



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Effect of different stages of maturity and postharvest treatments on quality and storability of pineapple

S. I. Kamol¹, J. Howlader^{2*}, G. C. Sutra Dhar³ and M. Aklimuzzaman¹

¹Dept. of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, ²Dept. of Horticulture, Patuakhali Science and Technology University, Patuakhali-8602 and ³Horticulture Development Centre, Bangladesh Agricultural Development Corporation, Patiya, Chittagong, Bangladesh, *E-mail: jewel.howlader81@gmail.com

Abstract

A study was undertaken to evaluate the effects of different maturity stages and postharvest treatments on the storage behavior of Pineapple fruits. Two distinct maturity stages viz., premature (30 days before attaining optimum maturity) and optimum mature fruits were harvested and placed in the laboratory room. On the same day six postharvest treatments viz., control, preserved in unperforated polyethylene bag, tilt, 100 ppm NAA, 200 ppm NAA, and 300 ppm NAA were assigned to that fruits. The two-factor experiment was laid out in a completely randomized design with three replications. There was significant variation between two maturity stages and among different treatments in relation to fruit characteristics. At 18 days of storage, premature fruits contained the maximum shelf-life (19.33 days), total weight loss (16.00%), moisture content (92.66%), total titratable acidity (0.77%), ascorbic acid content (17.49 mg/100g fruit) while the minimum (14.5 days), (14.67%), (90.66%), (0.68%), (9.75 mg/100g fruit) in optimum mature fruits, respectively. On the other hand, optimum mature fruits had higher dry matter content (14.78%), edible portion (67.77%), TSS (16.03%), pulp to peel ratio (2.56), total sugar content (13.5%) while these were minimum (12.57%), (65.16%), (14.43%), (2.37), (10.56%) in pre mature fruits, respectively. The fruits treated with 100 ppm NAA treatment showed the highest shelf life (22.83 days), pulp to peel ratio (2.94), total titratable acidity (0.67%), ascorbic acid content (16.78 mg/100g fruit pulp) and the lowest was in total sugar content (10.96%). Fruits treated with unperforated polythene bag gave the maximum edible portion (71.72%), moisture content (88.3%), and the minimum were in weight loss (3.42%), dry matter content (11.7%), TSS (14.68%). On the other hand, fruits with 5% tilt treatment showed the minimum total titratable acidity (0.58%) and ascorbic acid content (12.28 mg/100 g fruit pulp). Fruits with control represented the highest weight loss (19.135%), dry matter content (13.7%), total sugar content (12.75%) and the lowest were in shelf life (12.66 days), edible portion (60.098%), pulp to peel ratio (1.93). Among the treated and untreated fruits, unperforated polyethylene bag and 100 ppm NAA treatment exhibited better storage performance.

Keywords: Maturity, Postharvest, Quality, Storage, Pineapple

Introduction

Pineapple (*Ananas comosus* L. Merr.), belonging to the family Bromeliaceae, is one of the most promising fruits in Bangladesh. Total production of it in the world is about 1461 thousand MT in 2003 (FAO 2004). It is a popular fruit in Bangladesh having total production of 238360 MT in area of 16978 hectares during 2006-07 (Anonymous, 2008). It is mostly cultivated in the districts of Tangail, Sylhet, and Chittagong hill tracts. In respect of total production, it ranks 4th among the major fruits grown in Bangladesh. Pineapple is a good source of vitamin A and B and fairly rich in vitamin C and minerals like calcium, phosphorus and iron (Sen *et al.*, 1980). Pineapple provides a range of health promoting plant chemicals. It is a source of bromelain, a protein digestive enzyme (Lodh *et al.*, 1973). In Bangladesh, the peak harvesting season of pineapple is June to September. During this period, major bulk of fruits is harvested causing a glut in the market. Hence a good quantity of this perishable fruit gets spoiled due to difficulties in timely disposal for lack of proper marketing, storage and processing facilities. Irregular and delayed flowering and fruiting, short harvesting season and improper harvesting and postharvest handling practices are considered to be the principal bottlenecks in commercial pineapple cultivation in Bangladesh. Due to highly perishable in nature, fruits undergo serious losses after harvest. Several postharvest physico-chemical changes and microbial decay result in rapid post-harvest deterioration of pineapple. These postharvest losses of fruits can be reduced by applying modern technologies and extending shelf-life of fruits. Fruits harvested at different maturity stages cannot maintain uniform quality and exhibit significance variation in quality. The average minimum loss reported is 21%, and occasional instances indicate estimates of 40 to 50% and above (Salunkhe and Desai, 1984). It is another problem

associated with the spoilage of pineapple. Poignant (1970) reported treatment of fruits with NAA at 100 ppm immediately after picking resulted in prolonged storage life even at unfavorable temperature. Therefore, the present research work was under taken to define a suitable maturity standard for harvest and to select an appropriate postharvest treatment for pineapple fruits both for fresh consumption and use in processing industries.

Materials and Methods

The experiment was conducted in the laboratories of the Department of Horticulture, Biochemistry, and Plant Pathology, Bangladesh Agricultural University, Mymensingh, during the period from March to October 2007. The materials used for the experiment were freshly harvested pineapple fruits of variety Giant Kew from Madupur area of Tangail district, Bangladesh. The experiment consists of two factors like maturity stages and different postharvest treatments. The pineapple fruits were harvested at two distinct maturity stages viz., Premature (M_1): Fruits harvested 30 days before attaining optimum maturity and Optimum mature (M_2): Fruits harvested after attaining optimum maturity. Six post-harvest treatments viz., control (T_0), unperforated transparent polythene (LDPE) bag (T_1), Tilt (T_2), NAA 100ppm (T_3), NAA 200ppm (T_4), and NAA 300ppm (T_5) were assigned to the Pineapple fruits. The two-factor experiment was laid out in a completely randomized design (CRD) with three replications. For each replication of a treatment comprise 8 fruits. Two fruits were kept to record shelf-life, change in weight, peel color and other external fruit characteristics. The remaining 6 fruits were kept for destructive analysis at 3 different dates (at 6 days interval, two fruits from each replication of a treatment combination were chemically analyzed) on the changes in edible portion, ascorbic acid content, total titrable acidity, P^H , sugars, TSS content and TSS/acidity ratio of the fruit juice. The following parameters were studied.

Per cent total weight loss of fruit: Per cent weight loss was calculated by using following formula:

$$\text{Percent weight loss (\% WL)} = \frac{IW - FW}{IW} \times 100$$

Where, % WL: Per cent weight loss, IW: Initial fruit weight with crown and FW: Final fruit weight with crown.

Edible portions of fruit: Per cent edible portion of fruit was measured with the following formula:

$$\text{Percent edible portion of fruit} = \frac{\text{Weight of pulp (edible portion)}}{\text{Total weight of fruit}} \times 100$$

Pulp to peel ratio: The pulp to peel ratio was calculated with the following formula:

$$\text{Pulp to peel ratio} = \frac{\text{Weight of fruit pulp}}{\text{Weight of peel}}$$

Moisture content: The percentage of moisture content of fruit was calculated with the following formula:

$$\% \text{ moisture in fruit pulp} = \frac{FW - DW}{FW} \times 100$$

Where, FW= Fresh weight of fruit pulp and DW = Dried weight of fruit pul

Dry matter content: Percent dry matter content of the pulp was calculated from the data obtained during moisture estimation using the following formula:

$$\% \text{ dry matter} = 100 - \% \text{ moisture content}$$

Ascorbic acid content of fruit pulp: Ascorbic acid content was determined following the method of Ranganna (1994) by using 2, 6-Dichlorophenol-Indophenol Visual Titration method.

Total titratable acidity of fruit pulp: The titratable acidity of pineapple fruit was determined according to the method of Ranganna (1994).

Sugars in fruit pulp: Sugar content of fruit pulp was determined by using standard method.

Total soluble solid (TSS) content of fruit pulp: Total soluble solid (TSS) content of pineapple fruit pulp was estimated by using Abbe Hand Refractometer.

Shelf life: Shelf life is a period of time which started from harvesting and extends up to the start of rotting of fruits (Mondal, 2000). The shelf life of pineapple fruits as influenced by different post harvest treatment and varieties were calculated by counting the days required to attain last stage of ripening but the fruits remaining still for optimum marketing and eating qualities.

Statistical analysis: The collected data were statistically analyzed to find out the variation, resulting from experimental treatments following F-variance test. The means of different parameters were compared by least significant difference (LSD) at 5% level of probability as described by Gomez and Gomez (1984).

Results and Discussion

Total weight loss of fruit: Significant effects were observed in total weight loss of pineapple during storage in respect of stage of maturity of fruits and postharvest treatments. Total weight loss was always higher in pre-mature fruits during the entire period of storage (Table 1). The total weight loss was higher in pre-mature fruits (16.00%) where lower in optimum mature fruits (14.67%) at 18th day of storage. The maximum weight loss (19.135%) was recorded in control fruits, while it was minimum (3.42%) in fruits, those were kept in unperforated polythene bags as recorded at 18th day of storage (Fig. 1). The reduction of percent weight loss might be due to the presence of physical barrier in gas diffusion through fruit stomata. This finding was supported by the findings of Uddin and Hossain (1993).

Table 1. Main effects of stage of maturity on changes in weight loss, moisture content and dry matter content of pineapple fruit during storage

Stages of maturity	Weight loss (%)			Moisture (%) (94.5 ^X , 93.9 ^Y)			Dry matter (%) (5.5 ^X , 6.1 ^Y)		
	DAS			DAS			DAS		
	6	12	18	6	12	18	6	12	18
M ₁	7.37	12.79	16.00	92.66	90.04	87.43	7.34	9.96	12.57
M ₂	6.24	11.01	14.67	90.66	86.84	85.22	9.34	13.16	14.78
LSD _(0.05)	0.815	0.722	0.746	0.406	0.847	0.915	0.406	0.847	0.915
LSD _(0.01)	1.105	0.978	1.011	0.550	1.14	1.24	0.55	1.14	1.24
Level of significance	**	**	**	**	**	**	**	**	**

DAS: Days after storage

M₁: Pre-ripe (30 days before optimum mature), M₂: Full-ripe (optimum mature stage)

X: Initial value of premature, Y: Initial value of optimum mature

LSD: Least significance difference

** : Significant at 1% probability level

Moisture content of fruit pulp: The changes in moisture content of fruit during storage period were significantly influenced by maturity stages and different postharvest treatments. The moisture contents of fruit pulp were 92.66% and 90.66% in pre-mature and optimum mature fruits, respectively; which decreased gradually with the progress of storage period to 87.43% and 85.22% was recorded at 18th days of storage (Table 1). For all postharvest treatments, fruits showed a decline in moisture content with the increasing of storage duration. At 18th day of storage, the highest moisture content in unperforated polythene treated fruits (88.3%) and next to (87.767%) was recorded in the fruits treated with NAA (100ppm) (Fig. 2). The decrease in percentage of moisture content was probably due to transpiration and starch hydrolysis. Higher loss in moisture content of premature fruits could be due to their poor resistance mechanism.

Dry matter content: The post harvest treatments exhibited highly significant effect on dry matter content. At 18th day of storage 12.57% dry matter was observed in pre-mature fruits while it was 14.78% in optimum mature (Table 1). Highest dry matter content was found in control 13.7% and it was found 11.7% while fruits were treated with unperforated polythene at 18th day of storage (Fig. 3). The increase in dry matter percent with increasing storage period may be due to the increased water loss from the pulp.

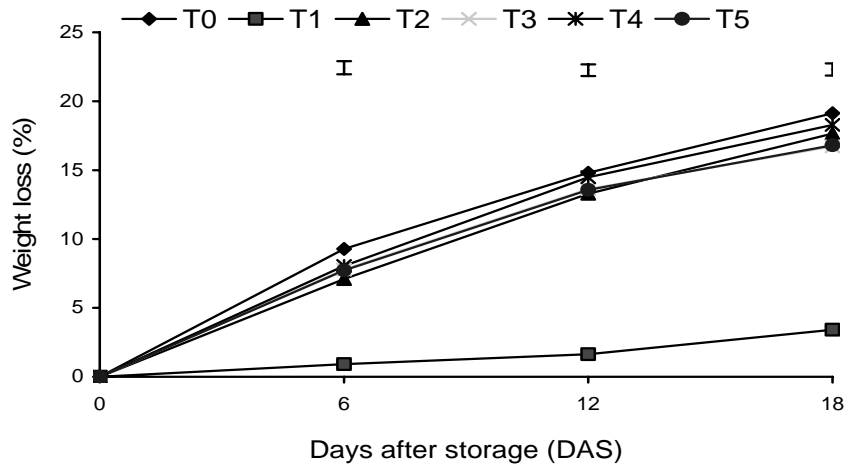


Fig. 1. Main effects of different postharvest treatments on weight loss of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability.

T₀: Control, T₁: Unperforated polythene bag, T₂: Tilt (5%), T₃: 100ppm NAA, T₄: 200ppm NAA, T₅: 300ppm NAA

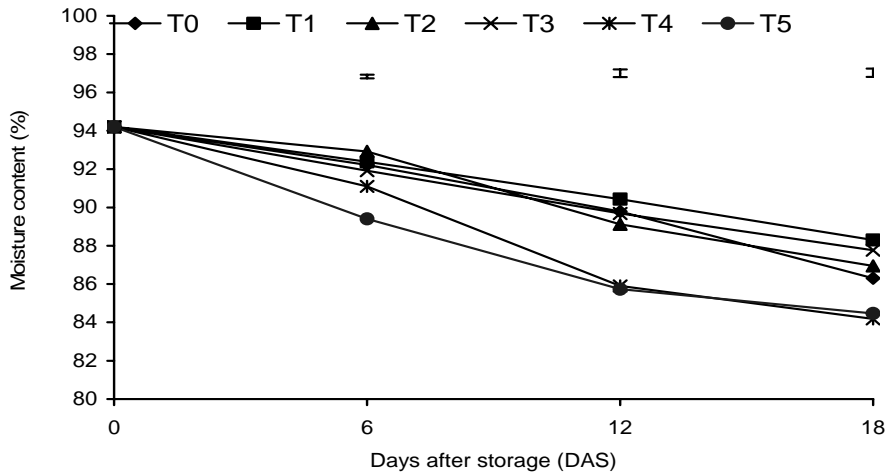


Fig. 2. Main effects of different postharvest treatments on moisture content of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability.

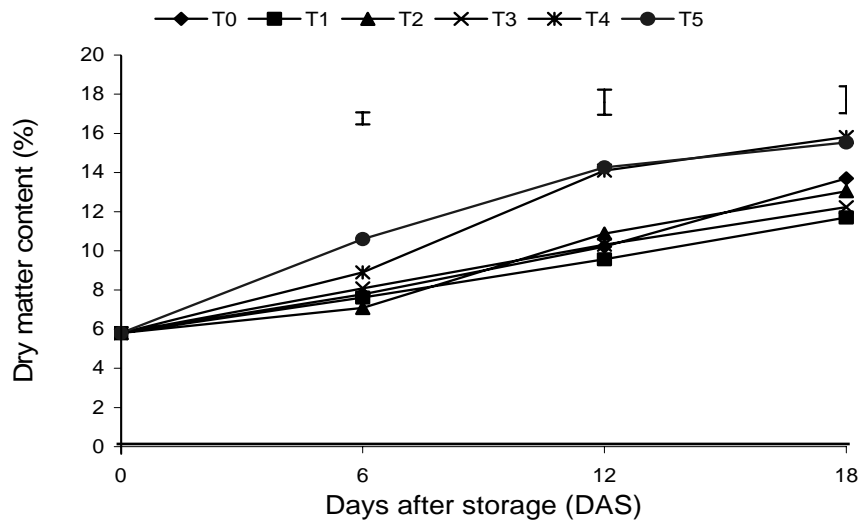


Fig. 3. Main effects of different postharvest treatments on dry matter content of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability

Edible portion of fruit: The edible portion of two maturity stages fruit was increased up to 12th day of storage (Table 3). Optimum mature fruits content the higher (67.77%) edible portion than the pre-mature fruits (65.16%) at 12th day of storage. At the 18th day of storage, the highest (71.72%) edible portion was recorded in fruits treated with unperforated polythene followed by (70.37%) treated with 100ppm NAA while the lowest (60.098%) in control fruits (Fig. 4).

Pulp to peel ratio: Pulp to peel ratio had no significant effect on maturity stages but significantly influenced on different postharvest treatments. It was observed that higher (2.56) pulp to peel ratio found in mature fruits while lower (2.37) in pre-mature fruits at 12th day of storage. Further it was observed that pulp to peel ratio increased with the advancement of storage period in pre-mature stage (Table 2). Pulp to peel ratio (2.94) at 18th days were recorded in fruits treated with 100ppm NAA while it was the lowest (1.93) in fruits in control condition (Fig. 5). Pulp to peel ratio was increased up to 12th of storage and then declined. The increase of pulp to peel ratio may be due to two factors. Firstly greater increase of sugar in pulp than peel and this lead to differential changes in osmotic pressure resulting in withdrawal of moisture from the skin and pulp. That was the reason of increased pulp to peel ratio. The second factors may be included loss of moisture from the skin.

Table 2. Main effects of stage of maturity on changes in edible portion, pulp to peel ratio and total sugar content of pineapple fruit during storage

Stages of maturity	Edible portion (%) (55.4 ^X ,58.7 ^Y)			Pulp to peel ratio (1.52 ^X ,1.75 ^Y)			Total sugar (%) (9.42 ^X ,11.87 ^Y)		
	DAS			DAS			DAS		
	6	12	18	6	12	18	6	12	18
M ₁	62.77	65.16	66.37	2.12	2.37	2.52	10.56	11.10	10.23
M ₂	64.86	67.77	65.18	2.29	2.56	2.29	13.50	14.28	13.44
LSD _(0.05)	--	2.512	--	--	--	--	0.479	0.536	0.478
LSD _(0.01)	--	--	--	--	--	--	0.650	0.726	0.648
Level of significance	NS	*	NS	NS	NS	NS	**	**	**

DAS: Days after storage

M₁: Pre-ripe (30 days before optimum mature), M₂: Full-ripe (optimum mature stage)

X: Initial value of premature, Y: Initial value of optimum mature

LSD: Least significance difference

NS: Not-significant

** : Significant at 1% probability level

*: Significant at 5% probability level

Table 3. Main effects of stage of maturity on changes in total soluble solid (% brix), titratable acidity (%), ascorbic acid (%) and shelf life of pineapple fruit during storage

Stages of maturity	Total soluble solid (% brix) (12.46 ^X ,14 ^Y)			Titratable acidity (%) (0.834 ^X ,0.732 ^Y)			Ascorbic acid (mg/ 100g) fruit pulp (28.30 ^X ,22.03 ^Y)			Shelf life
	DAS			DAS			DAS			
	6	12	18	6	12	18	6	12	18	
M ₁	13.47	13.95	14.43	0.77	0.73	0.69	24.60	20.19	17.49	19.33
M ₂	15.09	15.71	16.03	0.68	0.65	0.62	16.40	13.32	9.75	14.50
LSD _(0.05)	0.834	0.874	0.962	0.021	0.021	0.021	0.802	0.630	1.171	0.777
LSD _(0.01)	1.131	1.185	1.305	0.029	0.029	0.029	1.088	0.855	1.588	1.054
Level of significance	**	**	**	**	**	**	**	**	**	**

DAS: Days after storage

M₁: Pre-ripe (30 days before optimum mature), M₂: Full-ripe (optimum mature stage)

X: Initial value of premature, Y: Initial value of optimum mature

LSD: Least significance difference

** : Significant at 1% probability level

Total sugar content of fruit pulp

The maximum total sugar (13.5%) was recorded in fullmature fruits while it was minimum (10.56%) in premature fruits at initial stage. The increasing trend of total sugar found in the present study with the progress of storage period until 12th day of storage and decreasing thereafter (Table 2). Rahman *et al.* (1979) found similar result and they reported that the total sugar content increased initially and then gradually decrease towards the end of the storage period. The increase in total sugar associated with the advance of storage period is usually due to break down of polysaccharides and conversion of starch into sugar (Wills *et al.*, 1989). At 18th day of storage, the highest total sugar content (12.75%) was observed in control fruits. On the other hand it was minimum (10.96%) in fruits treated with 100 ppm NAA (Fig. 6).

Total soluble solid (TSS) content of fruit pulp: TSS is one of the most important quality factors for most of the fruits and for pineapple, a TSS of 13.8 to 17.0% indicates the highest quality of fruits to attain the optimum harvesting stage (Morton, 1987). Full mature fruits contained the highest TSS (16.03%) while it was minimum (14.43%) in pre mature fruits at 18th day of storage. Singleton and Gortner (1965) and Botrel *et al.* (1993) also found similar results. TSS increases up to 18th day of storage in two maturity stages of fruits (Table 3). Postharvest treatments were also found to have significant effects on maturity in TSS content of fruit juice during storage. The lowest TSS (14.68%) was recorded in unperforated polythene treatment fruits at 18th day of storage, which was statistically similar to 100 ppm NAA (14.76%) treatment (Fig. 7). Similar results were reported by Das and Medhi (1996).

Total titratable acidity in fruit pulp: Total titratable acidity of fruit pulp under stages of maturity and all postharvest treatments decreased with the advancement of storage period. Freshly harvested premature fruits contained the maximum (0.77%) total titratable acidity while the minimum (0.68%) in optimum mature fruits. It was decreased with the advancement of storage period (Table 3). At 18th day of storage the maximum total titratable acidity (0.67%) was observed in 100 ppm NAA treatment and was minimum (0.58%) in tilt treated fruits (Fig.8). In most climacteric fruits acidity declines as ripening advances (Wills *et al.*, 1989). But incase of pineapple, the highest level of acidity is attained at one or two weeks before full ripeness (Singleton and Gortner, 1965; Barua *et al.*, 1987). The decrease in titratable acidity during storage may be attributed to the utilization of organic acids in respiratory process and other biodegradable reactions.

Ascorbic acid content of fruit pulp: The effects of different maturity stages and postharvest treatments were significant at 6th, 12th and 18th days of storage. Results showed that the ascorbic acid content was decreased with the progress of ripening of fruits. At 18th day of storage the highest and lowest ascorbic acid contents were 17.49 mg/100g fruit pulp and 9.75 mg/100 g fruit pulp in pre-mature and optimum mature fruits, respectively (Table 3). Similar results were reported by Hossain (2000). The highest ascorbic acid content (16.78 mg/100g fruit pulp) at 18th day of storage was observed in fruits under 100 ppm NAA treatments while it was minimum (12.28 mg/100 g fruit pulp) in fruits under (5%) tilt treatment (Fig. 9). The decrease in ascorbic acid content of fruit juice with advancement of ripening stage of fruits and storage period was due to the conversion of this acid to sugar with the activity of ascorbic acid dehydrogenase (Rahman *et al.*, 1979).

Shelflife of fruit: The shelflife of pineapple fruit was significantly affected by their stage of maturity and postharvest treatments. The maximum shelf-life (19.33 days) was recorded for premature fruits followed by optimum mature fruits (14.5 days) (Table 3). The maximum shelf-life (22.83 days) was observed in fruit treated with 100ppm NAA; whereas minimum shelf-life (12.66 days) was recorded in control condition (Fig. 10). The results of the present experiment were in partial agreement with research findings of Uddin and Hossain (1993). Covering materials prolong the shelf-life in both mature fruits were probably due to the reduction of various gases (O₂, CO₂) exchange from the inner and outer atmosphere as well as slowing down the hydrolysis process. On the contrary, fruits treated with NAA pronged the shelf life by slowing down hydrolysis of starch in sugars and reduction of various gases.

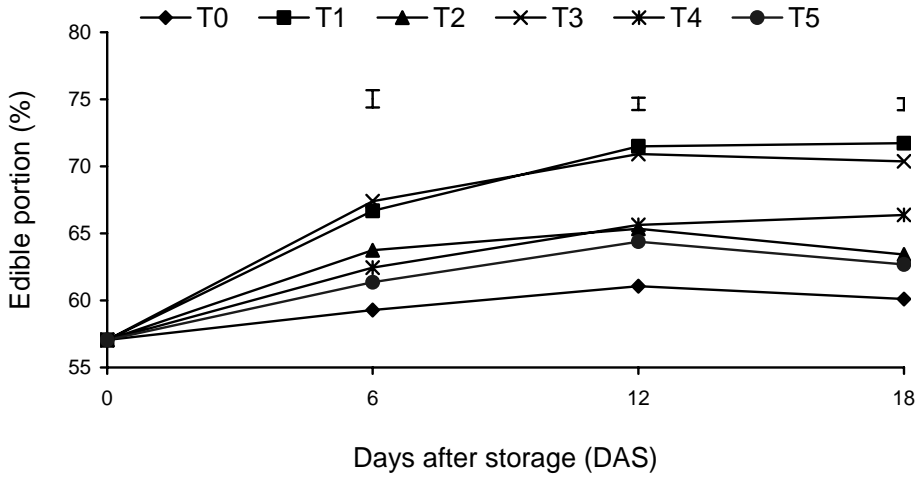


Fig. 4. Main effects of different postharvest treatments on edible portion of pineapple during storage. Vertical bars represent LSD at 0.05 level of probability

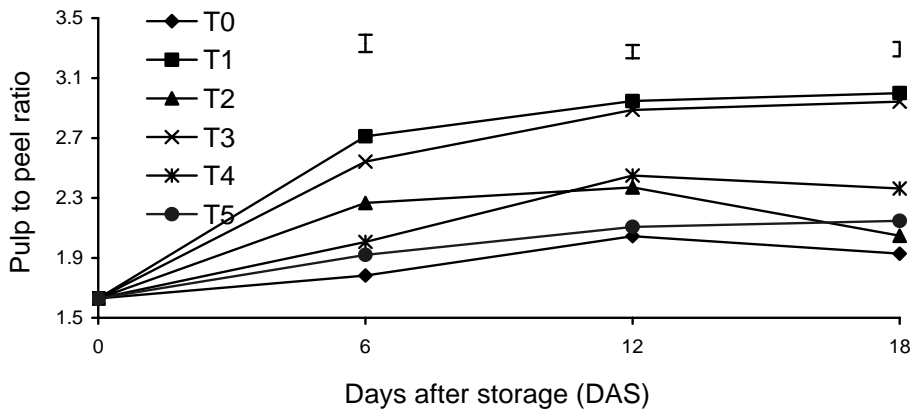


Fig. 5. Main effects of different postharvest treatments on pulp to peel ratio of pineapple during storage. Vertical bars represent LSD at 0.05 level of probability.

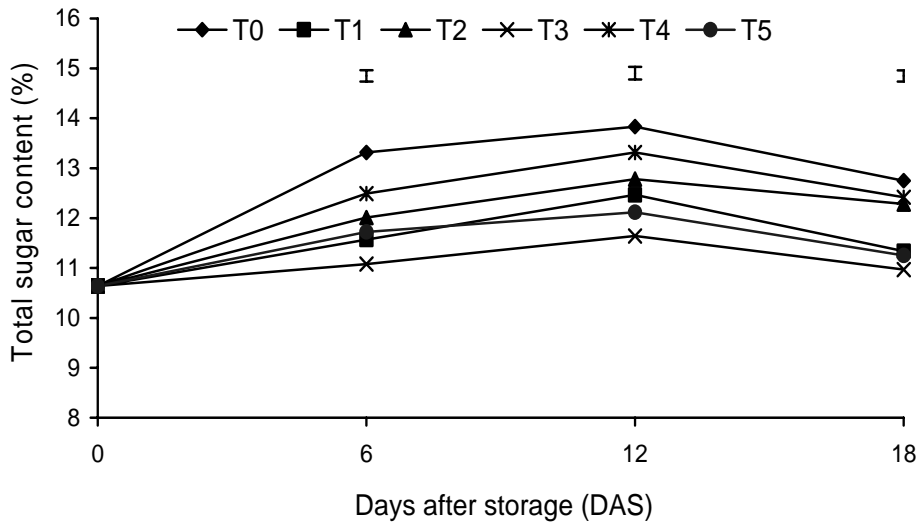


Fig. 6. Main effects of different postharvest treatments on total sugar content of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability.

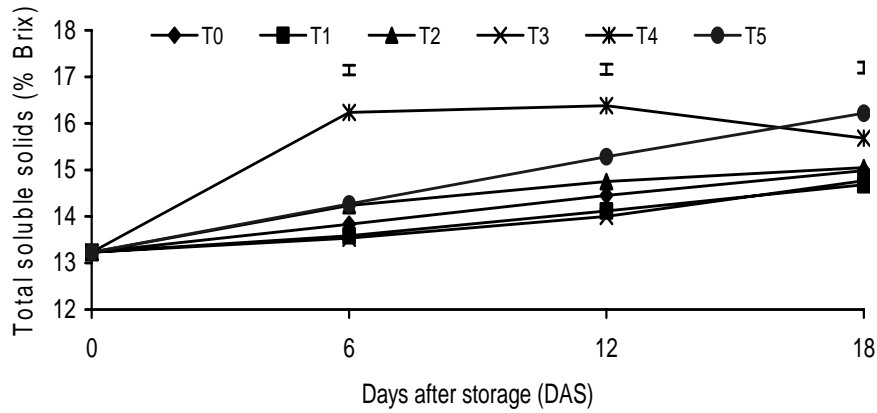


Fig. 7. Main effects of different postharvest treatments on total soluble solid of pineapple during storage. Vertical bars represent LSD at 0.05 level of probability.

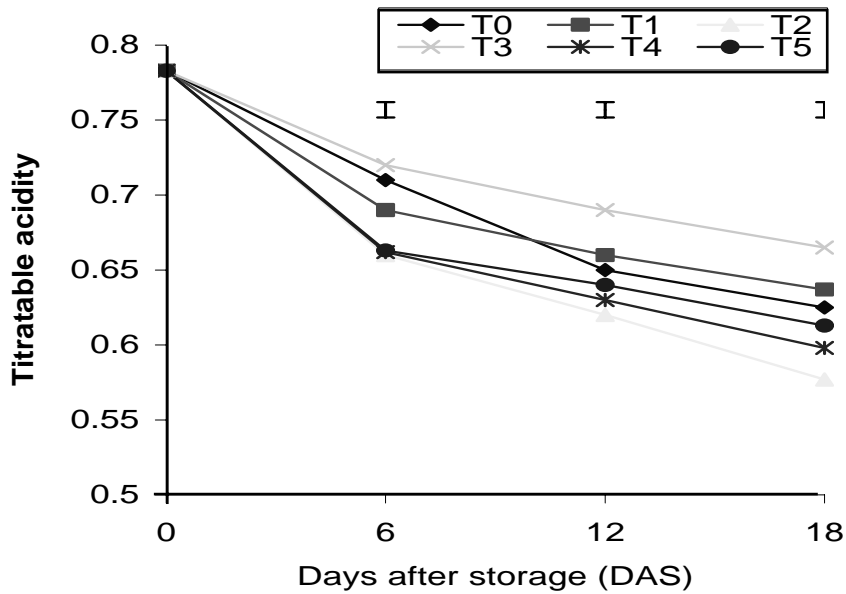


Fig. 8. Main effects of different postharvest treatments on titratable acidity of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability.

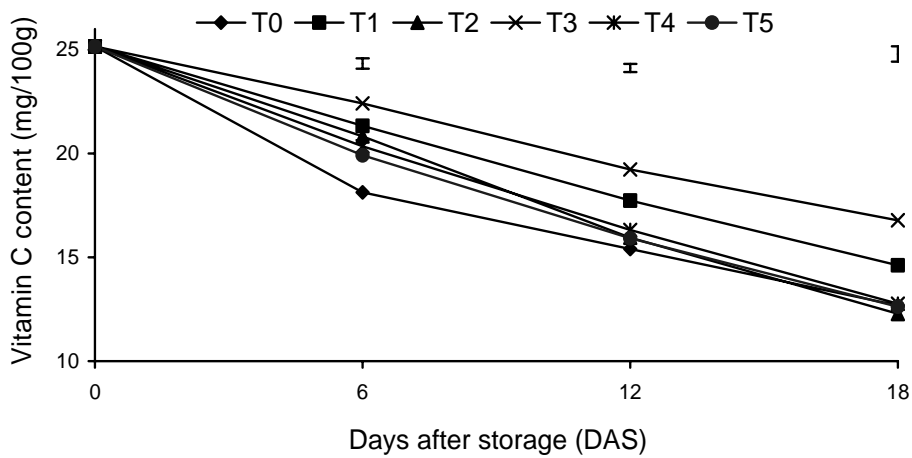


Fig. 9. Main effects of different postharvest treatments on vitamin C content of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability.

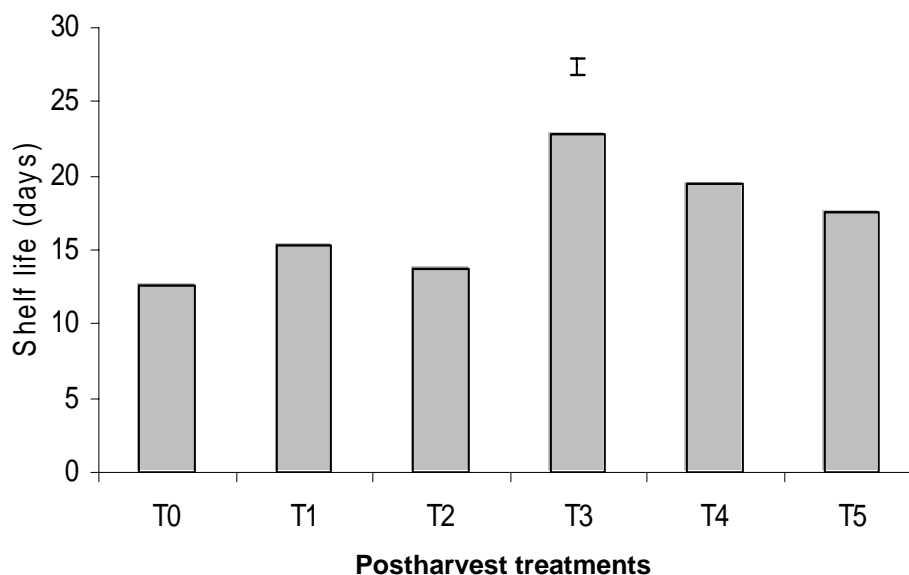


Fig. 10. Main Effects of different postharvest treatments on the shelf-life of pineapple during storage. Vertical bars represent LSD at 0.01 level of probability.

Conclusion

The changes in total weight loss, moisture content, dry matter content, of fruit during storage period were significantly influenced by maturity stages and different postharvest treatments. Total weight loss was always higher in pre-mature fruits during the entire period of storage. For all postharvest treatments and maturity stages, fruits showed a decline in moisture content and increase dry matter content with the increasing of storage duration. Edible portion and pulp to peel ratio had no significant effects but total sugar content had significant effects between the maturity stages. The effects of different postharvest treatments had significant effect on these. Edible portion, pulp to peel ratio and total sugar content was increased up to 12th of storage and then declined. In the present study, the TSS content of fruit juice was showed significant effect in different maturity stages and postharvest treatments during storage. For all postharvest treatments and maturity stages, fruits showed increase TSS with the increasing of storage duration except the fruits treated with NAA 200 ppm which was increase at first and then decline at 18 days of storage. The stage of maturity and postharvest treatments had highly significant effect on total titratable acidity and ascorbic acid content in fruit pulp. Under all postharvest treatments and stage of maturity, both of these were decreased with the advancement of ripening stage of fruits and storage period. The shelf-life of pineapple fruit was significantly affected by their stage of maturity and postharvest treatments during storage period.

References

- Barua, P.C.; N.K. Mohan and S. Baura. 1987. Biochemical changes during storage of pineapple fruits in relation to time of harvest. *South Indian Hort.*, 35(5): 375-377.
- Anonymous, 2008. Yearbook of Bangladesh Bureau of Statistics (Crop Statistics). Peoples Republic of Bangladesh, Dhaka, 5 p.
- Botrel, N., V.D. De-Carvalho and V.D. De-Capriade. 1993. Effect of fruit weight on internal browning and quality in pineapple Smooth Cayenne. III. Internal browning, total soluble solids, total titratable acidity, pH and sugars. *Pesquisa Agropequaria Brasileira*, 28(9): 1055-1064 [Cited from *Postharvest News and Information*, 9(2): 329, 1995].
- Das, R. and G. Medhi. 1998. Physico-chemical changes of pineapple fruits under certain postharvest treatments. *South Indian Hort. J.*, 30(1): 147.
- FAO. 2004. Production year book 2002. Food and Agriculture Organization of the United Nations, Rome, Italy, 63: 180-182.
- Gomez, K.A. and A.A. Gomez. 1984. *Statistical Procedures for Agricultural Research*. John Wiley and Sons, New York. pp. 28-92.

- Hossain, M.A. 2000. Effects of stage of maturity and postharvest treatments on physio-chemical changes in pineapple during storage. M.S. thesis. Department of Horticulture, BAU, Mymensingh. p. 80 .
- Lodh, S.B., N.G. Diwaker, K.L. Chadha, K.R. Melanta and Y. Selvaraj. 1973. Biochemical changes associated with growth and development of pineapple fruits var. Kew. III. Indian J. Hort., 30: 381-383.
- Mondal, M.F. 2000. Production and Storage of Fruits (in Bangla). Published by Mrs. Afia Mondal. BAU Campus, Mymensingh-2202. pp. 312.
- Poignant, A.1970. Effect of plant growth regulators on quality of pineapple fruits. Fruit d'outre Mer., 25: 877-885 [Cited from Fruits: Tropical and Subtropical by T.K. Bose and S.K. Mitra, Naya Prokash, Calcutta, pp. 252-279].
- Rahman, M.A., M.A. Quddus and M.S. Haque. 1979. Studies on pineapple: Part III-The effects of different physical treatments on the changes in physiological and biochemical characteristics in stored pineapples. Bangladesh J. Sci. Ind. Res., 14 (1-2): 109-118.
- Rahman, M.A., Shahidullah, M. and M.S. Haque. 1979. Studies on pineapple: Part III-The effects of different concentration of alpha naphthaleneacetic acid on the quality characteristics of mature ripe pineapples. Bangladesh J. Sci. Ind. Res., 14 (1-2): 126-130.
- Ranganna, S. 1994. Manual of Analysis of Fruit and Vegetable Products. Tata McGraw-Hill Publishing Company Limited, New Delhi, p. 634.
- Salunkhe, D.K. and B.B. Desai. 1984. Postharvest Biotechnology of Fruits. Vol. 2. CRC press, Inc., Boca Raton, Florida, p. 7.
- Sen, S. K., A. Roy and T.K. Bose.1980. Pineapple Production and Utilization. Jaydebpur University, Calcutta, pp. 13-23.
- Singleton, V.L. and W.A. Gortner. 1965. Chemical and Physical development of the pineapple fruit. II. Carbohydrate and acid constituents. J. Food Sci., 30(1): 19-29.
- Uddin, M.N. and A.K.M.A. Hossain. 1993. Study on the storage of pineapple. Bangladesh Hort., 21 (2): 7-12.
- Wills, R.B.H., W.B. McGlasson, D. Graham, T.H. Lee and E.G. Hall. 1989. Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables. Van Nostrand Reinhold, New York. p. 27.