Combined Effect of Citric Acid and Ascorbic Acid as Chemical Pre-Treatments to Prevent Enzymatic Browning in Fresh Cut Ambul Banana (*Musa* spp.)

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***Abstract*—** *Minimally processed products give several health benefits to consumer such as reducing meal preparation time, less storage space and reduced waste disposal. Texture and colour are the two of the most noticeable quality of parameters of fresh cut fruits and vegetables that may change during storage. Enzymatic browning affects the product's appearance by changing the cut surface colour into dark as a result of formation of dark pigments. Several chemicals such as acidulants are used to control browning. Ambul Banana slices are very sensitive to physiological browning, a problem that has precluded their use as fresh cut salad. Ambul banana were harvested from a farmer field in Anuradhapura. Fruits were selected at stage four of ripeness (more yellow than green). Banana were washed with water followed by immersion in 5% Hydrogen peroxide solution at 4 ˚C for 2 min. Fruits were cut in to slices with thickness of 0.5 cm and packed in transparent polystyrene containers with filling solution. Three different filling solutions (Sugar solutions) were prepared and the solution was filled by keeping the head space as 1 cm. The cups were kept under refrigerated condition (5±1 °C) for quality analysis during storage. The physicochemical characteristics such as pH, TSS (Total Soluble Solids), colour, firmness and Total Plate Count (TPC) were evaluated. Data obtained were in triplicate (n=3) and the results were assessed by Completely Randomized Design using ANOVA by SAS statistical package. Mean separation was done by using Least Significant Difference (LSD) at α= 0.05. Enzymatic browning in minimally processed Banana can be controlled by adding 2.5% citric acid + 1.5% ascorbic acid as preservatives incorporate with sugar solution (30° B). The shelf life of fresh cut Ambul banana can be extended up to 8 days under refrigerated condition (5±1 °C) without significant quality deterioration*.

Keywords*: Ambul Banana, Fresh Cut Storage, Quality Changes*

I. INTRODUCTION

Fresh cut fruits are defined as "any fresh fruit, vegetable or combination therefore that has been has been physically altered from its original form, but remain in a fresh state" according to International Fresh Cut Produce Association (IFCPA). Consumption of fresh fruits has been increased with the awareness of their health benefits such as antioxidant activity, low in fat and sodium and free from cholesterol (Jayathunge *et al*., 2012). Minimally processed products give several health benefits to consumers such as reducing meal preparation time, less storage space and reduced waste disposal. Processing technology associate with minimal processing increase their perishability and makes these commodities more vulnerable to spoilage (Wijeratnam, 2006). Flavor, texture, appearance and nutritional value are very important quality factors for the minimally processed products.

Texture and colour are the two of the most noticeable quality parameters of fresh cut fruits and vegetables that may change during storage. Enzymatic browning affects the product appearance by changing the cut surface colour into dark as a result of formation of dark pigments and browning remains a limiting factor in the preparation and marketing of many lightly processed fruits and vegetables. Several chemicals are used to control browning such as acidulants. Ambul banana cultivar is the widely grown and highest demanding banana variety in Sri Lanka (Wasala *et al*., 2015). Even though there are number of Banana cultivars available, Ambul banana is the major cultivar that uses for fruit salads in Sri Lanka. Banana slices are very sensitive to physiological browning, a problem that has precluded their use as fresh cut salad. Therefore this study was conducted to improve the colour retention of fresh cut Ambul banana by prevention of enzymatic browning during storage.

II. MATERIAL AND METHODS

A. Material selection

Ambul banana were harvested from farmer field at Anuradhapura. Fruits were selected at stage four of ripen (more yellow than green). Fruits were transported to

food processing laboratory of Institute of Post Harvest Technology (IPHT) for experimentation. Banana were washed with water followed by immersion in 5% Hydrogen peroxide solution at 4 ˚C for 2 min. Fruits were cut in to slices with thickness of 0.5 cm and packed in transparent polystyrene containers with filling solution. Filling solution which contains 30˚ Brix in total soluble solids was prepared by adding 850 ml of water in to 500 g of Liquid glucose. The preservatives in different concentrations were incorporated in to sugar solution such as, T1: 1.5% citric acid + 1.5% ascorbic acid; T2: 2.5% citric acid + 1.5% ascorbic acid and T3: control without any preservatives. Three different sugar solutions were prepared according to three treatments. The prepared sugar solutions were kept in refrigerator 5±1°C before adding into containers. After placing the banana slices, filling solution (Sugar solution) was poured on it by keeping the head space as 1 cm and the lid was placed. The cups were kept under refrigerator (5±1 °C) condition for quality analysis during storage period.

B. Physico- chemical evaluation

The fruit pieces were chopped and the pulp was analyzed in triplicate for pH, TSS (Total Soluble Solids) to evaluate the quality deterioration of the product during 8 days of storage. TSS was determined by direct reading on a Refractometer {ATAGO, Model: HR-5 (9-90%), Japan}. Reading was reported as ^{0}Brix. The pH of fruit pieces were determined using digital pH meter (9157 BN, Witchford, England). Colour in terms of *CIE* L*, a*, b* values was measured with colour difference meter (Konica Minolta TR 400). Firmness of fruit slices were measured by using a fruit firmness tester (Model CS1 -2, Italy).

C. Microbial quality

The total plate count was determined in fresh cut Ambul banana during storage according to AOAC 1990.

D. Sensory evaluation

Sensory evaluation was done to detect the consumer acceptability by 30 untrained panellists. Five point hedonic scale was used to evaluate the colour, aroma, taste, texture and overall acceptability of the fruit salad at the end of the storage period. (5-extremely like, 1-extremely dislikes).

E. Statistical analysis

Data obtained were in triplicate (*n=3*) and the results were assessed by Completely Randomized Design using ANOVA by SAS statistical package. Mean separation was done by using Least Significant Difference (LSD) at α= 0.05. Nonparametric data were analyzed by Friedman test using MINITAB statistical software.

III. RESULTS AND DISCUSSION

The quality changes of fresh cut Ambul banana during storage were given in Table 1.The results showed that the b* value of all treatment showed an increasing trend thereafter decreasing. The increase may be due to addition of different acid solutions as anti browning agents help to protect the colour of banana slices by preventing browning reaction. Jayathunge, *et al.* (2012) reported that the mixture of citric acid and ascorbic acid showed the combine effect on prevention of enzymatic browning and our findings were confirmation with that because the treatment two (T_2) showed higher L* value (62.78) at the end of storage indicating lowest browning . L* value is range from 0 to 100 which values close to zero indicate dark while close to 100 indicating whiteness. Therefore L* value of T_2 indicates minimum browning compared to other treatments.

According to results obtained TSS (Total soluble solid) content was not significantly different in three treatments throughout the storage. Final values of TSS in all three treatments are high compared to initial values. Break down of pectin and conversion of carbohydrates into simple sugars due to metabolic activities may cause rising in TSS within storage period.

Firmness of fresh cut Banana slices during the storage period shown in table 1. Fruit firmness of treatment one (T_1) and two (T_2) remained same within storage but treatment three (T_3) had lower values compared to other two treatments. Loss of firmness has been reported in minimally processed fruits and vegetables which adversely affects their quality. Minimally processed fruits and vegetables have soft and chewy texture which is undesirable (Shah & Nath, 2006). Firmness reduction of fresh cut fruit cubes occur due to dissolution of middle lamella and subsequent cell separation and is a consequence of the activity of pectin esterase, an enzyme that remains active even at low temperature (Roccui *et al.,* 2006).

Microbial count of the fresh cut Ambul banana slices shown in table 1 and values were recorded below the critical level of 1×10^5 reported by Harrigan 1998. Microbiological quality is a common criterion used to determine the acceptability and shelf life of minimally processed products. Destruction of surface tissues, during preparatory stage of minimal processing, exposes cytoplasm and provides a potentially richer source of nutrients for the microorganisms than intact produce. This together with high water activity facilitates microbial growth in minimally processed fruits and vegetables (Shah & Nath, 2006). Microbial count of minimally

processed foods depends on handling quality of utensils used during preparation and sanitary practices adopted.

Table 01. quality changes of fresh cut Banana slices under refrigerated storage (5±1 °C)

Parameters	Storage interval in days			
Treatment 1 (T_1)	**2**	**4**	**6**	**8**
Colour				
L*	65.55±0.53	67.89±2.56	62.07±1.89	56.08±2.89
a*	-0.35±0.18	-0.73±1.32	0.82±1.96	2.62±1.29
b*	25.12±0.08	27.43±3.13	26.96±1.89	24.04±0.93
TSS °(B)	17.27±0.12	24.37±0.21	24.72±0.06	25.36±0.06
pH	4.55±0.07	4.55±0.10	4.54±0.22	4.54±0.05
Firmness (kg/cm^2)	6.00±0.22	0.34±0.07	0.40±0.01	0.35±0.07
Total plate count (CFU/g)	1.2×10^1	1.3×10^1	1.4×10^1	1.5×10^1
Treatment 2 (T_2)				
Colour				
L*	65.48±0.48	67.30±2.23	67.23±1.57	62.78±3.43
a*	-0.70±0.16	-3.06±0.07	-5.41±0.52	-1.87±1.01
b*	26.27±0.04	27.66±1.73	28.07±3.41	27.75±2.65
TSS °(B)	17.50±0.10	20.33±0.06	21.34±0.06	22.53±0.12
pH	4.57±0.05	4.57±0.04	4.60±0.05	4.62±0.01
Firmness (kg/cm^2)	6.18±0.70	0.30±0.10	0.36±0.06	0.23±0.03
Total plate count (CFU/g)	1.1×10^1	1.3×10^1	1.3×10^1	1.4×10^1
Treatment 3 (T_3)				
Colour				
L*	65.82±0.61	59.02±1.78	56.49±1.36	53.97±3.23
a*	-0.55±0.24	-0.48±1.53	1.06±1.27	1.45±0.93
b*	25.21±0.11	25.07±1.68	24.81±2.91	21.40±2.50
TSS °(B)	17.27±0.12	21.33±0.06	21.50±0.10	24.17±0.22
pH	4.53±0.05	4.53±0.05	4.54±0.05	4.55±0.12
Firmness (kg/cm^2)	5.80±0.54	0.27±0.07	0.18±0.06	0.12±0.07
Total plate count (CFU/g)	1.1×10^1	1.4×10^1	1.5×10^3	1.7×10^3

Standard deviation for three replicate (*n*=3) determinations

The pH of fruit slices of treatment one and two were given lowest value (4.5) while control exhibited higher value than treatments. Treatments showed lower pH values due to absorption of filling solution with citric acid and ascorbic acid. There was no significant difference observed between treatments in pH levels.

Ascorbic acid is a highly effective inhibitor of enzymatic browning, primarily its ability to reduce quinones back to phenolic compounds before they can under go further reaction to form pigments. Unfortunately, once the ascorbic acid has been completely oxidized to dehydroascorbic acid, quinines can accumulate and under go browning. Citric acid acts as a chelating agent and acidulant which has two functions to inhibit PPO activity. In this experiment, T_2 has 2.5% citric acid level that fruit slices showed higher L* value indicating minimum browning at the end of the storage period.

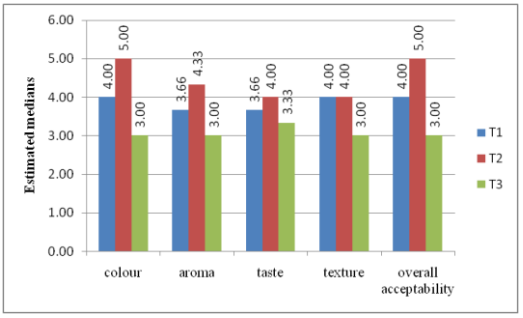

Figure 01. Sensory attributes of fresh cut banana slices

The test for sensory evaluation was conducted to determine the consumer acceptability to select most preferred treatments and the colour, aroma, taste and overall acceptability were evaluated. Treatment two was scored higher estimated median (4-like moderately to 5-Like extremely) for its all quality attributes and treatment three was the poorest performing treatment that scored lowest estimated median (3 – 3.33) for all attributes.

CONCLUSIONS

Enzymatic browning in minimally processed Banana can be controlled by adding 2.5% citric acid + 1.5% ascorbic acid as preservatives incorporate with sugar solution (30°B) as a filling solution. The shelf life of fresh cut Ambul banana can be extended up to 8 days under refrigerated condition (5±2 °C) without significant quality deterioration.

REFERENCES

AOAC (1990) Official methods of analysis of the Association of Official Analytical Chemists. 15th edn. Washington DC.

Harrigan WF (1998) Laboratory methods in food microbiology (3rd Ed).p.532.Academic press, United kindom.

Jayathunge KGLR, Rishana F, Illeperuma DCK, Thilakarathne BMKS, *et al* (2012) Suitability of micro-perforated PVC containers for modified atmosphere packaging of minimally processed fruit salad containing pineapple, papaya and mango. Asian Journal of Food and Agro-Industry., 5(06) 554-566.

Kaur C and Kapoor HC (2000) Minimally processing of fruits and vegetables. Journal of food science., 40(1) 156-163.

Roccui P, Romani S and Rosa MD (2005) Effect of modified atmospheric packaging with argon and nitrous oxide on quality maintenance of minimally processed Kiwifruit. Postharvest Biology and Technology., 35:319-328.

Shah NS, and Nath N (2006) Minimaly processed fruits and vegetables – Freshness with convenience. J. Food Sci. Technol.,43(6) 561-570.

Wasala WMCB, Dharmasena DAN, Dissanayake TMR, *et al* (2015) Vibration simulation testing of Banana bulk transpoprt packaging systems.Tropical Agricultural Research., 26(2) 355-367.

Wijeratnam SH (2006) Fresh cut fruits and vegetables. Proceedings of the international conference on value addition in horticultural products. pp. 189-194.

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