Effect of Ripening Stage on Astringency Removal of ‘Rama Forte’ Persimmon

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Abstract

Ripening stage is one of the most important factors that influence astringency removal from persimmon fruit. This work aimed to evaluate the efficiency of tannin polymerization for fruit harvested at different ripening stages and its influence on quality parameters. Fruit at three ripening stages (yellow, orange and red) were exposed to 70 kPa CO_2 during 12 and 18h, at 22°C and 95% RH. The soluble tannin content decreased abruptly two days after CO_2 treatment, regardless of ripening stage and exposure time. Yellow fruit exposed for 18h were completely non-astringent one day after treatment. In general, with the advance in ripening and increase in exposure time, fruit firmness decreased. Astringency removal with CO_2 promoted an immediate increase in respiration rate, significantly higher for red fruit. The stress caused by high CO_2 induced a significant increase in ethylene synthesis after two days at 22°C. In yellow fruit, the exposition to 70 kPa CO_2 for 18h, maintains firmness during 16 days and completely removes the astringency after two days.

INTRODUCTION

The ‘Rama Forte’ persimmon belongs to the variable group, which present astringency and clear flesh when paternocarpic development of the fruit occurs, and dark flesh, non astringent on the presence of seeds (Campo-Dall’Orto et al., 1996). This fact implies the necessity of a postharvest treatment to remove the astringency before fruit commercialization. One of the methods used to remove astringency in persimmons utilizes atmospheres with high carbon dioxide concentrations or atmospheres with low oxygen concentrations (Arnal and Del Rio, 2003; Salvador et al., 2005). The effectiveness of these methods occurs due to the fact that it promotes anaerobic respiration of the fruit, which accumulates acetaldehyde. This accumulated compound reacts with soluble tannins (responsible for the astringency) making these tannins become insoluble or polymerized (Matsuo and Itoo, 1982; Oshida et al., 1996; Taira et al., 1997; Salvador et al., 2007).

Persimmon fruits at different ripening stages have a different response in relation to firmness maintenance, when submitted to astringency removal treatments and following storage (Salvador et al., 2005). The fruits at a more advanced ripening stage tend to have a rapid softening during storage, while fruits at an earlier ripening stage lose firmness in a slower way, probably due to the lesser respiration rates and in ethylene production.

The objective of this work was to evaluate the influence of ripening stages of ‘Rama Forte’ persimmon fruit, on efficiency of the astringency removal process and its influence on maintenance of fruit quality stored at room temperature.

MATERIALS AND METHODS

Persimmons of cultivar ‘Rama Forte’ were harvested at different ripening stages (yellow, orange and red) and transported to the Postharvest Physiology Laboratory at the University of Sao Paulo in Piracicaba. Fruit were selected according to ripening stage, uniformity on weight and shape, and damaged and blemished fruit was removed. Fruit of each treatment was placed into cardboard boxes and afterwards into chambers where the astringency removal process was applied under a 70% CO_2 atmosphere for 12 and 18h.

After the astringency removal process the fruit were stored at room temperature (22 ± 1°C and 90% RH) and were evaluated by the following parameters: flesh firmness, astringency index and soluble tannins content. The evaluations were made at harvest, immediately after CO_2 treatment (-1 day), and following intervals of two days for a period of 16 days of shelf life. Flesh firmness was measured with a digital penetrometer; measurements were performed on two opposite sides of each individual fruit after peel removal, with an 8 mm diameter tip. The degree of soluble tannins was estimated visually by evaluating color development during the reaction between tannin with ferric chloride. Persimmons were cut equatorially, and immediately the freshly cut surface was printed in a paper filter previously treated with a 5% $FeCl_3$ solution as proposed by Gazit and Levy (1963). The printed paper was scored visually on a scale from 5 (extremely astringent) to 1 (not astringent). The soluble tannins content was determined spectrophotometrically utilizing Folin-Ciocalteu reagent, according to the method described by Taira (1996).

Respiration rate and ethylene production were also evaluated. Fruit were put in glass hermetic recipients for two hours and maintained at 22 ± 1ºC and 90% RH. The measurements were taken daily, during 11 days, using a gas chromatograph equipped with a FID detector.

The experimental design was entirely random, at the factorial schedule 6 x 12. The study's factors were: treatments, in 6 levels, and storage periods in 12 levels (before treatment, after treatment and in the 16 following days). Four repetitions were used, each one of them with three fruits. The results were submitted to standard deviation error analysis.

RESULTS AND DISCUSSION

Flesh Firmness

The yellow persimmons presented an initial flesh firmness of 53.7 N, while the orange and red persimmons presented 33.5 and 36.7 N of flesh firmness respectively (Fig. 1). After the application of astringency removal treatments reduction in fruit flesh firmness was observed, regardless of CO_2 exposure time. Red fruit exposed to CO_2 during 18h had a decrease of firmness values near of 4.8 N, which limited shelf life of these fruit to eight days at a temperature of 22 ± 1ºC (Fig. 1), while fruit of other treatments did not present such a sharp decrease in flesh firmness, maintaining values above the minimal level for commercialization (10 N) until the end of storage.

It is well know that CO_2 has beneficial effects on maintenance of fruit quality. However, a high concentration can contribute to physiological disorders such as flesh softening (Pesis and Ben-Arie, 1984). This fact, combined with the advanced ripening stage of these persimmons, might explain flesh softening behavior presented by red fruit exposed to CO_2 for 18h.

The formation of three distinct groups was also verified. One group formed by yellow fruit, that regardless of exposure time to CO_2, presented higher flesh firmness, was followed by a group of red fruit treated for 12h and orange fruit exposed to CO_2 for 12 and 18h, that presented median firmness values, and finally by a group of red fruit treated for 18h, that presented the lowest flesh firmness values.

Astringency Index

In relation to the astringency index, it was verified that all the fruit, regardless of the treatment submitted by those, presented index 5 at initial evaluation. At the final of treatments red fruit exposed to CO_2 for 12h were still very astringent (3.8 index), while other fruit presented slight astringency to astringency (Fig. 2).

It was observed that on the first day of storage, yellow fruit treated for 12 and 18h were already slightly astringent to non astringent, 1.75 and 1.0 index, respectively, while other fruit were still astringent. On the second storage day only orange and red fruit treated for 12h showed astringency, indicating that for these ripening stages a longer exposure to CO_2 is recommended to obtain a better astringency removal. After the second storage day fruit of all treatments have variability between slight astringency and non astringency with the exception of orange fruit treated for 12h that were medially astringent until the 14th day of storage.

Orange fruit exposed to CO_2 for 12 and 18h presented astringency recurrence on the 8th and 10th storage day, respectively. This might have occurred due to the fact that the process of astringency removal on these fruit was not complete, hence promoting tannin resolubilization, a phenomenon reported previously on 'Triumph' (Ben-Arie and Sonego, 1993) and 'Rama Forte' persimmon (Edagi et al., 2006). This process is called astringency resurgence.

Tannins Soluble Content

It was observed after the end of astringency removal process that yellow fruit exposed to CO_2 for 12 and 18h presented 4.9 and 3.2 µg of gallic acid (Fig. 3), respectively, being significantly different from the orange and red fruit treated with CO_2 for 12h (14 and 19.9 µg of gallic acid, respectively). These results, when compared to those from the astringency index, strengthen the efficiency obtained by the astringency removal treatments for the fruit at the yellow ripening stage.

All persimmon fruit have a decrease in the soluble tannins content during the storage period. This decline in soluble tannin as storage time elapsed may well result from accelerated condensation reactions, possibly between the tannin and accumulated acetaldehyde (Matsuo and Itoo, 1982).

Thereafter 8 and 10 days of shelf life, the orange fruit exposed to CO_2 during 12 and 18h, presented an increase in soluble tannins values. This enhancement corroborates with the highest astringency index observed and indicates once again the event of the astringency resurgence process (Figs. 2 and 3).

Respiration Rates and Ethylene Production

As showed in Figure 4, one day after treatments, two distinct groups as regards the respiratory activity were observed. Fruit exposed to CO_2 during 18h, regardless of ripening stage, presented greater respiration rates (30.9-32.4 ml CO_2 kg^{-1} h^{-1}), followed by the fruit treated for 12h (18.7-24.1 ml CO_2 kg^{-1} h^{-1}) (Fig. 4). After 48h, a reduction in fruit respiratory activity was found, with the maintenance of initial behavior, except for the red fruit treated during 12 and 18h, because these fruit presented respiration rates significantly higher than yellow and orange fruits treated during the same period of time.

Persimmon fruits normally produce small amounts of ethylene (Kader, 1992). Nevertheless, they are very sensitive to ethylene action, and exposure to low concentrations of ethylene accelerates ripening. An increase in ethylene production was observed after 48h. in orange fruit exposed to CO_2 during 18h and in the red fruit exposed to CO_2 during 12h (Fig. 4), while the red fruit treated during 18h presented an ethylene peak production after 72h of CO_2 treatment. An ethylene peak of production was also observed but with smaller intensity on the other treatments and for some of those treatments this peak occurs only 96h after the astringency removal process. Itamura et al. (1997) also reported enhancement on ethylene production in 'Saijo' persimmon treated with CO_2 to remove astringency.

It is possible to notice, therefore, that astringency removal with CO_2 promotes immediate increase in fruit respiration rates, while an ethylene peak production is verified only after 48, 72 or 96h, besides that, the stress caused by exposure to high CO_2 concentrations appears to be greater in fruit that have an advanced ripening stage, being responsible for the maintenance of respiration rates in higher levels and for greater ethylene syntheses, with inherent consequences to ripening and senescence process.

CONCLUSIONS

The yellow fruit, regardless of exposure time to CO_2, had higher flesh firmness, differing of others treatments.

Orange fruit, regardless of exposure time to CO_2, presented astringency recurrence and remained slightly astringent during the entire storage period.

Persimmon fruit in an advanced ripening stage submitted to astringency removal treatments suffer a greater stress due to this process and during the storage period it has higher respiration rates and a greater ethylene peak production, what implies in rapid fruit softening.

In a general way, it is recommended that the astringency removal process in 'Rama Forte' persimmons, at the yellow ripening stage, be conducted with exposure of the fruit to 70% CO_2 atmosphere during 12 or 18h, which will result in slightly or non astringent fruit from the first day and in a suitable flesh firmness during 16 days under 22°C with 90% RH.

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Figures

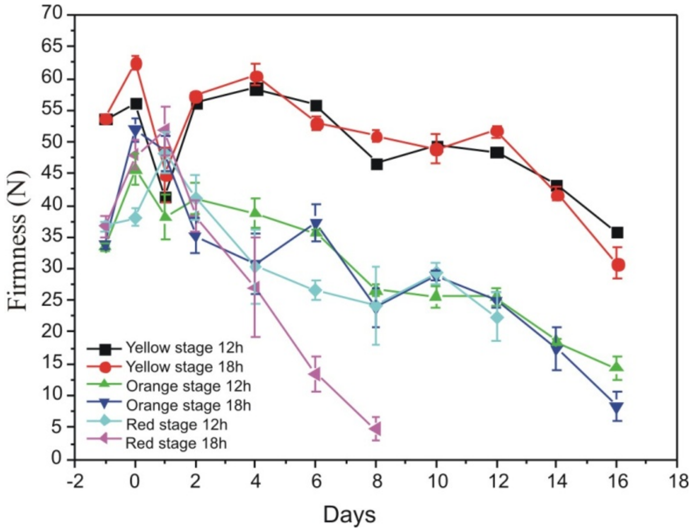

Fig. 1. Flesh firmness of ‘Rama Forte’ persimmon fruit stored during 16 days under 22 ± 1ºC and 90% RH. (-1 day = before astringency removal).

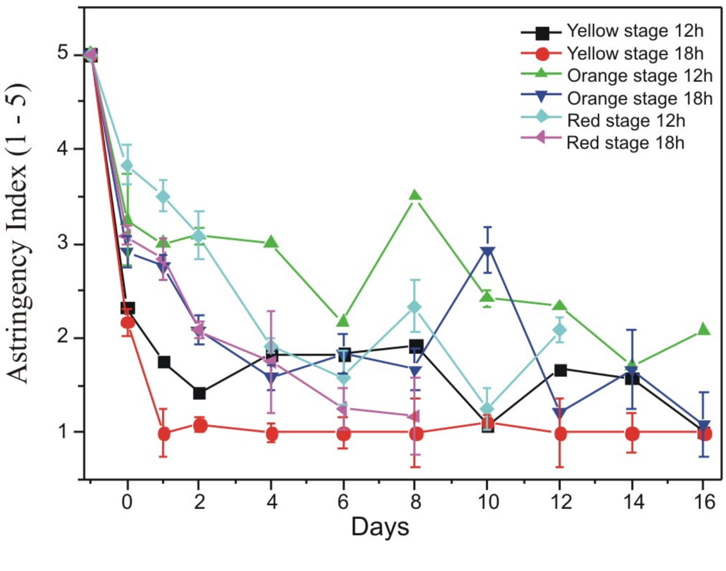

Fig. 2. Astringency index (5 to 1) of ‘Rama Forte’ persimmon fruit stored during 16 days under 22 ± 1ºC and 90% RH. The grades correspond to: 5=very astringent; 4=astringent; 3=medium astringent; 2=slightly astringent; 1=non astringent (-1 day = before astringency removal).

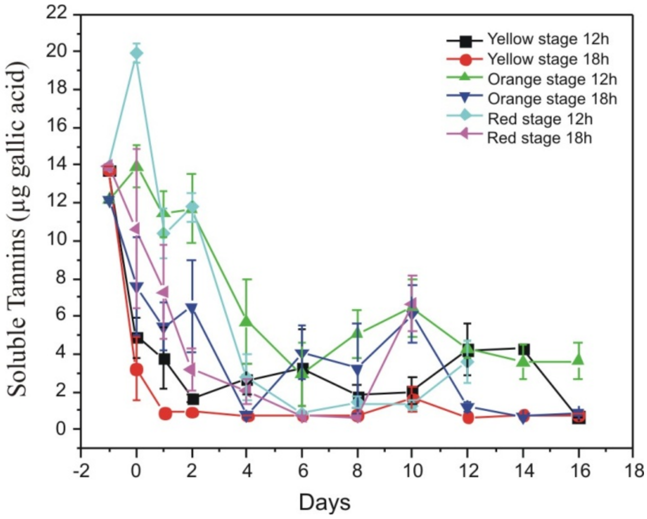

Fig. 3. Soluble tannins content (µg of gallic acid) of 'Rama Forte' persimmon fruit stored during 16 days under 22 ± 1ºC and 90% RH. (-1 day = before astringency removal).

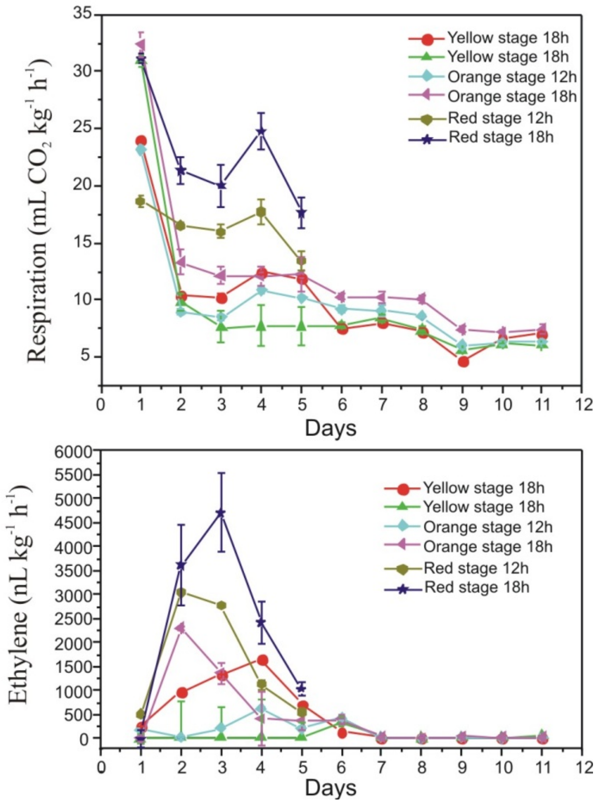

Fig. 4. Respiration rate (ml CO_2 kg^{-1} h^{-1}) and ethylene synthesis (nl C_2H_4 kg^{-1} h^{-1}) of 'Rama Forte' persimmon fruit stored during 16 days under 22 ± 1ºC and 90% RH. (-1 day = before astringency removal).