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Effect of Hot Water Treatment and Storage Temperature on Biochemical Properties of Pineapple cv. Mauritius

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ABSTRACT

Pineapple fruits harvested at stage 1 maturity (0–25% eyes yellow) meant for distant market were subjected to hot water dip at 50 ± 20ºC for one minute and stored under 24ºC and ambient temperature (32ºC) along with untreated fruits to evaluate their efficiency in influencing the biochemical quality parameters. Fruits treated with hot water and stored under low temperature had minimum TSS (14.26 °B), total sugar (10.45%) and reducing sugar (4.36%), highest acidity (0.91%), non-reducing sugar (6.09%) and vitamin C (22.85%) after 12 days of storage. Untreated pineapple fruits stored under ambient temperature had least shelf life (12 days) with poor chemical quality parameters. Hot water treatment alone gave better quality pineapple fruits compared to untreated ones and hot water treated fruits when stored under low temperature had resulted in better chemical quality parameters. Chemical quality parameters like TSS, total sugar and reducing sugar of pineapple fruit increased with the advancement of storage period, whereas acidity, non-reducing sugar and vitamin C content showed a declining trend during storage irrespective of the treatments.

Keywords: Pineapple, Hot water treatment, Low temperature storage, Quality.

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INTRODUCTION

Pineapple (*Ananas comosus* (L.) Merr.) belonging to family Bromeliaceae is originated from South America, most probably from the region between Brazil and Paraguay (Paull and Lobo 2012). It is one of the most popular fruits of the tropical region of the world. India is the fifth largest producer of pineapple in the world. In Kerala pineapple is cultivated in an area of 8220 ha with a production of 69,720 tons (NHB 2018). Due to the arrival of new market avenues cultivation of pineapple has become an enterprising business. Mauritius is a dominant cultivated variety recommended for large scale commercial cultivation in Kerala due to its unique aroma, flavur and sweetness, high sugar content and low acidity. The commercial cultivation of Mauritius is extensive in some areas of Ernakulam, Kottayam, Pathanamthitta and Idukki districts of Kerala due to its high market preference and consumer acceptability. But a considerable amount of the produce is lost due to improper harvesting, absence of pre-treatments and lack of good storage facilities.

Post-harvest management practices start immediately after the harvesting of fruits, eliminating undesirable elements and improve product appearance, as well as ensuring that the product complies with established quality standards for fresh products. A small difference in maturity of pineapple influences eating quality and consequently consumer satisfaction. Even though pineapple has good demand and vast export potential, it is traded in fresh form only in a limited scale because of its perishable nature. Post harvest management plays an important role in extending the shelf life and maintaining the quality of the fruit until the final consumption stage and is also a critical component to reduce post harvest losses both quantitatively and qualitatively. Heat treatment after harvest is a non-contaminating physical treatment that delays the ripening process, reduces chilling injury and controls the activity of pathogens and hence is currently used commercially for quality control of fresh products (Ferguson *et al.* 2000). Hence the present study was conducted to evaluate the effect of hot water treatment and storage temperature on biochemical properties of pineapple variety Mauritius during storage.

MATERIALS AND METHODS

Pineapple fruits (var. Mauritius) were harvested with crown and two cm stalk from fields of pineapple growers of Thiruvananthapuram district at stage 1 (0–25% eyes yellow) maturity meant for distant market, which were maintained as per the package of Practice Recommendations of Kerala Agricultural University (KAU 2016). Fruits with uniform quality parameters viz., size, weight and shape, without any pests, diseases and other damages were selected for the experiment.

Harvested pineapple fruits were subjected to hot water treatment at 50 ± 20ºC for 1 minute, spread out to remove excess moisture and stored under two storage conditions viz., low temperature of 240ºC and at ambient temperature of 320ºC along with untreated fruits. Thus the treatments were four viz., T_1 : Hot water treated fruits stored under low temperature of 240ºC, T_2 : Hot water treated fruits stored underambient temperature (320ºC), T_3 : Untreated fruits stored under low temperature (240ºC) and T_4 : Untreated fruits stored under ambient temperature (320ºC), replicated four times under statistical design, CRD. The stored fruits were evaluated for biochemical changes during storage at an interval of 3 days till the end of shelf life.

Total Soluble Solids (TSS) of the fruits was assessed using digital refractometer (Atago- 0 to 53%) and expressed in degree brix (ºBrix). Titrable acidity, reducing sugar and total sugar and ascorbic acid content of pineapple fruits were analyzed as per the procedure described by Ranganna (1986). Nonreducing sugar content of pineapple fruits was assessed by subtracting the reducing sugar content from total sugar. Ascorbic acid content was measured by DCPIP (2, 6 -dichlorophenol indophenol) dye method and expressed as mg $100g^{-1}$.

The data generated from each experiment were tabulated and analyzed statistically using analysis of variance (ANOVA). The treatments at final stage were compared using two sample case t-test.

RESULTS AND DISCUSSION

Untreated fruits stored under low and ambient temperature were damaged by 15^{th} day of storage and hence discarded. All the fruits except those treated with hot water and stored at low temperature were damaged by 18^{th} day of storage.

Total Soluble Solids (TSS) content of pineapple fruits, which is considered as an index of fruit ripening had increased during storage (Table 1). It increased from 13.04 ⁰Brix to 17.07 ºBrix during 12 days of storage. Among the treatments, the highest value of 15.43 ºBrix was recorded for the untreated fruits stored under ambient temperature and the lowest TSS of 14.26 ºBrix was for the fruits pre-treated with hot water and stored at low temperature. Pineapple fruits pre-treated with hot water and stored at low temperature recorded minimum TSS (16.75 °Brix) on 15^{th} day of storage which was followed by hot water treated fruits stored under ambient temperature with 17.52 °Brix. Hot water treated fruits stored at low temperature recorded minimum TSS of 16.66 °Brix and 16.63 °Brix on 18^{th} and 21^{st} days of storage respectively. Pineapple fruits treated with hot water and stored under low temperature had increased TSS during storage and then it was decreased at the end of storage in both maturity stages. These results were in tune with the findings Ali *et al.* (2015) in different varieties of pineapple. They observed that increasing trend of TSS during initial day of storage is due to break down of complex starch and pectin into simple sugars during ripening and further decrease is due to hydrolysis. Hot water treatment associated with low

Table 1. Effect of hot water treatment and storage temperature on TSS (ºB) of pineapple fruit.

Treatments	At the day of storage	3	6	9	12	Treat-ment mean	15	18	21
	TSS (ºB) Days after storage								
T_1 (Hot water treated fruits stored at low temperature	13.02	13.55	13.84	14.55	16.36	14.26	16.75	16.66	16.63
T_2 (Hot water treated fruits stored under ambient tempera-ture	13.05	13.62	13.89	14.59	16.19	14.27	17.52	–	–
T_3 (Untreated fruits stored at low tempe-rature	13.01	14.00	14.92	15.74	16.85	14.90	–	–	–
T_4 (Untreated fruits stored under ambient tem-perature)	13.10	14.19	15.09	15.91	18.87	15.43	–	–	–
Days (D) Mean	13.04	13.84	14.43	15.20	17.07				
	SE ± (m)			CD (0.05)					
Treatments (T)	– 0.097			0.275		p value–0.021			
Days (D)	– 0.108			0.308					
Treatments (T) × Days (D)	– 0.217			0.615					

temperature storage delayed the ripening process and resulted in minimum TSS.

Acidity of pineapple fruits are mainly associated with organic acids viz., citric acid and malic acid. The acidity of pineapple fruits decreased from 0.18 % at the time of storage to 0.56 % after 12 days of storage (Table 2). Pineapple fruits pre- treated with

Table 2. Effect of hot water treatment and storage temperature on acidity of pineapple fruit.

Treatments	At the day of storage 3	6	Acidity (%) 9	12	Days after storage Treatment mean		15	18	21
T_1 (Hot water treated fruits stored at low temperature)	1.06	1.00	0.92	0.83	0.74	0.91	0.65	0.59	0.54
T_2 (Hot water treated fruits stored under ambient temperature)	1.06	0.92	0.82	0.72	0.60	0.82	0.49	-	-

Table 2. Continued.

Treatments	Acidity (%) At the day of storage 3	6	9	12	Days after storage Treatment mean		15	18	21
T_3 (Untreated fruits stored at low temperature)	1.04	0.90	0.77	0.67	0.51	0.78	-	-	-
T_4(Untreated fruits stored under ambient temperature)	1.01	0.86	0.69	0.51	0.40	0.69	-	-	-
Days (D) Mean	1.04	0.92	0.80	0.68	0.56				

	SE± (m)	CD(0.05)	
Treatments (T)	– 0.022	0.061	p value–0.045
Days (D)	– 0.024	0.068	
Treatments (T) × Days (D)	– 0.048	NS	

hot water and stored at low temperature recorded the highest mean acidity of 0.91% while the lowest acidity of 0.69% was reported in untreated fruits stored under ambient temperature after the storage of 12 days. Pineapple fruits pre-treated with hot water and stored at low temperature recorded a higher acidity of 0.65% on 15th day of storage. This was followed by fruits treated with hot water and stored under ambient temperature (0.49%). Hot water treated fruits stored at low temperature recorded acidity of 0.59% and 0.54% on 18th and 21st days of storage respectively. Acidity of stage 1 pineapple fruits showed a declining trend during storage irrespective of the treatments. This was due to the loss of citric acid as reported by Othman (2011). The decline in acidity during storage might be attributed to the utilization of organic acids in respiratory process as reported by Ali *et al.* (2015) in Pineapple.

Sugars mainly include total sugar, reducing sugar and non reducing sugar. Sweetness of pineapple fruit is mainly associated with sucrose, glucose and fructose. During the process of ripening, accumulation of sugar is one of the main changes occurring in fruit composition (Li *et al.* 2011).The total sugar content increased from 9.27 % at the time of storage to 12.63 % on the 12th day of storage (Table 3). Pineapple fruits treated with hot water and stored under low temperature had lowest total sugar of 10.45% after 12 days of storage which was followed by hot water treated fruits stored under ambient temperature with 10.78 %, which was on par with untreated fruits stored under ambient temperature (10.88%). This may be due to the inhibition of the activity of amylase enzyme by hot water associated low temperature which slowdown the breakdown of starch into simple sugars. Sugar content reached maximum at the optimum ripening stage by the conversion of starch to sugar and further decreased as sugars are used as substrate for respiration as reported by Bhooriya *et al.* (2018) in guava. Untreated fruits of both maturity stages stored under ambient temperature recorded maximum total sugar content. The highest total sugar content of 11.21% was observed in untreated fruits stored under ambient temperature after 12 days of storage. Pineapple fruits pre-treated with hot water and stored at low temperature recorded a total sugar of 12.61% on 15th day of storage. Hot water treated fruits stored at low temperature recorded total sugar content of 12.50% and 12.48% on 18th and 21st days of storage respectively.

Reducing sugar of pineapple fruits mainly includes glucose and fructose. Reducing sugar of

Table 3. Effect of hot water treatment and storage temperature on total sugar (%) of pineapple fruit.

Treatments	Total sugar (%) Days after storage								
	At the day of storage	3	6	9	12	Treat-ment mean	15	18	21
T_1 (Hot water treated fruits stored at low temperature)	9.24	9.51	10.41	11.12	11.98	10.45	12.61	12.50	12.48
T_2 (Hot water treated fruits stored under ambient temperature)	9.28	9.72	10.85	11.44	12.61	10.78	13.03	-	-
T_3 (Untreated fruits stored at low temperature)	9.29	9.76	10.88	11.56	12.90	10.88	-	-	-
T_4 (Untreated fruits stored under ambient temperature)	9.27	10.28	11.28	12.21	13.01	11.21	-	-	-
Days (D) Mean	9.27	9.82	10.85	11.58	12.63				
		SE ± (m)	CD (0.05)						
Treatments (T)		–0.062	0.176						
Days (D)		–0.069	0.196				NS		
reatments (T) × Days (D)		– 0.139	0.393						

pineapple fruit in all treatments increased with the advancement of storage period. Similar findings were reported by Hossain *et al.* (2018) in kew and MD-2 variety of pineapple. Increment in sugar content occurs due to the break down of complex poly saccharides in the cell wall. Pineapple fruits treated with hot water and stored under low temperature had lowest reducing sugar of 4.36 % in stage 1 pineapple which was followed by hot water treated fruits stored under ambient temperature with 5.18% reducing sugar, which was on par with untreated fruits stored at low temperature (5.45%) after 12 days of storage (Table 4). Untreated fruits stored under ambient temperature had highest reducing sugar of 6.11% in stage1 pineapple after 12 days of storage. The highest reducing sugar of 6.11% was observed in untreated fruits stored under ambient temperature. Reducing sugar content of stage 1 pineapple fruits increased from 2.63% at the time of storage to 8.14% on the 12th day of storage. Pineapple fruits pre-treated with hot water and stored at low temperature recorded a lower reducing sugar 8.00% on 15th day of storage. This was followed by fruits treated with hot water and stored under ambient temperature (9.32%). Hot water treated fruits stored at low temperature recorded reducing sugar content of 8.21% and 8.70% on 18th and 21st days of storage respectively. Non reducing sugar of stage 1 pineapple decreased during storage irrespective of treatments. Similar findings were reported in pineapple by Hong *et al.* (2013). Decrease

Table 4. Effect of hot water treatment and storage temperature on reducing sugar (%) of pineapple fruit.

Treatments	Reducing sugar (%) At the day of storage	3	6	9	12	Days after storage Treatment mean	15	18	21
T_1 (Hot water treated fruits stored at low temperature)	2.44	2.94	4.27	5.35	6.80	4.36	8.00	8.21	8.70
T_2 (Hot water treated fruits stored under ambient temperature)	2.57	3.38	5.07	6.41	8.45	5.18	9.32	-	-
T_3 (Untreated fruits stored at low temperature)	2.73	3.77	5.22	6.73	8.79	5.45	-	-	-
T_4 (Untreated fruits stored under ambient temperature)	2.80	4.48	5.97	7.74	9.58	6.11	-	-	-
Days (D) Mean	2.63	3.64	5.13	6.56	8.41				

	SE± (m)	CD (0.05)	
Treatments (T)	– 0.096	0.274	p value–0.004
Days (D)	– 0.108	0.306	
Treatments (T) × Days (D)	– 0.216	0.612	

in sucrose content during storage mainly occurs due to the high activity of invertase enzyme resulting in the conversion of sucrose into glucose and fructose as reported by Sanchez *et al.* (2012) in pineapple. Pineapple fruit treated with hot water and stored at low temperature recorded highest non reducing sugar of 6.09% in stage 1 pineapple after 12 days of storage. These results were in accordance with the findings of Reshma (2014) in Mauritius variety of pineapple. Non reducing sugar content was decreased during storage as reported by Arina *et al.* (2010) in Eksotika papaya. Non reducing sugar content showed significant difference among days of storage. At the initial day of storage, non reducing sugar of stage 1 pineapple fruits was 6.64% which was decreased to 4.22% on 12 days of storage (Table 5). Pineapple fruits pre-treated with hot water and stored at low temperature recorded a higher non reducing sugar of 4.61% on 15th day of storage. This was followed by fruits treated with hot water and stored under ambient temperature with 3.71% non- reducing sugars. Hot water treated fruits stored at low temperature recorded non reducing sugar content of 4.30% and 3.77% on 18th and 21st days of storage respectively.

Vitamin C content determines the nutritional quality of fruits and it decreased with the advancement of storage period in all treatments of stage 1 pineapple. These results are in conformity with the findings of Ali *et al.* (2015) in different varieties of pineapple.The rapid conversion of L-ascorbic acid into dehydro ascorbic acid by the enzyme ascorbinase enhanced the loss of vitamin C during storage. At

Table 5. Effect of hot water treatment and storage temperature on non-reducing sugar (%) of pineapple fruit.

Treatments	At the day of storage	3	6	9	12	Treatment mean	15	18	21
	Non reducing sugar (%) Days after storage								
T_1 (Hot water treated fruits stored at low temperature)	6.81	6.57	6.13	5.78	5.18	6.09	4.61	4.30	3.77
T_2 (Hot water treated stored under ambient temperature)	6.71	6.34	5.78	5.03	4.16	5.60	3.71	-	-
T_3 (Untreated fruits stored at low temperature)	6.57	5.99	5.66	4.83	4.12	5.43	-	-	-
T_4 (Untreated fruits stored under ambient temperature)	6.47	5.80	5.30	4.47	3.44	5.10	-	-	-
Days (D) Mean	6.64	6.18	5.72	5.03	4.22				

	SE± (m)	CD (0.05)	
Treatments (T)	- 0.120	0.340	p value- 0.045
Days (D)	- 0.134	0.380	
Treatments (T) × Days (D)	- 0.268	NS	

the time of storage vitamin C content of the stage 1 pineapple fruits did not differ significantly among treatments and ranged from 28.57 mg 100g^{-1} to 30.95 mg 100 g^{-1} (Table 6). Pineapple fruits pre- treated with hot water and stored at low temperature recorded the highest mean vitamin C content of 22.85 mg 100 g^{-1} followed by hot water treated fruits stored under ambient temperature with 21.18 mg 100 g^{-1}. These observations are in accordance with the report of Dhar *et al.* (2008) in pineapple where low temperature had resulted in highest acidity and it is more effective in checking the decline in ascorbic acid content during storage. The lowest vitamin C content of 15.47 mg 100 g^{-1} was observed in untreated fruits stored under ambient temperature after 12 days of storage. Pineapple fruits pre-treated with hot water and stored at low temperature recorded a higher vitamin C content of 13.1 mg 100 g^{-1} on 15th day of storage which was followed by hot water treated fruits stored under ambient temperature. Hot water treated fruits stored at low temperature recorded vitamin C content of 8.33 mg 100g^{-1} and 5.95 mg 100 g^{-1} on 18th and 21st day of storage respectively.

CONCLUSION

In general, fruits treated with hot water when stored under low temperature conditions had better chemical quality parameters. Hot water treatment alone gave better quality pineapple fruits compared to untreated ones and a combination of hot water treatment and low temperature storage further improved the quality of fruits. It can be concluded that pineapple fruits (var Mauritius) harvested with crown and two cm stalk at stage 1 (0– 25% eyes predominantly yellow)

Table 6. Effect of hot water treatment and storage temperature on vitamin C content (mg 100 g^{-1}) of pineapple fruit.

Treatments	Vitamin C (mg 100g^{-1}) Days after storage: At the day of storage	3	6	9	12	Treatment mean	15	18	21
T_1 (Hot water treated fruits stored at low temperature)	30.95	27.38	22.61	17.85	15.47	22.85	13.1	8.33	5.95
T_2 (Hot water treated fruits stored under ambient temperature)	29.76	23.80	20.23	17.85	14.28	21.18	7.14	-	-
T_3(Untreated fruits stored at low temperature)	28.57	20.23	17.85	14.28	9.52	18.09	-	-	-
T_4 (Untreated fruits stored under ambient temperature)	29.76	17.85	14.28	10.71	4.76	15.47	-	-	-
Days (D) Mean	29.76	22.31	18.74	15.17	11.01				

	SE± (m)	CD(0.05)	
Treatments (T)	- 0.476	1.350	p value – 0.017
Days (D)	- 0.532	1.510	
Treatments (T) × Days (D)	– 1.065	3.019	

maturity when subjected to hot water treatment at 50 ± 20ºC for 1 minute and stored at a temperature of 240ºC had resulted in enhanced biochemical quality parameters.

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