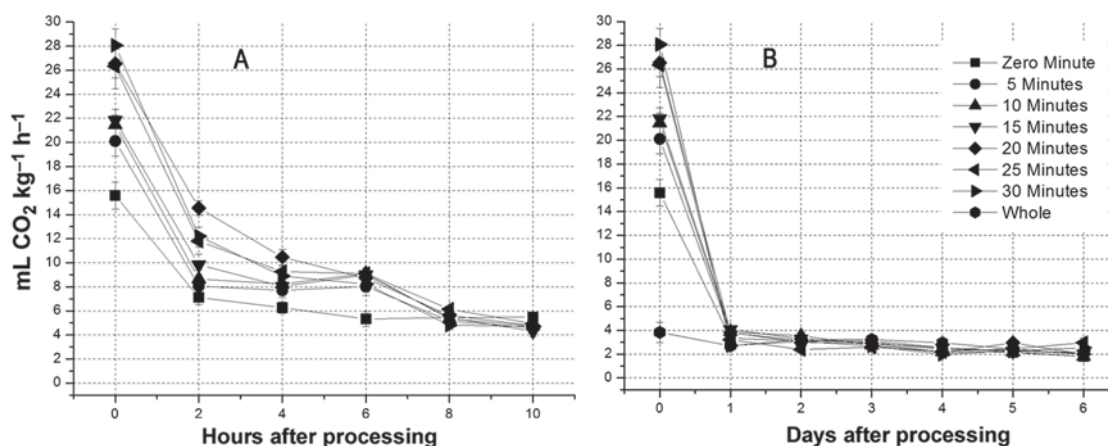


Figure 1 – CO₂ production of 'Murcott' tanger stored at 5 °C. Hours after processing (A) and days after processing (B). Vertical bars indicate the standard error (n = 6). Zero time represents the value found immediately after peeling. 0 minute = control.

treated with hot water had larger increase in first minutes of treatment (Zhou et al., 2002).

The pulp temperature of fruits with 30 min of heating (35 °C) was similar to the temperature commonly observed in fruits at the moment of the crop and during other parts of the production chain and commercialization process. Therefore, it is believed that this temperature does not result in the alteration of the quality of the fresh-cut fruits. Additionally, immediately after peeling, these fruits are again cooled (Pinheiro et al, 2009).

Neither hydrothermal treatment nor storage time has influenced external color, soluble solids, titratable acidity and ascorbic acid ($p > 0.05$) (Figure 3A, 3B, 3C e 3D). Fresh-cut 'Ponca' tangerines had a decrease of the L-value on the 6th day of storage at 0 °C and 10 °C (Damiani et al., 2008). Fresh-cut 'Murcott' tangors, stored at 6 °C for nine days, did not present difference in soluble solids in storage (Kluge et al., 2003). Vitamin C level in fresh-cut 'Ponca' tangerines decreased during storage at 5 °C (Pinto et al., 2007).

The levels of contamination from aciduric microorganisms (yeasts, molds and aciduric bacteria) were as low for as those from lactic bacteria reaching at the highest 2.9×10^2 CFU g^{-1} (table 1). There is no legislation setting a maximum

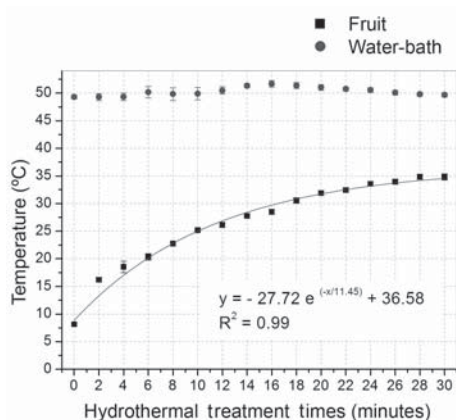


Figure 2 – Internal temperature (2 cm depth in relation to the epicarp) of fruits submitted to hydrothermal treatment (50 °C) for 30 min. Vertical bars indicate the standard error (n = 8).

Table 1 – Total count of aciduric microorganisms and lactic bacteria in fresh-cut 'Murcott' tangor, storage at 5 °C¹.

Hydrothermal treatment time (minutes)	Aciduric Microorganisms		Lactic Bacteria	
	Day 0	Day 6	Day 0	Day 6
0	2.0×10	5.0×10	2.9×10^2	< 10
5	1.0×10	2.5×10	< 10	< 10
10	3.0×10	1.0×10	1.5×10	1.0×10
15	1.0×10	1.5×10	1.0×10	< 10
20	1.0×10	2.5×10	< 10	< 10
25	1.0×10	1.5×10	< 10	1.0×10
30	< 10	1.0×10	< 10	< 10

¹The obtained results represent Colony Forming Unit of aciduric microorganisms or lactic bacteria (CFU g^{-1}).

amount of microorganisms or bacteria allowed to be present in food. However, fresh-cut products with high amounts of these microorganisms ($> 10^5$ CFU g^{-1}) are inappropriate for consumption (Morton, 2001).

All of samples presented an absence of total coliforms and thermo-tolerant coliforms. In agreement with the microbiologic patterns established by ANVISA, fresh fruits (peeled, selected or fractional) should present at the most 5.0×10^2 thermo-tolerant coliforms g^{-1} (Anvisa, 2010).

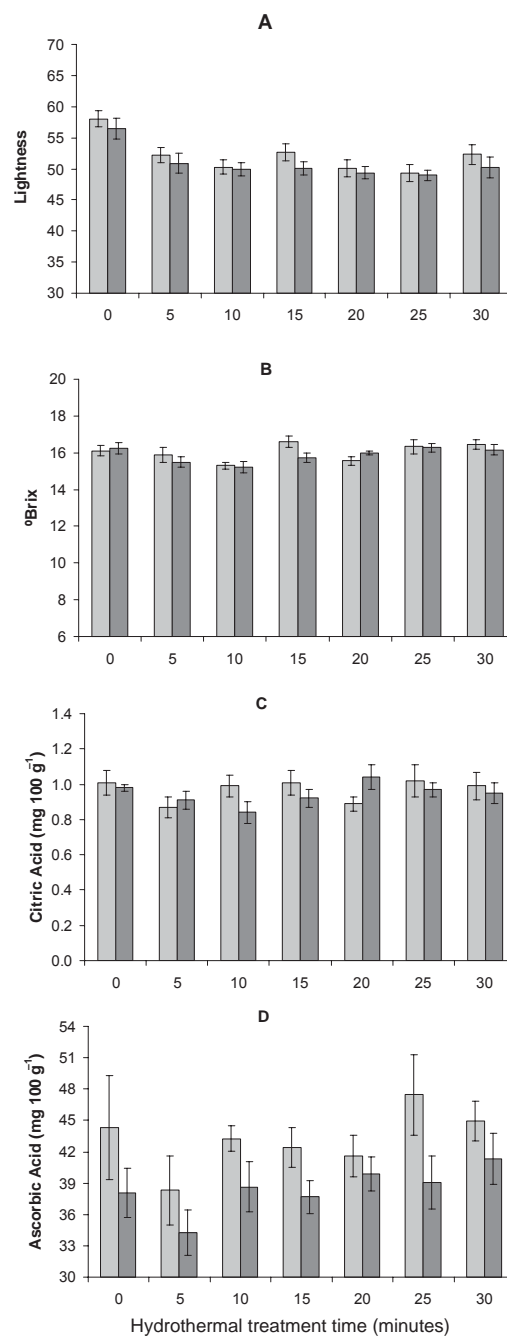


Figure 3 – Physicochemical qualities of fresh-cut 'Murcott' tangor submitted or not to hydrothermal treatment (50 °C) and stored at 5 °C: external color (A), soluble solids (B), titratable acidity (C) and ascorbic acid (D). Vertical bars indicate the standard error (n = 4).

Regarding the sensorial analysis, the number of correct answers indicating that hydrothermally treated fruits had a flavor different from that of the control samples was 9 and 12 in 1st and 6th day respectively. This demonstrates that the hydrothermal treatment did not interfere in flavor of the fruits. The minimal number of correct answers to characterize a difference between samples at 5 % significance is 15 (O'Mahony, 1986).

The flavor of 'Pera' sweet oranges submitted to hydrothermal treatment (50 °C for 8 to 30 min) was not altered (Arruda et al, 2008; Pinheiro et al., 2009). To judge appearance, two tests were accomplished: a paired-preference test and a visual quality test. The paired-preference test showed that judges preferred hydrothermally treated fruits to the control fruits. During the 1st day of storage at 5 °C, 21 judges preferred the hydrothermally treated sample to the control sample. On the sixth day, 23 judges preferred the treated sample. A minimum of 21 answers in favor of a certain sample is necessary to characterize a significant difference between samples at 5 % significance level (Meilgaard et al., 1991).

According to the visual quality test, hydrothermally treated fruit presented superior reviews ($p \leq 0.05$). While these fruits obtained ratings between 4 and 5 (between good and excellent),

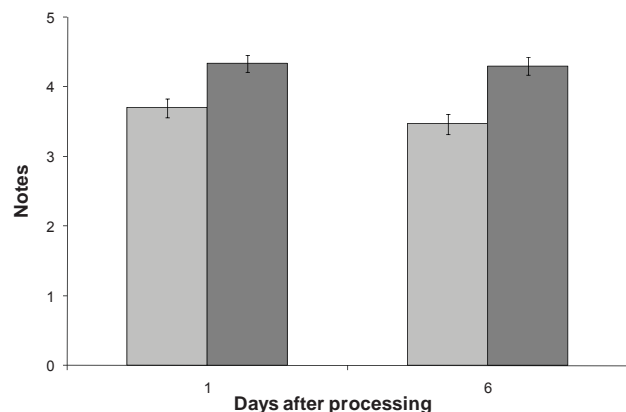


Figure 4 – Appearance of fresh-cut fruits treated (50 °C for 30 min) or not, and storage at 5 °C. Notes: 5 – excellent; 4 – good; 3 – fair; 2 – bad; 1 – very bad.

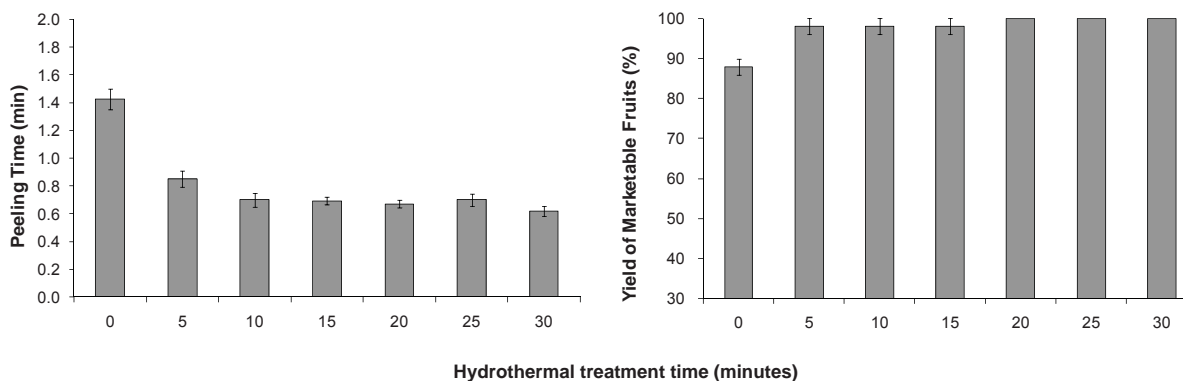


Figure 5 – Average time for peeling one 'Murcott' tangor and yield of marketable fruits in fresh-cut 'Murcott' tangor submitted or not to hydrothermal treatment. Vertical bars indicate the standard error (n = 5).

the untreated fruits obtained ratings between 3 and 4 (between fair and good) (Figure 4). The appearance of 'Pera' sweet oranges peeled through the use of hydrothermal treatment for eight to 30 min had the consumers' preference. The smaller immersion times enabled the total removal of the albedo, while the fruits without this treatment presented albedo traces (Arruda et al., 2008; Pinheiro et al., 2009).

Hydrothermal treatment decreased the peeling time of 'Murcott' tangors ($p \leq 0.05$) and increased the yield of marketable fruits ($p \leq 0.05$) (Figure 5). Peeling an untreated 'Murcott' tangor required an average time of 1.43 min. For the fruits that had undergone 5 min of hydrothermal treatment, the average peeling time was 0.85 min (what corresponds a decrease of 41 % in the time) and the average peeling time was only 0.62 min for fruits treated for 30 min (decrease of 57 %). No treated fruits differed of the others ($p \leq 0.05$), and the fruits treated for 5 min differed of those treated with 30 min ($p \leq 0.05$).

The yield of marketable fruits was greater for treated fruits ($p \leq 0.05$). The yield for peeled fruits with no treatment reached a level of 88 % and the yield for peeled fruits with hydrothermal treatment reached 98-100 % (Figure 4). Treated fruit did not differ among them in the yield marketable fruits ($p > 0.05$).

'Pera' sweet orange submitted to hydrothermal treatment (50 °C) for 10 to 30 min had a reduction in peeling time of up to 78 % from the amount of time used to peel untreated oranges. Peeled untreated oranges produced a yield of 60 %, and the yield of treated peeled oranges reached levels in a range of 90-96 % (Pinheiro et al., 2009).

Conclusions

Hydrothermal treatment performed for 5 to 30 min at 50 °C can be used as peeling technique for 'Murcott' tangors. This treatment makes peeling of fruits easier and increases the yield of marketable fruits even when using the shortest immersion time. Additionally, it is found to improve the appearance of the fruits. Hydrothermal treatment neither alters the physicochemical and microbiologic characteristics nor the flavor of the fruits. Changes in the fruits' CO₂ production are not persistent.

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