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The Effect of Anti-Browning Treatments for Fresh-Cut Guava Slices in Prevention of Browning during Dehydration

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ABSTRACT

Purpose : *Guava cultivations are spreading rapidly among Sri Lankan farmers, especially in dry zone. Surplus production is observed in certain months of the year. Dehydration can be used as an effective method to preserve the surplus. During dehydration, browning of guava impairs the quality of the final product. This experiment was carried out to find out the most effective browning inhibitor.*

Research Method : *Four treatments were used prior to dehydration namely, Citric acid (CA), Ascorbic acid (AA), Sodium metabisulfite (SMS) and Blanching for 2 minute in 60 °C (BL) as twenty different combinations. The L*, a* and b* values, were recorded. Colour differences with fresh slices, total colour difference (TCD) and browning index (BI) were calculated.*

Findings : *L*, a* and b* values were significantly different (P<0.05) among treatments. The lowest L* value difference was observed in CA 0.3% with BL (3.18±0.7). Lowest total colour difference and the lowest browning index were observed in blanching treatment followed by CA 0.3% with BL. Whereas the highest TCD was in control sample (21.86 ± 2.75) and the highest BI was in SMS 0.5% with BL (55.38±8.59). Results revealed that out of the treatments under study, BL only and CA 0.3% with BL were the most effective solutions to overcome the browning of guava during dehydration.*

Originality/ Value : *Research findings could be used in guava dehydration industry to preserve the colour and visual quality of the dehydrated products which will increase the consumer acceptability and demand thereby reducing postharvest losses.*

Keywords: *Browning, Color, Dehydration, Guava, Postharvest, Value addition*

INTRODUCTION

Sri Lanka is a tropical country blessed with a high diversity of fruit crops grown naturally throughout the country. Most of them are seasonal bearers producing large amounts during the season, lowering market price. Guava (*Psidium guajava* L.) is popular among Sri Lankans because of its inherent flavor and eating quality. It is an excellent source of vitamin C, containing about 17 % dry matter and 80 % moisture along with an appreciable amount of minerals such as phosphorus, calcium, iron, potassium, magnesium as well as vitamins like niacin, pantothenic acid, thiamin, riboflavin and vitamin A (Rana *et al.,* 2015; Mahendran, 2010). In addition, it contains antioxidant pigments of carotenoids and polyphenols providing a high dietary antioxidant value (Ellong, 2015). Cultivated guavas produce fruits throughout the year with little seasonal effect. The Guava cultivations are spreading faster among Sri Lankan farmers especially in dry zone, who cultivate mainly "*kilo pera"*(Malaysian variety) in earlier days and presently, the cultivar Bangkok giant called "*Apple guava*". Even though majority of farmers cultivate these two cultivars, the Department of Agriculture has introduced many guava varieties

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namely, Horana red, Horana white, Pubudu, Lanka giant, Horana sweet, Sweet giant and Hoarana rosy (DOA, 2020).

However, the market price of guava reduces considerably during the fruit season mainly because of higher production and the availability of diversity of fruits in the market leading to a lower demand. With the availability of varieties of fruits in the market, the demand for a particular fruit reduces, hence farmers suffer to sell their products during the season and surplus get wasted leading higher postharvest losses. Focusing on the value added products, is one of the major solutions to reduce the postharvest losses. However, value added products of guava is not popular among Sri Lankans, even though there are many forms of value added products available in the global markets namely; Guava puree, Jam, jelly, juice, powder, vine, bottled guava slices, dehydrated guava etc. Among the various ways and means of product processing, dehydration or drying is the most common and effective food preservation method (Kek *et al*., 2013). Dehydrated guava is one of the most popular products in Thailand (Duangmal and Khachonsakmetee, 2009). Even though dehydrated guava is not commonly consumed in Sri Lanka, it is being exported. Exported amount in 2017 was 2 tones and in 2018 it was 45 tones (DOA, 2019) showing an increasing trend and demand in the global scenario. However, browning of guava slices during dehydration is a major quality drawback for the mostly cultivated guava variety which is the “Apple Guava” in Sri Lanka. Color of the food commodities is generally subjected to changes when they are undergone food processing. However, color is a vital quality attribute of food products which is directly linked with the consumer attractiveness and acceptability. Therefore, the principal hypothesis of this study was to recognize if the selected treatments were effective in preserving color when dehydrating where the specific objectives were to improve the color during dehydration and to evaluate the color parameters of dehydrated guava.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted in the laboratory of National Institute of Post Harvest Management, Anuradhapura. Guava cultivar “Bangkok giant” was harvested at the correct maturity stage from selected Guava cultivations in Ipalogama, Anuradhapura, Sri Lanka.

Sample Preparation and Experimental Treatments

Harvested fruits were packed in plastic crates and transported to laboratory of National Institute of Post Harvest Management. Fruits free from any visible defects were selected. Twenty treatment combinations were used with 4 treatments namely, Citric acid (CA), Ascorbic acid (AA) Sodium metabisulfite (SMS) and Water blanching for 2 minute in 60 °C (BL). These treatments were selected based on literature and applied as a dipping treatment for sliced guava for 10 minutes. Control is the dipping in water for 10 minutes.

The treatment combinations were,

- Blanching at 60 °C for 2 minutes
- SMS -0.3% without blanching
- SMS -0.3% with blanching
- SMS -0.5% without blanching
- SMS -0.5% with blanching
- Citric acid (CA) – 0.5% without blanching
- Citric acid (CA) – 0.5% with blanching
- Citric acid (CA) – 0.3% without blanching
- Citric acid (CA) – 0.3% with blanching
- Citric acid (CA) – 0.1% without blanching
- Citric acid (CA) – 0.1% with blanching
- Ascorbic acid (AA) - 0.5% without blanching
- Ascorbic acid (AA) - 0.5% with blanching
- Ascorbic acid (AA) - 0.3% without blanching

- Ascorbic acid (AA) - 0.3% with and with blanching
- Ascorbic acid (AA) - 0.1% without blanching
- Ascorbic acid (AA) - 0.1% with blanching
- AA – 0.3% with CA - 0.3%
- AA - 0.1 % with CA - 0.5%
- AA - 0.5% with CA - 0.5%

From above combinations, five were selected based on visual color for further analysis after dehydration. The selected treatment combinations were,

- Blanching at 60 °C for 2 minutes (BL)
- Citric acid (CA) – 0.3% with BL
- Citric acid (CA) – 0.5% with BL
- Ascorbic acid (AA) - 0.5% with BL
- SMS -0.5% with BL

Selected fresh fruits were cut into slices (5 – 8 mm thickness) and then the above treatments were applied following dehydration. Dehydration was done in hot air oven dryer at 60 °C for 24 hours. Color values were measured using Hunter lab color difference meter (CR 400, Konica Minolta), the values of L*, a* and b* were recorded (McGuire, 1992). Eight dehydrated samples (as replicates) were used for each treatment where colour values from 3 points were taken per replicate and averaged them. Color differences of L*, a* and b* were calculated with the fresh slices. Total colour difference was calculated using the formula given by Maskan (2001); Saricoban and Yilmaz (2010). The formula is

$$\Delta E = ((L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2)^{1/2}$$

ΔE = Total color difference, L_o= L value of fresh sample, L = L* value of treated sample, a_o = a* value of fresh sample, a = a* value of treated sample, b_o =b* value of fresh sample, b = b* value of treated sample

Browning index was calculated based on the formula used by Maskan (2001); Saricoban and Yilmaz (2010); Kasim and Kasim (2015). Used formula was,

$$BI = \frac{[(x - 0.31)]}{0.17}$$

Where,

$$x = \frac{(a + 1.7L)}{(5.645L + a - 3.012b)}$$

The experiment was conducted as a complete randomized design. The data were analyzed using analysis of variance and means were separated using Duncan's multiple range test at P<0.05 with SPSS statistical software 20.0.

RESULTS AND DISCUSSION

Fruits dried using hot air in conventional tray, cabinet or vacuum dryers show poor product quality, and hence less acceptance by the consumers (Jain *et al*., 2011). Basically when fruits are undergone to dehydration processes, color change is a common scenario which reduces the consumer preference and it has a greater impact on marketability of the product. Hence color should be preserved to increase the consumer acceptability.

Results of the present study revealed that the browning reaction was occurred during the dehydration process whereas any color change was not observed in fresh cuts (without any treatment) even after 24h of storage. Hence, it should not be the enzymatic browning. Changes of L*, a* and b* color values were observed differently with different treatments (Table 01).

The L* coordinate indicates darkness or lightness of color and ranges from black (0) to white (100). Coordinates of a* and b* indicate the color directions. Negative a* values indicate the greenness whereas positive values indicate redness. Negative b* values indicate the blueness and positive values indicate the yellowness (McGuire, 1992).

Table 01: Color values of L*, a* and b* of fresh and dehydrated guava samples with different treatments

Color	Fresh	Control	BL	CA_0.3%+ BL	CA _0.5% + BL	AA_0.5%+ BL	SMS_0.5%+ BL
L*	85.74±1.3^{a}	67.91±4.1^{e}	80.59±5.9^{b}	83.16±1.7^{ab}	78.12±3.9^{c}	73.87±3.1^{d}	75.21±3.7^{cd}
a*	-3.22±1.2^{a}	3.27±1.4^{e}	0.32±1.1^{b}	0.46±0.7^{bc}	1.43±0.7^{cd}	4.11±0.8^{e}	1.69±0.8^{d}
b*	13.67±2.7^{a}	24.70±3.5^{bc}	23.50±3.3^{b}	27.14±1.2^{c}	30.99±3.1^{d}	24.98±3.2^{bc}	32.20±4.3^{d}

Each value represents ± S.D. of eight replicates. Values in the same row with different superscript letters differ significantly (P<0.05). L- lightness, a*- green to red., b*- yellow to blue. BL=Blanching at 60°C for 2 minutes, CA= Citric acid, AA=Ascorbic acid, SMS= Sodium metabisulfite.*

Guava fruits change their color into a greater extent when dehydrating (Table 01) where the results of the study revealed that the L* value of the guava samples decreased significantly (P<0.05) after dehydration. The highest lightness (L* value) was observed in fresh samples whereas the lowest in control sample (Table 01) indicating the considerable color change. Reduction of L* value indicates that the browning takes place during the dehydration leading to discolored final product. Reduction of L* value was also observed by Damasceno *et al*. (2008) for cashew apple juice when undergone higher temperature treatments showing non enzymatic browning. According to the results of the present study (Table 02), the lowest L* value difference (LD) was observed in CA treated guava samples for 10 minutes with the concentration of 0.3% combined with BL. The second lowest LD was observed with the samples undergone blanching treatment (Table 02). There was no significant difference (P>0.05) observed between these two treatments whereas significant difference (P<0.05) was observed with other treatments for LD.

Fresh guava samples attained the lowest a* value while AA 0.5% with BL treated sample showed the highest followed by the control samples (Table 01). Color values of a* were significantly different (P<0.05) among all the treatments except for CA 0.3% with BL and the blanching treatment for 2 minutes at 60°C. The lowest difference of a* value with fresh sample was observed in blanching treatment followed by CA 0.3% with BL (Table 02).

The lowest b* value was obtained by fresh guava samples while the highest was in SMS 0.5% with BL followed by CA 0.5% with BL (Table 01). Blanching treatment for 2 minutes with 60 °C was exhibited the lowest b* value difference compared with the fresh samples (Table 02) maintaining b* value nearest to the fresh samples showing lesser color change.

Table 02: Differences of L*, a* and b* color values of dehydrated guava samples in different treatments compared with fresh sample

Color	Control	BL	CA_0.3%+ BL	CA _0.5% + BL	AA_0.5%+ BL	SMS_0.5%+ BL
L*	18.23±2.7^{d}	4.37±2.7^{a}	3.18±0.7^{a}	8.22±2.7^{b}	12.27±1.6^{c}	10.93±2.1^{c}
a*	6.50±1.1^{b}	3.54±1.5^{a}	3.68±1.5^{a}	4.65±1.5^{a}	7.34±1.3^{b}	4.91±1.3^{a}
b*	11.04±1.6^{a}	9.83±5.1^{a}	13.48±3.2^{ab}	17.32±3.8^{bc}	11.31±4.3^{a}	18.53±5.4^{c}

Each value represents ± S.D. of eight replicates. Values in the same row with different superscript letters differ significantly (P<0.05). L- lightness, a*- green to red., b*- yellow to blue. BL=Blanching at 60°C for 2 minutes, CA= Citric acid, AA=Ascorbic acid, SMS= Sodium metabisulfite.*

It is quite difficult to select a treatment which shows the lowest color difference by comparing L*, a* and b* color values separately because their behavior was different in different treatments (table 1, 2). Therefore, it is important to focus on the total color difference which gives an overall value of color change. Results of the present study shows that the lowest total color difference was obtained from BL treatment followed by CA 0.3% treatment combined with BL (Table 03). And the statistical analysis showed that there was no significant difference (P>0.05) between these two treatments while significant difference (P<0.05) was observed with other treatments.

Because of the brown color of the final product caused by browning reactions, it is important to focus on browning index when selecting an effective browning inhibitor while focusing on color changes and color differences. The highest browning index showed the highest brown color whereas the lowest browning index gives the lowest brown color of the final product. According to the results, the lowest browning index was reported from the samples undergone BL treatment followed by CA 0.3% treatment combined with BL (Table 03) where no significant difference (P>0.05) was observed between these two treatments.

Ascorbic acid acts as an antioxidant and is naturally present in fresh fruits and vegetables (kabasakalis *et al*., 2000). Citric acid is more predominantly present in berries, citrus and tropical fruits (del Campo *et al*., 2006). Hence these two chemical compounds are consumed daily by majority of the people where it is safe to use as treatments in food industry. Apart from that sodium metabisulfite is a commonly used chemical compound to prevent enzymatic and non-enzymatic browning of fruits and vegetables (Molnar-Perl and Friedman, 1990; Lim and Wong, 2018). Citric acid, ascorbic acid and sulfites are considered as effective treatments in controlling browning (Garcia and Barrett, 2002; Cortez-Vega *et al*., 2008; Suttirak and Manurakchinakorn, 2010).

Even though ascorbic acid and SMS considered as effective browning inhibiters, results of the present study showed that they were not effective in controlling browning of guava when dehydrating even with the combination with hot water blanching. Contrary to the results of the present study, SMS was given promising results to prevent color changes of dried chili and apple (Chaethongnand and Pongsawatmanit, 2015; Cortez-Vega *et al*., 2008). Ascorbic acid aggravated browning and SMS increased the b* value which indicates the increment of yellow color in dehydrated guava samples. Ascorbic acid induced browning reactions may be occurred during the dehydration which may be the reason for increment of browning in ascorbic acid treated guava samples (Bradshaw *et al*., 2001). Cortez-Vega *et al*. (2008) also revealed that the ascorbic acid was not much effective in controlling the browning of minimally processed apple compared with SMS treatment. Contrary to that, ascorbic acid and SMS were effective in controlling the browning of green coconut water when subjected to thermal processing where the effectiveness of SMS was higher than ascorbic acid even though both were effective (Tan *et al*., 2015). Furthermore, 1% (w/v) Ascorbic acid was more effective in preventing browning of Golden Delicious and Elstar apple varieties (Shrestha *et al*., 2020). However, according to the results of the present study, ascorbic acid individually or combined with hot water blanching was not much effective in controlling browning of guava when dehydrating.

CA_0.3%+ BL was given promising results compared with AA_0.5%+ BL, SMS_0.5%+ BL and SMS_0.5%+ BL treatments in the present study. These results revealed that the minor concentration of citric acid combined with blanching was effective in controlling browning of guava during dehydration. In previous studies, the effect of citric acid in prevention of browning was investigated and promising results were obtained for banana slices (Moline *et al*., 1999). Furthermore, Suttirak and Manurakchinakorn (2010) revealed that the Citric acid is more effective in prevention of browning when combined with other anti-browning agents like Ascorbic acid even though it was not success in present study. Citric acid was more effective in present study when it was used as a combination with blanching.

Table 03: Total color difference and browning index of dehydrated guava samples with different treatments.

Treatment	TCD	BI
Control	21.86 ± 2.75[a]	47.86±10.04[a]
BL	12.50±3.12[b]	33.35±4.88[b]
CA_0.3%+ BL	14.45±3.01[b]	38.91±2.32[bc]
CA_0.5%+ BL	20.15±2.70[ac]	50.74±7.55[ad]
AA_0.5%+ BL	18.39±2.46[c]	44.23±6.31[ac]
SMS_0.5%+ BL	22.20±3.85[a]	55.38±8.59[d]

Each value represents ± S.D. of eight replicates. Values in the same column with different superscript letters differ significantly (P<0.05). TCD=Total color difference, BI= Browning index. BL=Blanching at 60°C for 2 minutes, CA= Citric acid, AA=Ascorbic acid, SMS= Sodium metabisulfite

Blanching treatment for 2 minutes in 60°C showed positive results towards the reduction of color change in dehydrated guava samples. This may be due to inhibition or deactivation of the compounds which are responsible for the browning reaction of Guava. Blanching was used to get effective results for mango and Indian gooseberry as well in preventing browning in previous studies (Ndiaye, Xu & Wang, 2009; Gudapaty *et al*., 2010). In addition to that the best results were obtained with blanching treatment for Japanese quince fruits when they produce dehydrated candied (Krasnova *et al*., 2018). Positive results of blanching were obtained for salak fruit dehydration where effectively minimized browning during dehydration and appreciable color change was observed during storage (Ong and Law, 2011). Furthermore, the effectiveness of hot water blanching combination with Citric acid was observed for some apple varieties (Shrestha *et al*., 2020).

Considering all the color values with the tested treatment combinations, it was revealed that the lowest color change was observed in blanching treatment at 60 °C for 2 minutes followed by the CA 0.3% with BL treatment. However, the effectiveness on browning prevention is mainly dependent on the produce types and cultivars, and concentrations of anti-browning agents (Suttirak and Manurakchinakorn, 2010).

However, the browning process for the cultivar 'Apple Guava' should be studied further to clarify and to deeply understand the type of browning occurred, where the present study was mainly aimed at identifying the effective browning inhibitors during dehydration rather than focusing on the type of browning.

CONCLUSIONS

Experimental results showed that, the blanching at 60 °C for 2 minutes was more effective in controlling the browning of guava during dehydration. However, citric acid 0.3% combined with blanching treatment was also effective in controlling the browning of guava when dehydrating. Even though these two treatments effectively inhibit the browning, the water blanching treatment (60°C for 2 minutes) is more suitable to use in the industry as it reduces the cost for the treatments.

Conflict of Interest

The authors declare that there is no conflict of interest.

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