Effect of Citric Acid on Storage Quality of Fresh-Cut Huaimun Pineapple

Panida Maketup* Dr.Mayuree Krajayklang**

ABSTRACT

Development of browning after cutting pineapple fruit is a major problem affecting the fresh cut quality of the fruit, and shortens storage life. The purpose of this study was to reduce the incidence of browning and to delay senescence of fresh-cut pineapples *(Ananas comosus* L. Mess. cv. Huaimun) by using citric acid. Pineapples with a shell color corresponding to stages 2 and 3, meaning 25-50% shell color change were washed, and sliced, the slices were air dried and then divided into three portions. The first was dipped in distilled water, with 0% acid, as a control, the second and third portions were dipped in 0.5% and 1.0% w/v of citric acid (CA) solution for 2 min, respectively. The slices were then packed in clamshell trays and stored at 2.5 $^{\circ}$C for 12 days. The amount of browning was observed every two days. The best results were obtained from the 0.5% citric acid solution which showed reduced browning incidence at day 6 ($p < 0.05$), which was associated with a change in L* value of pineapple slices. As well, electrolyte leakage was lower in the slices treated with the 0.5% solution on days 1, 2, 4, and 8 than those in the 0% control and 1% citric acid solutions, but not significantly. The soluble solids content of the pineapple slices showed a significant affect from both citric acid treatment levels after 12 days. All of the pineapple slices developed an off-odor over the storage period of the 12 days, but the off-odor of the slices in the 0.5% level slices was lowest, but not significantly lower than the control. Fruit quality, as in firmness, was well maintained significantly better in the 0.5% treated fruit for the first 4 days of storage than the other two treatments. The results suggest that treating the fresh-cut pineapple with a 0.5% solution of citric acid resulted in better fruit quality, best visual appearance with less browning and delaying senescence of the fresh-cut pineapple. The acceptable storage life of the fresh-cut pineapple was extended in the 0.5% citric acid treated fruit to 8.5 days at 2.5 $^{\circ}$C while the storage life of the control and the 1.0% citric acid treated fruit extended to 7.5 and 7 days, respectively. However, this indicates that there were no significant differences in storage life among the treatments ($p > 0.05$).

Keywords: Fresh-cut pineapple, Browning, Citric acid

* *Student, Master of Science Program in Agricultural Science in a Major of Postharvest Technology, Faculty of Agriculture, Natural Resources and Environment, Naresuan University*

** *Assistant Professor, Faculty of Agriculture, Natural Resources and Environment, Naresuan University; Excellent Research Center on Postharvest Technology, Naresuan University*

Introduction

Fresh-cut pineapple is popular with consumers primarily because of its convenience, but also its freshness. However, fresh-cut pineapple deteriorates faster than intact produce because cutting the fruit causes wounding at the cut surface. Even when packaged, this action results in deterioration in the quality of the fruit which deters consumers from buying the product (Puthmee *et al*., 2010) . Particularly, fresh-cut pineapple fruit is vulnerable to discoloration because of the damaged cells and tissues, which reduces the shelf-life, changes the taste and also results in the development of unpalatable smell (Somgaew, 2009).

Huaimun is a cultivar of pineapple (*Ananas comosus* L. Mess. cv. Huaimun) developed in Uttaradit province in northern Thailand and gaining popularity for both cultivation and consumption in Thailand (Department of Intellectual Property, 2013). Its increasing popularity amongst consumers is due to its wide cylindrical shape, yellow skin and a regal crown with the fruit weighing around 2.2 kg. The fruit has a spiny thin skin with fibrous yellow flesh and crisp fruit texture. The fruit has high sugar content and therefore a sweet taste (Department of Intellectual Property, 2013). However, it is necessary to develop techniques to be used by the fresh-cut pineapple for promotion and export Huaimun pineapple. The development of this cultivar, and the resultant high quality and marketability have made this fruit an important crop in farming communities, and to marketers. Unfortunately, this high quality fruit is also susceptible to browning and quality deterioration when cut.

Citric acid (CA) is a widely used natural inhibitor of browning and maintenance of nutrients and therefore is useful for inhibiting browning on fresh-cut fruit surfaces (Lee *et al.*, 2003). Citric acid inhibition of this enzymatic browning has been demonstrated on apple slices, inhibiting browning for up to 3 hours period before sample were kept at room temperature (Son *et al*., 2001). This method may be useful for fresh-cut pineapple. Therefore, Huaimun was selected as the test pineapple cultivar for the reasons of its high quality and marketability, and importance to the developers and growers as well as little information available for this cultivar.

Objective of the study

To find the most suitable concentration of citric acid to be applied to cut pineapple slices to achieve maintenance of fruit quality, inhibition of browning and to extend shelf life.

Materials and methods

Pineapple sampling

Pineapple fruit *(Ananas comosus* L. Merr. cv. Huaimun) were harvested at the commercial maturity stage (between 25 and 50% shell color change) from a commercial field located in Uttaradit province, Thailand. The fruits were washed in water with 200 ppm sodium hypochlorite and then peeled and manually sliced. The slices measured approximately 10 cm with 4 cm thickness and their cores were not removed. The pineapple slice samples were prepared with either 0.5% citric acid solution or 1% of citric acid solution, as anti-browning solutions or with distilled water as the control. The pineapple slices were dipped in these test solutions for 2 min then drained and placed in a plastic clamshell container. These were then kept in a refrigerated room at 2.5°C and 68.67±0.38 relative humidity for 12 days. During this period the fruit slices were evaluated for quality every 2 days.

Weight loss

Weight loss during storage was determined every two days. The value was expressed as a percentage of weight loss and calculated as:

$$\text{Weight loss (\%)} = (W_i - W_t)/W_i \times 100$$

Where W_i is the initial weight and W_t is the weight measured during storage.

Firmness

The firmness of the pineapple was measured by Texture Analysis (Brookfield Model QTS25, USA). A slice of pineapple measuring 4 cm x 2.54 cm × 2.54 cm (1 inch) was removed for this test. The firmness measure was the force required for a 2 mm diameter probe to penetrate this pineapple slice at a speed of 60 mm/s to a depth 4 mm at the geometric center of the slice. Firmness was expressed in grams (g). Each measurement was repeated at second time for each pineapple slice.

Color measurement

The cut pineapple surface color values were measured with a colorimeter (MiniSacn XE PLUS, Hunter Associates laboratory, USA) and reported as L* values. An L* value is a measure of coloration intensity between black (0) and white (100) (Siddiqui et al., 2011), and in this case is measuring the degree of browning (AOAC, 1990).

Electrolyte leakage

Electrolyte leakage (EC) of the pulp around the core. The pulp was cut into 0.5 cm cubes. The cubes were washed with deionized water 3 times and submerged in 50 mL of a 0.4 M mannitol solution and shaken at 100 rev/min on a rotary shaker for 1 h. The electrical conductivity was measured using a conductivity meter (L_0) (Sartorius Ducu-pH meter, Germany). The samples were then placed in an autoclave at 121 °C for 30 min and then left to cool at room temperature, after which the electrical conductivity was measured again (L_1). Actual electrolyte leakage was expressed as a percentage of this maximum electrolyte leakage as:

$$\text{Electrolyte leakage \%} = \frac{(L_0)}{(L_1)} \times 100$$

Soluble Solids Content (SSC), Titratable acidity (TA) and pH

The juice content of the sample fruit was extracted by hand and the soluble solids content of the juice was determined by a digital refractometer (ATAGO, Japan). The results are reported as °Brix.

A 5 ml sample of the extracted juice was prepared with 0.1 N NaOH and 1-2 drops of phenolphthalein 1% as the indicator and swung until the solution changed to a pink color. Titratable acidity was calculated by titration and expressed as a percentage of citric acid according to the AOAC method of analysis (AOAC, 1990).

pH measurement of the extracted juice was determined by a pH meter (Thermo Scientific Orion 3-Star Plus, USA).

Vitamin C

Vitamin C level was determined using AOAC method (AOAC 1990). A sample with 2 ml of the extracted juice with meta-phosphoric acid acetic 5 ml were titrated with 2, 6- dichloroindophenol solution until light rose pink persisted for 15 s. The amount of 2, 6-dichloroindophenol solution used in the titration was determined and used in the calculation for ascorbic acid content. The results were expressed as mg ascorbic acid per 100 ml juice.

Gas analysis

The change in CO_2 and C_2H_4 concentrations were measured by randomly picked 1 pineapple slice kept in closed plastic container of 1,800 ml, and placed at room temperature for 3 hours. Headspace samples were withdrawn and analyzed for CO_2 and C_2H_4 by gas chromatography (SHIMADZU GC-14B, Japan), equipped with a thermo conductivity detector (TCD) and a flame ionization detector (FID), respectively. The gases were separated in an active carbon column. All respiration rate and ethylene production were done in four replications and the results were expressed as CO_2 mg/kg/h and C_2H_4µl/kg/h, respectively.

Sensory analysis

Sensory properties were evaluated at room temperature under normal lighting condition. The quality attributes were described as color, texture, odor, flavor and also acceptability by six panelists. A 9-hedonic rating scale was used with 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely. A score of 5, which corresponds to ‘‘I liked it slightly,’’ was used to indicate overall acceptability, and also recorded for the storage life.

Statistical Analysis

Results were analyzed by using analysis of variance (ANOVA). Significantly difference means were separated by using a Duncan’s new multiple range test (DMRT) at $p<0.05$ with statistical software.

Results and Discussion

Color measurement

The color of fresh-cut fruits is an important organoleptic factor because color affects consumers’ evaluation on the product (Olivas and Barbosa-Cánovas, 2005). Similarly, the deterioration of the fruit tissue results in browning with extending period of storage, and this becomes a major problem in fresh-cut pineapple (González-Aguilar *et al*., 2004). An increase in browning in fresh-cut pineapple was observed by a decrease in L* value in this study. In this case is measuring the degree of browning during storage (AOAC, 1990). The L* value was increased for the first 2 days of storage, and then rapidly declined in control slices with a significant lowest (darkening or browning) at day 6 of the storage compared to both citric acid slices ($p<0.05$) (Figure 1A). A 0.5% citric acid solution was the most effective condition to maintain the color throughout the experiment. However, the change in L* was not significant difference after day 6 of the storage ($p>0.05$). Similarly, Son *et al*. (2001) reported that a solution of 1.0% citric acid was effective in reducing the level of browning in fresh-cut apple. The solution of citric acid is commonly used in the food industry to reduce food browning as because of the citric acid substance could inhibit enzymatic browning (Tanchroensukjit, 2008).

Weight loss and firmness

The intensity of the fruit cell trimming is vital to the quality of the fresh-cut fruit. The fresh cut fruit on keeping up have the low quality by deteriorating (Song *et al*., 2013) such as weight loss arising from the degradation of cell walls, and the loss of pectin on a cell wall. The cells cannot remain the same save, therefore, is become weight loss (Mart'ınez-Romero *et al*., 2006). In this study, weight loss increased during storage but the weight loss of citric acid slices was significantly ($p<0.05$) reduced than the control at the first two days of storage at 2.5°C. However, after that the solution of citric acid was not effective in reducing weight loss in this study (data not shown). The weight loss is mainly due to the evaporation of water facilities by the gradient pressure steam (Yaman and Bayoindirli, 2002). The results in such manner as may arise from storage up with relatively low humidity (68.67 ± 0.38% RH) within the temperature controlled in this study.

Texture is one of the quality attributes in pineapple slices. Softening of the texture is related to weight loss and degradation by cell-wall degrading-enzymes such as polygalacturonase and pectin esterase (Martinez-Ferrer *et al*., 2002). However, the solution of citric acid did not delay the softening of fruit slices in this study (data not shown). Fruit firmness slightly declined throughout the duration of storage.

Eelectrolyte leakage (EC)

The process for fresh-cut fruits normally damaged the cell and affected fruit quality. The deterioration of the fruit could occur such as increases in respiration, weight loss, and texture softening (Lee *et al*., 2003). Finally, this resulted in electrolyte leakage of intracellular ions of the cell. The electrolyte leakage is used to measure the deterioration of cell membrane. Since the cell membrane have been destroyed and therefore loss of water (Buanong and Wongs-Aree, 2012). In this study, electrolyte leakage was lower in the slices treated with the 0.5% solution throughout the experiment than those in the 0% control and 1% citric acid solutions, but not significantly (Figure 1B). It is possible that the electrolyte leakage of that occurs as a result of the deterioration of pectin in the fruit tissue when the long-term storage in conjunction with a wound to the cells (Siripanit, 1998), and as shown in a result, cells electrolyte leakage charge more in a control slices after day 6 of the storage (Figure 1B).

Soluble Solids Content (SSC), Titratable acidity (TA), pH and Vitamin C in fruit juices

The soluble solids content of fresh-cut pineapple slightly increased with the duration of the storage. At the end of the storage, SSC was significantly highest in a control slice (Table 1). Both citric acid solutions could maintain the level of dissolved solids in fruit slices than those in a control throughout the storage.

Titratable acidity in the juice of fresh-cut pineapple treated with citric acid was likely to increase slightly throughout the storage period (Table 1), but not significantly among treatments.

The solution of citric acid had no effect on a change in pH in juices throughout the duration of storage in this study (Table 1). Overall, a pH change was in the range of 3.92 to 4.35 in all treatments in this study, which was in the acidity range that possibly could inhibit the function of such enzymes. For example, the function of the enzyme activity of poly phenol oxidase was in a neutral range of pH 6.0-6.5 (Son *et al*., 2001). In acidic conditions, thus affecting the functioning of the enzyme was reduced (Tanchroensukjit, 2008) by inhibiting the activity of the enzyme, if the pH was in the range of 4.5 (Oms-Oliu *et al*., 2010).

The level of vitamin C was high at the beginning of the storage, and then steadily declined until the end of storage in all treatments (Table 1). The solution of citric acid had no effect on vitamin C levels in this study. Similarly to the study of Ahvenainen *et al*. (1996) found that vitamin C level in potato slices dipped in citric acid also decreased during storage.

Ethylene production and respiration rate

The amount of ethylene production was equal 1.2-1.45 µl C_2H_4/kg/h at the beginning of the storage, and tended to decline throughout the period of storage in all treatments with no significant differences (data not shown). A low temperature storage at 2.5°C could possibly retard the amount of ethylene production in this study. The optimum temperature for fresh-cut fruit was recommended at 5 to 10°C (González-Aguilar *et al*., 2004). Furthermore, pineapple has been known as a non-climacteric fruit, therefore the ethylene production rate was already low (Siripanit, 1998).

The respiration rate as the production of carbon dioxide tended to increase with the longer storage in this study. However, there was no significant difference among treatments (data not shown). This was associated in the study of Marrero and Kader (2006) found that the storage of fresh-cut pineapple more than two days could induce the rate of respiration more and more than those in the fresh fruit. Once cells of fruit were destroyed with cutting process, an increase in the rate of respiration was induced (Watada, 1999).

Sensory evaluation

Color of pineapple slice was light yellow at the beginning of the storage, and then the incidence of a darker color in pineapple slices occurred during storage in all treatments. A 0.5% citric acid solution was the most effective in delaying browning of fruit slices, especially at day 6 of the storage (Table 2), similarly to the study of González-Aguilar *et al*. (2004).

All of the pineapple slices developed an off-odor over the storage period of the 12 days, but the off-odor of the slices in the 0.5% level slices was lowest, but not significantly lower than the control (Table 2).

Fruit quality, as in firmness, was well maintained significantly better in the 0.5% treated fruit for the first 4 days of storage than the other two treatments (Table 2). The results suggest that treating the fresh cut pineapple with a 0.5% solution of citric acid results in better fruit quality, best visual appearance with less browning and delaying senescence of the fresh-cut pineapple.

The acceptable storage life of the fresh-cut pineapple was extended in the 0.5% citric acid treated fruit to 8.5 days at 2.5°C while the storage life of the control and the 1.0% citric acid treated fruit extended to 7.5 and 7 days, respectively (Figure 1C). However, this indicates that there were no significant differences in storage life between the treatments ($p>0.05$). Fresh-cut artichokes treated with citric acid solution alone could be stored up to 5-7 days in the study of Ghidelli *et al*., (2013). However, the efficiency of citric acid was increased by adding ascorbic acid in a ratio of 0.5% CA: 0.5% AA, which reduced the browning incidence in fresh products (Ahvenainen, 1996). Therefore, this mixed solution may be useful for the fresh-cut products, and be necessary for future study.

Conclusions

The solution of citric acid at 0.5% was most effective in delaying the deterioration of Huaimun pineapple slices during storage in this study as shown by better fruit quality, best visual appearance with less browning. The acceptable storage life of the fresh-cut pineapple was extended in the 0.5% citric acid treated fruit to 8.5 days at 2.5°C while the storage life of the control and the 1.0% citric acid treated fruit extended to 7.5 and 7 days, respectively. However, there were no significant differences in storage life between the treatments ($p>0.05$).

References

Ahvenainen R. New approaches in improving the shelf life of minimally processed fruit and vegetables. Trends in Food Science & Technology 1996; 7(6): 179-187.

AOAC. Official methods of analysis of the association of office analytical chemists 15 th ed. Washington, D.C: Association of official Analytical Chemists 1990.

Buanong M, Wongs-Aree C. Effect of Maturity Stages on Internal Browning of Pineapple Fruits cv. 'Trad Sri Thong'. Agricultural Sci 2012; J. 43(3) (Suppl.): 427-430.

Department of Intellectual Property [online] 2013 [cite 2015 Aug 30]. Available from: ttp://www.ipthailand.go.th/en/

Ghidelli C, Mateos M, Rojas-Argudo C, Pérez-Gago M B. Antibrowning effect of antioxidants on extract, precipitate, and fresh-cut tissue of artichokes. LWT-Food Science and Technology 2013; 51(2): 462-468.

González-Aguilar G A, Ruiz-Cruz S, Cruz-Valenzuela R, Rodrıguez-Félix A, Wang CY. Physiological and quality changes of fresh-cut pineapple treated with antibrowning agents. LWT-Food Science and Technology 2004; 37(3): 369-376.

Lee JY, Park HJ, Lee CY, Choi WY. Extending shelf-life of minimally processed apples with edible coatings and antibrowning agents. LWT-Food Science and Technology 2003; 36(3): 323-329.

Martinez-Ferrer M, Harper C, Pérez-Muñoz F, Chaparro M. Modified atmosphere packaging of minimally processed mango and pineapple fruits. Journal of food science-chicago 2002; 67(9): 3365-3371.

Martínez-Romero D, Alburquerque N, Valverde JM, Guillén F, Castillo S, Valero D,Serrano M. Postharvest sweet cherry quality and safety maintenance by Aloe vera treatment: A new edible coating. Postharvest Biology and Technology 2006; 39(1): 93-100.

Marrero A, Kader AA. Optimal temperature and modified atmosphere for keeping quality of fresh-cut pineapples. Postharvest Biology and Technology 2006; 39(2): 163-168.

Olivas GI, Barbosa-Cánovas GV. Edible coatings for fresh-cut fruits. Critical Reviews in Food Science and Nutrition 2005; 45(7-8): 657-670.

Oms-Oliu G, Rojas-Graü MA, González LA, Varela P, Soliva-Fortuny R, Hernando MIH, Martín-Belloso O. Recent approaches using chemical treatments to preserve quality of fresh-cut fruit : A review. Postharvest Biology and Technology 2010; 57(3): 139-148.

Puthmee T, Matulaprungsan B, Kanlayanarat S. Cutting Styles of Fresh-cut Pineapple cv. Trad Seethong on Quality after Storage. Agricultural Science 2010; J. 41(3)(Suppl.): 125-128.

Siripanit J. Physiology and Postharvest fruits and vegetables. Nakhon Pathom. Kamphaeng saen, Kasetsart university 1998; 396 page

Song HY, Jo WS, Song NB, Min SC, Song KB. Quality change of apple slices coated with Aloe vera gel during storage. Journal of food science 2013; 78(6): C817-C822.

Somgaew J. Cutting Style on Quality of Mango and Pineapple During Storage. [Master Thesis in Science (Postharvest Technology)]. Chiang Mai : The Graduate School, Chiang Mai university ; 2009. [in thai]

Son SM, Moon KD, Lee CY. Inhibitory effects of various antibrowning agents on apple slices. Food Chemistry 2001; 73(1): 23-30.

Tanchroensukjit S. Quality Maintenance of Fresh-cut Pineapple cv. Phuket Using Antibrowning and Controlled Atmosphere Storage. [Master Thesis in Science (Food Science)] Bangkok : The Graduate School, Kasetsart university ; 2008. [in thai]

Watada AE, Qi L. Quality of fresh-cut produce. Postharvest Biology and Technology 1999; 15(3): 201-205.

Yaman Ö, Bayoindirl L. Effects of an edible coating and cold storage on shelf-life and quality of cherries. LWT-Food science and Technology 2002; 35(2): 146-150.

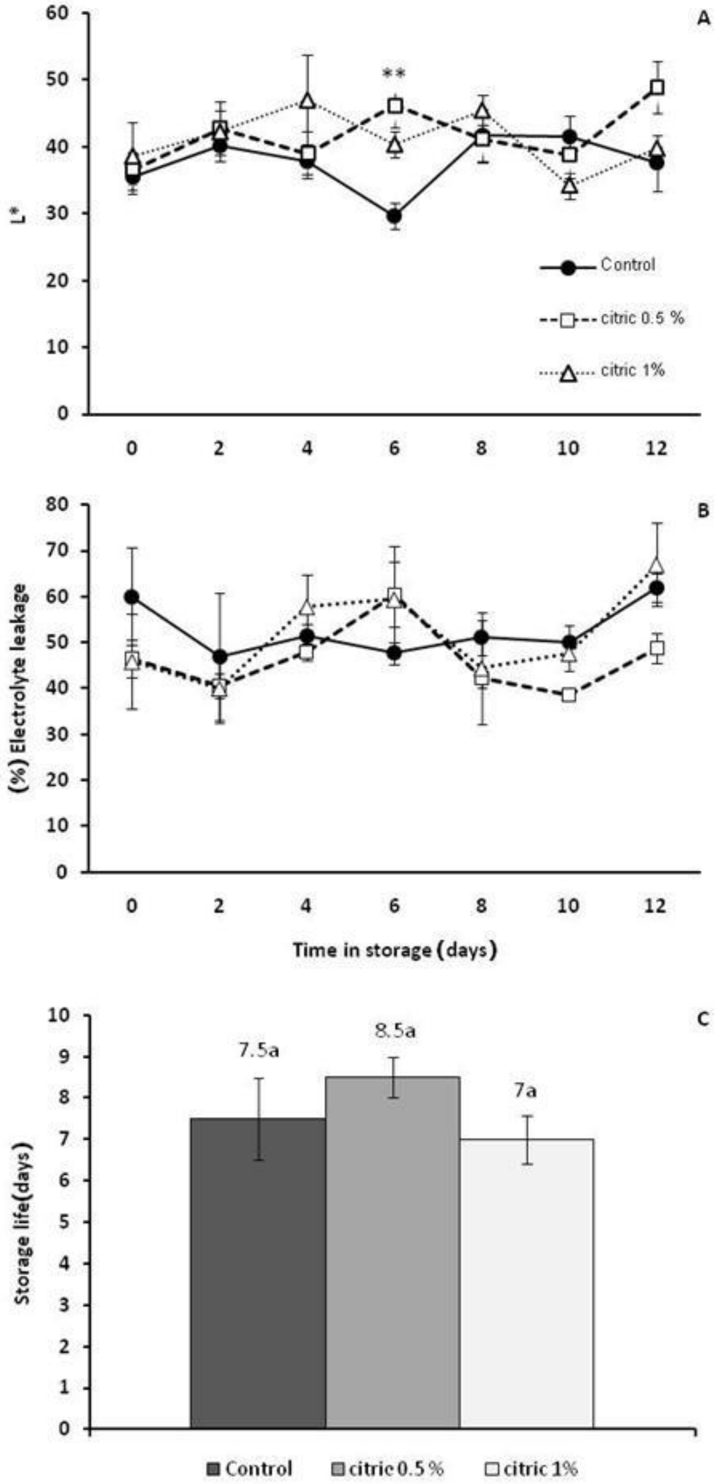

Figure 1 The change of L*(A), electrolyte leakage (B) and storage life (C) of processed pineapple slices with citric acid 0% (a control), 0.5 and 1% w/v, respectively, after storage at 2.5°C for 12 days. Vertical bars represent S.E. with 4 replications.

Table 1 Effect of citric acid on soluble solids content (SSC; °Brix), titratable acidity (TA; %), pH, and vitamin C of the fresh- cut pineapple (mg/100 ml juice) after storage at 2.5°C for 12 days.

		Days of storage						
Parameters	Treatment	0	2	4	6	8	10	12
SSC	Control	13.03[1/]	13.98	13.60	13.95	15.70	16.58	16.00b
	Citric 0.5 %	15.38	13.25	14.75	15.6	15.70	14.68	15.05a
	Citric 1.0 %	13.28	14.90	15.50	14.20	15.70	14.63	14.95a
	F-test	ns	ns	ns	ns	ns	ns	*
TA	Control	3.25[1/]	3.84	4.40	3.25	3.55	3.53	3.75
	Citric 0.5 %	2.83	5.38	3.33	3.90	3.33	3.30	3.83
	Citric 1.0 %	2.96	4.73	3.15	2.53	4.03	3.60	3.38
	F-test	ns	ns	ns	ns	ns	ns	ns
pH	Control	4.15[1/]	4.02	3.99	4.18	4.18	4.03	4.15
	Citric 0.5 %	4.35	3.92	4.18	4.11	4.17	4.18	4.11
	Citric 1.0 %	4.28	4.07	4.24	4.23	4.09	3.92	4.09
	F-test	ns	ns	ns	ns	ns	ns	ns
Vitamin C	Control	13.66[1/]	5.41	3.84	3.42	3.84	2.84	2.72
	Citric 0.5 %	13.66	5.55	3.56	3.56	3.13	3.08	2.96
	Citric 1.0 %	13.66	5.12	3.27	3.13	3.70	3.31	2.13
	F-test	ns	ns	ns	ns	ns	ns	ns

[1/] Means within column followed by different letter are significantly different by using Duncan's new multiple range test at $p<0.05$; (ns) = not significant, (*) = significant at $p<0.05$.

Table 2 Overall quality and sensory of processed pineapple slices treated with 0% (control), 0.5% w/v and 1% w/v citric acid and storage at 2.5°C for 12 days.

		Days of storage						
Parameters	Treatment	0	2	4	6	8	10	12
Color[2/]	Control	2.25[1/]	1.88	2.00	4.50b	3.88	4.38	5.75
	Citric 0.5 %	2.25	2.13	2.50	2.62a	4.13	5.00	5.75
	Citric 1.0 %	2.25	1.88	2.50	4.75b	3.13	3.25	6.13
	F-test	ns	ns	ns	*	ns	ns	ns
Firmness[2/]	Control	4.89b[1/]	5.56	4.56a	4.50	4.88	4.71	4.63
	Citric 0.5 %	4.05a	5.93	5.02a	4.90	5.28	5.63	5.46
	Citric 1.0 %	4.69ab	5.76	6.13b	4.40	5.23	5.79	4.75
	F-test	*	ns	*	ns	ns	ns	ns
Off-odor[2/]	Control	1.00[1/]	1.00	2.00	1.38	2.50	3.13	5.75
	Citric 0.5 %	1.00	1.00	1.25	1.00	2.25	3.50	5.75
	Citric 1.0 %	1.00	1.25	1.00	1.63	1.63	2.50	6.50
	F-test	ns	ns	ns	ns	ns	ns	ns
Sweet[2/]	Control	6.06[1/]	5.08	4.40	4.65	4.15	4.75	3.98
	Citric 0.5 %	5.02	6.17	4.55	4.29	6.48	2.93	2.40
	Citric 1.0 %	5.75	6.85	6.17	4.21	6.38	3.45	3.54
	F-test	ns	ns	ns	ns	ns	ns	ns
Sour[2/]	Control	2.72[1/]	3.76	3.50	4.27	4.96	3.67	4.54
	Citric 0.5 %	3.04	3.13	3.28	3.66	4.27	4.58	6.33
	Citric 1.0 %	2.73	2.44	2.98	1.67	2.81	3.42	5.67
	F-test	ns	ns	ns	ns	ns	ns	ns
Acceptability[2/]	Control	9.00[1/]	5.50	4.46	4.89	4.15	4.29	3.67
	Citric 0.5 %	9.00	5.93	4.50	5.10	5.86	3.96	1.99
	Citric 1.0 %	9.00	7.31	6.26	4.49	6.08	3.64	3.71
	F-test	ns	ns	ns	ns	ns	ns	ns

[1/] Means within column followed by different letter are significantly different by using Duncan's new multiple range test at $p<0.05$; (ns) = not significant, (*) = significant at $p<0.05$.

[2/] A9-hedonic scale was sued for evaluation; for color (1-9) while 1= less color and 9= darkening; for firmness (1-9) while 1= softening and 9= more firmness; for off-odor (1-9) while 1= nor mal aroma and 9= high abnormal aroma; for sweet and sour (1-9) while 1= less sweet or sour and 9= high sweet or sour; for acceptability (1-9) while 1= unlike mostly and 9 = like mostly.