EFFECT OF POST-HARVEST TREATMENTS ON QUALITY AND SHELF LIFE OF PINEAPPLE FRUITS AT AMBIENT STORAGE CONDITION

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CERTIFICATE

This is to certify that thesis entitled ***"EFFECT OF POST-HARVEST TREATMENTS ON QUALITY AND SHELF LIFE OF PINEAPPLE FRUITS AT AMBIENT STORAGE CONDITION"*** *submitted to the* ***Department of Horticulture,*** *Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE,*** *embodies the result of a piece of bona fide research work carried out by MD. AZIZUL ISLAM, Registration No. 14-06024 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated: June, 2021
Place: Dhaka, Bangladesh

_____

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DEDICATED
TO
MY BELOVED
PARENTS

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ABSTRACT

The present study conducted at the laboratories of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from 8 Janurary 2020 to 26 January 2020. The experiment was carried out to investigate the role of different preservatives in extending the shelf life of pineapple fruits and improve the shelf life and post-harvest quality of pineapple fruits at ambient storage condition. A total of nine postharvest treatments *viz.*, T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1} and kept in open condition; T_2 = Fruit dipping in Gibberellic Acid (GA_3) at 100 mg L^{-1} and kept in open condition; T_3 = Fruit dipping in Salicylic Acid (SA) at 5 m M L^{-1} and kept in open condition; T_4 = Fruit dipping in Maleic Hydrazide (MH) at 500 mg L^{-1} and kept in open condition; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Covering with dry straw; T_8 = Hot water treatment, and T_9 = Control were used on fruit to investigate physico-chemical qualities and shelf life of pineapple cv. Honey Queen. Experiment was laid out in Complete Randomized Design (CRD) with three replications. Study revealed that among the different treatments, fruits treated with GA_3 at 100 mg L^{-1} showed delayed response of ripening and increase shelf life (18.50 days). At 15 days after storage (DAS), skin colour remained quarter yellow (average score: 3.4), crown condition good with slight tip yellowing (average score: 2.2), slightly infected and 10% fruit decay with high juice content (70.23%), whereas, fruits showed considerably higher amount of TSS (20.25°Brix), total sugar (13.91%) and ascorbic acid content (20.13 mg 100 g $pulp^{-1}$) with less weight loss (10.57%) when fruits treated with GA_3 at 100 mg L^{-1}. However, among the other treatments, SA (5.0 mM) and MH (500 mg L^{-1}) performed well in terms of fruit physico-chemical properties and shelf life.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BBS	Bangladesh Bureau of Statistics
CV	Coefficient of variation
CRD	Complete Randomized Design
d.f.	Degrees of freedom
DAS	Days After Storage
et al.	And others
FAO	Food and Agriculture Organization
GA_3	Gibberellic Acid
Ha	Hectare
J.	Journal
LSD	Least Significant Difference
MH	Maleic Hydrazide
MP	Muriate of Potash
NAA	Napthalene Acetic Acid
SA	Salicylic Acid
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
TSS	Total Soluble Solid

CHAPTER I

INTRODUCTION

Pineapple (*Ananas comosus* L. Merr.), which is known as 'Golden Queen' for its attractive golden yellow color at ripening and its enticing sugar acid blending, is one of the important tropical fruit crops of Bangladesh, belongs to Bromeliaceae family. It is believed that it was originated in southern Brazil and Paraguay (Morton, 1987). Pineapple is also widely cultivated in tropical and subtropical regions. The leading pineapple growing countries of the world are Africa, Philippines, Thailand, Srilanka, Malaysia, North and Central America, China, India, South Africa, Brazil, Australia and Bangladesh (FAO, 2004). The total production of pineapple of the world was about 1461 thousand MT in 2003 (Kamol *et al*., 2014). In Bangladesh, the total area under pineapple is about 5.33% of total area under fruits and it contributes to about 7.7% of the total fruit production of the country (Ahmmed, 2011). It is a popular fruit in Bangladesh having a total production of 208401 MT in an area of 35237 acres with a yield of 5.91 MT per acre (BBS, 2018). It is mostly cultivated in the districts of Tangail, Sylhet and Chattagram Hill tracts. The most cultivated varieties are Giant Kew (locally *kalendar*), Honey Queen (*jaldubi*) and Red Spanish (*ghorashal*). In respect of total production, it ranks 4th among the major fruits grown in the country (Kamol *et al*., 2014).

The fruit is rich in sugar, minerals (calcium, iron), organic acids and fairly rich in vitamins (A, B and C) and minerals, like, calcium, phosphorus and iron (Sen, 1980). Pineapple provides a range of health promoting plant chemicals. It is a source of bromeline, a protein digestive enzyme (Lodh *et al.*, 1973). Pineapple fruits contains 85% moisture, 13% sugar, 0.7% protein, 0.05% mineral, 0.3% fibre, 0.04% calcium,

0.01% phosphorus, 0.9% iron, 60 IU vitamin A, 120 mg/100g vitamin B_2 and 63 mg/100g vitamin C.

Pineapples in fresh fruit market or in transit to canning industries are generally transferred in unrefrigerated condition which led the fruit for faster deterioration in edible quality and neutraceuticals content. Certainly, at ambient condition, enhanced biochemical transformation of starch to sugar made the fruit rich in sugar which consequently gets affected by microbial spoilage. Thus, pineapples have a short post-harvest shelf life at ambient temperature and deteriorate quickly (Lu *et al.,* 2010). The average minimum loss reported is 21% and occasional instance estimated of 40 to 50 % and above (Salunkhe and Desai, 1984).

Due to highly perishable nature, pineapple fruits undergo serious losses after harvest. Several postharvest physico-chemical changes and microbial decay result in rapid post-harvest deterioration of pineapple. This is a major shortcoming in the successful trading and export of fresh pineapple fruit. However, cold storage or refrigerated supply is effective at inhibiting the development of decay in pineapple fruit, but symptoms of chilling injury, especially internal browning are observed (Paull and Rohrbach, 1985). Poignant (1970) reported treatment of fruits with NAA at 100 ppm immediately after picking resulted in prolonged storage life even at unfavorable temperature. Therefore, it is of utmost importance to develop a technique for extending the shelf life of pineapple at ambient temperature by reducing the post-harvest decay and maintaining the physico-chemical qualities of fruit.

Considering the above facts, the experiment has been undertaken with the following objectives:

- To investigate the role of different post-harvest treatments in extending the shelf life of pineapple fruits; and
- To investigate the role of different post-harvest treatments on the post-harvest quality of pineapple fruits.

CHAPTER II

REVIEW OF LITERATURE

Since the consumers purchase fruits on the basis of quality, it is essential to understand the physicochemical basis of the quality factors to improve the quality of fruits. The quality of pineapple fruit is largely dependent on the stage of maturity of fruits and various postharvest treatments which are principally applied to increase the store ability of fruits. Changes in physicochemical characteristics during storage must be determined for maintaining the fitness of pineapple fruits for canning industry and fresh fruit market. The scientific literature dose include a very few studies on physicochemical changes in pineapple fruits but they are neither adequate nor conclusive. The research findings related to the present investigation have been reviewed here in this chapter.

2.1. Stage of maturity

Gortner *et al*., (2006) stated that the period of fruit development covers the stages of pre-maturation and maturation, the latter of which includes ripening. Pre-maturation stage is characterized by extensive cell enlargement. During maturation stage, the fruit emerges from the incomplete stage to attain a fullness of growth and maximum edible quality. The terminal period of maturation is the period during which the fruits attains its full development and its maximum aesthetic and edible quality. Primarily chemical changes taking place during ripening period.

In India, Chadha *et al.,* (1998) reported that the stage of harvesting in pineapple is very important. If it is harvested at immature stage, it does not develop its full sugar content and flavor. If left until it is too ripe it loses its flavor and appearance, resulting

in flat-and-insipid fruits. Hence, it is very essential to harvest fruits at an ideal stage of ripening.

Deka *et al.,* (2005) found that fruit harvested during 146-150 days after flowering (1/2 color development stage) was found to be the right stage of harvesting pineapple. However, the fruit may also be harvested during 141-145 days after flowering (1/4 color development stage). Days after flowering (146-150), specific gravity (0.93-0.98), respiration rate (7-10 mg/kg/hr), TSS (18-19^0 Brix), acidity (0.77-0.83%) and TSS : acid ratio (23-25) might be considered as suggested indices for harvesting 'Kew' pineapple at the right stage for local as well as distant markets during November-December.

2.2. Changes in different physic-chemical parameter

2.2.1. Shelf-life of fruit

Mandal *et al.,* (2015) reported that there were significant variation in shelf life of the pineapple due to different treatment under their study. Maximum shelf life (19.05 days) was observed in case of the fruits treated with GA_3 compared with control.

Gholami *et al.,* (2010) reported that GA_3 treated sweet cherry fruit got delayed ripening as it decreased the ethylene production.

Hakim *et al.,* (2013) observed maximum shelf life (13.0 days) in banana fruit when treated with GA_3 at 400 ppm. Lu *et al.,* (2010) observed that post harvest treatment with 5.0 m M SA delayed ripening and extended shelf life of pineapple cv. Comte de Paris.

Rahman (2003) carried out an experiment in the Department of Horticulture in BAU, Mymensingh and showed that the fruits treated with GA (100 ppm) and NAA (500 ppm) could be stored up to 29 and 27 days, respectively without deterioration in their desirable against 15 days in control.

In the field laboratory of BARI at Joydebpur, Uddin and Hossain (2000) conducted trials with stored mature pineapple cv. Giant Kew at room temperature with treated NAA (500 ppm), GA_3 (100 ppm), covering with polythene bag and without treatment. They reported that fruit treated with NAA and GA_3 could be stored up to 30 and 35 days respectively without deterioration of their quality up to 15 days in polythene bags and control.

Shelf-life is the period of time which start from the time of harvesting and extend up to the start of rotting of fruit (Mondal, 2000) and it is the basic quality of fruit as well as it is the most important parameter in loss of reduction biochemical reaction of fruit. Biochemical reaction known to continue in harvested fruit until ripened, this process cannot be stopped. These biochemical reactions decreased free energy and increase the randomness of the system.

Hossain (2000) carried out an experiment on the shelf life of pineapple with different maturity stages (*viz*. premature, half ripe and full ripe) and postharvest treatments *viz*. control, low temperature (12 ± 1^0C). 100 ppm NAA and covering with straw. He observed that the highest shelf life (30 days) was in premature fruits under low temperature treatments followed by 27.3 days in half-ripe fruit under the low temperature treatment and it was lowest 9.3 days in fruits under the control.

2.2.2. External color change

Mandal *et al.*, (2015) carried out an experiment with post-harvest treatments on quality and shelf life of pineapple fruits at ambient storage condition. He observed that from mature green stage, fruit color gradually intensified through the time of storage. Similar findings were mentioned by Wijesinghe and Sarananda (2002). However, the degree of color break varied among the different treatments. Out of the

nine treatments under study, GA_3 at 100 mg/L caused retardation of peel color change (average score: 3.2, quarter yellow; at 15 DAS).

Hakim *et al.,* (2013) opined that GA_3, MH has the ability to retain the total chlorophyll a and chlorophyll b which caused delaying in color development in banana fruit. Influence of SA on color development was reported by Nemeth *et al.,* (2002).

Scapim and Clemente (2005) studied that a higher number of fruit were affected by endogenous darkening at 8^0C. The incidence of this disorder was more rapid and with higher intensity at 8^0C. The incidence of this disorder was more rapid and with higher intensity at 8^0C than 12^0C. In both temperatures, the unpacked fruit were more affected by this injury, while the fruit kept in not perforated polyethylene showed less darkening.

Uddin and Hossain (2000) carried out an experiment with growth regulators on storage behavior of pineapple and found that fruits which were in control turned entirely yellow (i.e. 100%), after 10 days of storage while color development was 59.2% and 56.6% in GA_3 (100 ppm) and NAA (500 ppm) treated fruits, respectively after similar storage period. Fruits treated with GA_3 (100 ppm) and NAA (500 ppm) turned 100% yellow after 15 days of storage.

2.2.3. Flesh color

Generally flesh color of pineapple fruit also changed through ripening process. Mandal *et al.,* (2015) opined that there was consistent increase in flesh color score during the period of storage. Fruits kept under control attained maximum flesh color (average score:5, golden yellow) at 10 DAS. Flesh color of fruit become yellow for NAA at 100 mg/L, Polythene bagging, newspaper bagging and straw cover within 10 days of storage. He also found that the fruits got faster ripening within 10 days of

storage under these treatments. However, at 15 DAS, flesh color remained more white than yellow for fruits treated with GA_3, SA or coated with wax which manifested delaying of ripening.

Prasad and Singh (1993) reported that paraffin coating and GA_3 delayed ripening in banana.

2.2.3. Skin texture

Firmness of fruit gradually decreased through the period of storage. Mandal *et al.,* (2015) revealed that fruits at control or covered with perforated newspaper bags lost its firmness within 10 days of storage, whereas, fruits were moderately firm when treated with GA_3 at 100 mg/L or SA at 5.0 m M even at 15 DAS.

Othman (2008) described that fruit firmness decreased as fruit firmness decreased as fruit mature. Fruit ripening and softening of vegetative tissues are usually accompanied by catabolism of cell wall polysaccharides (hemicellulose). The breakdown of polymetric carbohydrates, especially pectic substances and hemicellulose, weaken cell walls and caused reduction in fruit firmness.

2.2.3. Total weight loss of fruit and decrease in length and diameter

Mandal *et al.,* (2015) observed that percentage loss of fruit, decrease in fruit length and diameter was minimum (11.34%, 2.76% and 2.51%) in case of fruits coated with wax at 60 g/L followed by treated with GA_3 at 100 mg/L (11.61%, 3.56% and 3.34%) compared with other treatments at 15 DAS.

Kabir *et al.,* (2010) reported that fruits treated with GA_3 200 mg/L were found to have minimum weight loss of pineapple fruits at 16^{th} days of storage.

It was observed by Hu *et al.,* (2011) that waxing significantly reduced weight loss of pineapple fruits at storage. Fruit weight loss is mainly associated with respiration and moisture evaporation through the skin. Coating act as barriers, thereby restricting

water transfer and protecting fruit skin from mechanical injuries and delayed dehydration. Juice content for the pineapple fruit increased along the period of storage in all the treatments.

An experiment was conducted by Uddin and Hossain (2000) in the field laboratory of BARI at Joydebpur with weighed pineapple fruits (cv. Giant Kew) storage in ploythene bag or not and treated with GA_3 (100 ppm) and NAA (500 ppm) in room temperature. Fruit weight decreased gradually during storage and weight loss differed significantly among the treatment. They also found that at twenty days of storage the cumulative weight loss of fruit was maximum (21.6%) in control while it was minimum (7.6%) in fruit covered with polythene bags.

Scapim and Clemente (2005) studied that there was an increase in fresh weight loss of pineapple (*Ananas comosus* L merr.) cv. smooth cayenne during storage at 8^0C and 12^0C.

2.2.4. Juice content of fruit pulp

Othman (2008) found that juice content remained low (71.63% and 72.09%) in case of fruits treated with SA or GA_3 compared with other treatments at 15 DAS, which signified delaying of fruit ripening under these treatments, as ripening accelerates the juice content of pineapple fruit.

From an observation in India, Ahmed and Bora (2004) found that pineapple fruits (cv. Kew) harvested during different months of the year showed significant variations in per cent juice content. They noticed that fruits harvested during July to December were very juicy (73 to 74% in the 1^{st} year and 72 to 74% in the 2^{nd} year), while those harvested during January to June were less juicy (67 to 70% in the 1^{st} year and 67 to 69% in the 2^{nd} year).

2.2.5. Edible portion of fruit

An experiment was carried out by Hossain (2000) in the Department of Horticulture, BAU, Mymensingh to study the effect of stage of maturity and postharvest treatment on pineapple during storage and observed that premature fruit gave the minimum edible portion (62.08%) while full-ripe fruits gave maximum (72.8%).

An experiment was carried out by Uddin and Hossain (2000) in the field laboratory of BARI at Joydebpur to study effect of planting materials on pineapple. They found that pineapple fruit contained 57.88% edible portion.

2.2.6. Pulp to peel ration

Uddin and Hossain (2000) carried out an experiment on the pineapple fruits (cv. Giant Kew) in the field laboratory of BARI at Joydebpur. They found that pulp to peel ratio increased up to 15 days of storage after which it decreased slightly.

2.2.7. Biochemical parameters

Mandal *et al.,* (2015) found that except the fruits at control, for the other treatments, total sugar and TSS content gradually increased up to 5 DAS and afterward declined. However, titratable acidity was found low (1.01 and 1.02%) in fruits treated with GA_3 or SA at 15 DAS. Ascorbic acid content of the fruit was maximum (18.86 to 23.14 mg 100 g/pulp) on 0 DAS and it declined afterwards.

Kabir *et al.,* (2010) also had similar kind of increase in TSS and total sugar content of pineapple fruit up to 12 DAS at ambient storage.

Maturity studies conducted with pineapple (cv. Giant Kew) in India, Morton (1987) showed that the highest quality was attained when the fruit was harvested at a TSS of 13.8 to 17.0%.

Scapim and Clemente (2005) studied that there was an increase in soluble solids of pineapple (*Ananas comosus* L Merr.) cv. smooth cayenne during storage at 8^0C and 12^0C.

2.2.8. Physiological disorder and fungal incidence

Mandal *et al.,* (2015) reported that at 15 DAS, incidence of external diseases and fruit decay percentage was found maximum in fruit at control. Fruits which were covered either with polythene/newspaper bag or straw showed severe external infection and high fruit decay score at 15 DAS. But he also found that the fruits treated with GA_3 100 mg/L or SA at 5.0 m M showed significantly less or no external disease infections and fruit decay even at 15 DAS.

Sudha *et al.,* (2007) reported that GA_3 arrest the growth and spread of microorganisms in Sapota. It was claimed that exogenous application of SA could enhance resistance to pathogen and delay post harvest decay.

Uddin and Hossain (2000) conducted a laboratory experiment of mature pineapple cv. Gain Kew. They stored fruits at room temperature treated with 500 ppm NAA, 100 ppm GA_3, covering with polythene bag and without treatment. They observed that at 10 days in storage, 50% of the fruits (by number) in polythene bags were damaged and only 11.6% was damaged in other treatment. At 15 days of storage maximum rotting occurred in control (83%) and rotting was 50% in other treatments. Rotting was rapid in ploythene bags and control and there was 100% rottage of fruits 20 days after storing.

CHAPTER III

MATERIALS AND METHODS

This chapter arranges the materials and methods including a brief description of the experimental period, site description, climate condition, experimental design, treatments and analytical methods used for the experiment. The details of research procedure are described here.

3.1. Experimental location

The experiment was conducted at the laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar. Dhaka-1207 during the period from January 2020 to February 2020. The maximum and minimum temperature as well as relative humidity in the storage room was 26.4^0 C and 22.0^0 C and 70% and 60% respectively (Appendix 1). Temperature and relative humidity of the storage room were recorded with a digital Temperature-humidity recorder (Thermo, Germany).

3.2. Experimental materials

The materials used for the experiment were freshly harvested pineapple fruits of variety Honey Queen (*jaldubi*) from Rangamti where pineapple is grown extensively. For the confirmation of maturity stages preliminary observations were made and finally uniform size, shape and color were collected. The fruits were harvested in the forenoon and same day transferred to the laboratory, Sher-e-Bangla Agricultural University. During transportation adequate care was taken to prevent injuries.

3.3. Experimental design

The experiment was laid out in the Completely Randomized Design (CRD) with three replications. Each replication of a treatment comprised 5 fruits. Three fruits were kept to record shelf life, weight loss, color and other external fruit characteristics at 6 different dates at 3 days interval. The remaining 2 fruits from each replication of a treatment were chemically analyzed on the changes in edible portion, TSS content and juice content.

3.4. Treatments of the experiment

Nine post-harvest treatments *viz*.,

T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1} and kept in open condition

T_2 = Fruit dipping in Gibberellic Acid (GA_3) at 100 mg L^{-1} and kept in open condition

T_3 = Fruit dipping in Salicylic Acid (SA) at 5 m M L^{-1} kept in open condition

T_4 = Fruit dipping in Maleic Hydrazide (MH) at 500 mg L^{-1} kept in open condition

T_5 = Covering with perforated polythene

T_6 = Covering with newspaper bag

T_7 = Covering with dry straw

T_8 = Hot water treatment

T_9 = Control

3.5. Application of experimental treatments

The selected pineapple fruits were randomly assigned in the study for the post harvest treatments. After the application of treatments, the fruits were kept on a paper previously placed on laboratory floor at room temperature. The procedures of applying the post harvest treatments to the fruits of each variety were as follows.

3.5.1. Naphthalene Acetic Acid (NAA) at 100 mg L^{-1} (0.1%)

Napthalene Acetic Acid (0.1% solution) was prepared and the pineapple were dipped into solution for five minutes ensuring that appropriate quantity of NAA (0.1% solution) was being absorbed.

3.5.2. Gibberellic Acid (GA_3) at 100 mg L^{-1} (0.1%)

Gibberellic Acid (GA_3) at 100 mg L^{-1} (0.1% solution) was prepared and the pineapple were dipped into solution for five minutes ensuring that appropriate quantity of GA_3 (0.1% solution) was being absorbed.

3.5.3. Salicylic Acid (SA) at 5 m M L^{-1}

The molar mass of salicylic acid (SA) is 138.12 g/mol. So, 5 × 138.12 = 690.6 g salicylic acid was added in one liter water and the solution was prepared. After that the pineapple were dipped into solution for five minutes ensuring that appropriate quantity of SA was being absorbed.

3.5.4. Maleic Hydrazide (MH) at 500 mg L^{-1} (0.5%)

Maleic Hydrazide (MH) at 500 mg L^{-1} (0.5% solution) was prepared and the pineapple were dipped into solution for five minutes ensuring that appropriate quantity of MH (0.5% solution) was being absorbed.

3.5.5. Covering with perforated polythene

Polythene cover was perforated using a plastic sealer machine. The polythene cover had 5 perforations. Pineapples were held in the perforated cover, the tops were tied with a string. The sealed polythene cover was then placed on the laboratory floor at ambient conditions.

3.5.6. Covering with newspaper bag

The pineapple were individually held in un-perforated newspaper bag. The top of the bag was tied with a string and placed them on the laboratory table at ambient condition.

3.5.7. Dry straw

Dry straw was used to cover the pineapple and the pineapple then placed on the laboratory floor at ambient condition.

3.5.8. Hot water treatment

For hot water treatment, the pineapple were immersed into hot water (40^0C ± 2) for 10 minutes before placing them on the laboratory table at ambient temperature.

3.5.9. Control

For control treatment, the pineapple were immersed into normal water for 10 minutes before placing on the laboratory table at ambient temperature.

3.6. Observation

During the entire storage period, the fruits, used for the experiment, were keenly observed every day and data was recorded on TSS as well as physico-chemical changes during 0^{th}, 3^{rd}, 6^{th}, 9^{th}, 12^{th} and 15^{th} days after storage (DAS) as influenced by different treatments.

3.7. Collection of data

To assess the effects of different post-harvest treatments on quality and shelf life of pineapple at ambient condition, the data on different physico and chemical parameters were collected during the storage period at 3 days interval. The change in color, fruit weight, crown condition and shelf life have been studied during the entire storage period (Plate 1-2).

3.8. Parameter studied

The following physical and chemical parameters were recorded

i. Scoring of visual quality indices
ii. Total weight loss of fruit (%)
iii. Shelf life of fruit (days)
iv. Percent of fungal incidence (%)
v. Disease severity (%)
vi. TSS (Total Soluble Solids) content of fruit pulp
vii. Ascorbic acid content
viii. p^H of fruit pulp
ix. Determination of juice content (%)

3.9. Methods of studying different parameter

3.9.1. Scoring of visual quality indices

Following visual quality indices (Table 1) of fruits *viz*., skin color, crown condition, external disease and fruit decay, were recorded as per the standard procedure described by Teisson *et al.*, 1979 and Abdullah *et al.*, 1986.

Table 1: Scores for visual observation with indices

Score	**Indices**			
	Skin color	**Crown condition**	**External disease**	**Fruit decay percentage**
1	Mature green	Good fresh and green	None	None
2	Breaking (beginning to yellow at the base	Good with slightly yellow at tips	Slightly infected	10% decay
3	Quarter yellow	Moderate, dry tips and yellowing	Moderately infected	25% decay
4	Half yellow	Dry tips and more	Severely	50% decay

Score	Indices			
	Skin color	**Crown condition**	**External disease**	**Fruit decay percentage**
		yellowing	infected	
5	Three quarter yellow	Severe yellowing	-	75% decay
6	Fully yellow	-	-	100% decay

3.9.2. Determination of weight loss

Fruit for each treatment were tagged and weighed at 3 days interval using an electronic balance. The percentage weight loss was calculated by the following equation:

Percentage weight loss at n^{th} day = $\frac{Weight\ loss\ (0\ day - nth\ day)}{Weight\ at\ 0\ day}$ x 100

3.9.3. Determination of juice content (%)

The percentage of juice content of the fruit pulp was calculated by using the following equation:

Percentage of juice in fruit pulp = $\frac{Wt.of\ juice}{Wt.of\ pulp}$ x 100

3.9.4. Biochemical parameters

Analysis were carried out for biochemical parameters *viz*., total soluble solids (TSS), total sugar and ascorbic acid content following standard procedure described by Ranganna (1997).

3.9.4.1. Ascorbic Acid

Ascorbic Acid was determined following the method of Rangana (1997).

1. 3% Meta phosphoric acid (HPO_3): Prepared by dissolving the sticks or pellets of HPO_3 in glass-distilled water.

2. Ascorbic acid standard: Weighed accurately 100 mg of L-ascorbic acid and made up to 100 ml with 3% HPO_3. Dilute 10 ml to 100 ml with 3% HPO_3(1 mg = 0.3 mg of ascorbic acid).

3. Dye solution: 50 mg of the sodium salt of 2,6-Dichlorophenol indophenol was dissolved in approximately 150 ml of hot glass distilled water containing 42 mg of sodium bicarbonate and cooled and diluted with glass-distilled water to 200 ml. Store in a refrigerator and standardize every day.

The dye 2,6-Dichlorophenol indophenol is blue in alkaline solution and is reduced to light red at pH range of 1 to 3.5.

Standardization of dye: 5 ml of standard ascorbic acid solution was taken in a conical flask and 5 ml of HPO_3 was then added. A micro burette was filled with dye. The ascorbic acid solution was titrated with the dye to pink color, which persisted for 15 seconds. Dye factor (i.e. mg of ascorbic acid required to neutralize per ml of the dye) was determined by using the following formula:

$$\text{Dye factor} = \frac{Ascorbic\ acid\ present\ in\ the\ solution\ titrate}{Titrate\ (volume\ of\ dye)}$$

Preparation of the samples: 10 ml of the pineapple pulp was taken and made up to 100 ml with 3% HPO_3 and then filtered. 10 ml of the aliquot was taken in a 150 ml conical flask. 1 ml of 40% formaldehyde and 0.1 ml of HCl were added to it and kept for 10 minutes. This was titrated with the standard dye to a light pink color (end point), which persisted for 15 seconds.

Calculation:

$$\text{mg of ascorbic acid per 100 ml} = \frac{Titre\ x\ Dye\ factor\ x\ Vol.made\ up\ x\ 100}{Aliquot\ of\ extract\ taken\ for\ estimation\ x\ Wt\ or\ Vol.\ of\ the\ sample\ taken\ for\ estimation} \text{ x } 100$$

3.9.4.2. Sugar content

The reagents used for the estimation of reducing, non-reducing and total sugar were as follows:

1. Fehling's solution (A)
2. Fehling's solution (B)
3. Methylene blue indicator
4. 45% Neutral lead acetate solution
5. 22% potassium oxalate solution

Standardization of Fehling's solution: 10 ml of both Fehling's solution A and Fehling's solution B were mixed together in a beaker. 10 ml of mixed solution was pipetted into a 250 ml conical flask and 25 ml distilled water was added to it. Standard sugar solution was taken in a burette. The conical flask containing mixed solution was heated on a hot plate. When the solution began to boil, three drops of methylene blue indicator solution was added to it. Mixed solution was titrated by standard sugar solution. The end point was indicated by decolorization of the indicator.

Fehling's factor was calculated by using the following formula:

$$\text{Fehling's facor} = \frac{Titre\ x\ 2.5}{1000}$$

A. Reducing Sugar

Sample preparation: 10 g of filtered juice and 100 ml of distilled water were mixed in a homogenizer and transferred to 250 ml volumetric flask. The mixture was neutralized with 0.1 N NaOH and 2 ml of lead acetate solution was added and allowed to stand for 10 minutes. 5 ml potassium oxalate solution was added and made to a volume of 250 ml. Then the mixture was filtered and made the dilution.

Titration: 10 ml of mixed Fehling's solution was taken in a conical flask and 25 ml of distilled water was added to it. Purified pineapple juice was taken in a burette. Conical flask containing mixed Fehling's solution was added to the flask when boiling started and titrated with solution taken in the burette at the same time. The end point was indicated by decolorization of indicator.

Percent reducing sugar was calculated by using the following formula:

$$\% \text{ Reducing sugar} = \frac{I \; x \; D \; x \; 100}{T \; x \; W \; x \; 100}$$

Where,

I = mg of invert sugar required to reduce known volume of Fehling's solution

D = Dilution factor

T = Titration

W = Weight of sample

B. Non-reducing sugar

50 ml purified solution was taken in a conical flask. 50 ml distilled water and 5 gm of citric acid were added to it. Then the conical flask was heated for 10 minutes for addition of sucrose and finally cooled. The sample was then neutralized by 0.1 n NaOH solution using phenolphthalein as indicator. The volume was made up to 100 ml with distilled water. The mixed Fehling's solution was titrated using similar procedure followed as that for reducing sugar. The percent invert sugar was then calculated by the similar procedure as for reducing sugar from which the percent non-reducing sugar is calculated as follows:

% Non-reducing sugar = % Invert sugar - % reducing sugar

Estimation of total sugar = Total sugar can be calculated as follows:

% Total sugar = % Reducing sugar + % Non-reducing sugar

3.9.5.3. Total soluble solid (TSS) content of fruit pulp

Total soluble solid (TSS) content of pineapple pulp was estimated by using Abbe refractometer. A drop of pulp solution squinted from the fruit pulp was placed on the prism of refractometer. Percent TSS was obtained from direct reading of the instrument. Temperature correction was made by using the methods described by Ranganna (1997).

3.10.6. Shelf life

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

3.7. Statistical analysis

The data obtained from the experiment were analyzed statistically using MSTAT computer package program to find out the significance of the difference among the treatments. The significance of the differences among the pairs of treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez. 1984) for the interpretation of results.

CHAPTER IV

RESULTS AND DISCUSSION

The effects of different post-harvest treatment on quality and shelf life of pineapple during storage at ambient condition was investigated. The results have been presented and discussed in this chapter. A summary of the analyses of variances (ANOVA) of the data in respect of all the parameters have been shown in Appendices II to VIII. The results have been presented and discussed and possible interpretations have been given under the following headings:

4.1. Skin color

Skin color of pineapple fruits markedly changed during storage. It was observed that from mature green stage, fruit color gradually intensified through the time of storage (Table 1 and Plate 1). Similar findings were mentioned by Wijesinghe and Sarananda (2002). However, the degree of color break varied among the different treatments. Out of the nine treatments under study, GA_3 at 100 mg L^{-1} (T_2) caused retardation of peel color change (average score: 3.4, quarter yellow; at 15 DAS). Similar result was reported by Mandal *et al.* (2015) that GA lengthens shelf life, delay ripening and peel color change in queen pineapple. Similar result was also found by Obrero (2006) and reported that gibberellins have been found to regulate ageing process in many plant tissues including fruits. GA caused regreening in citrus fruit (Coggins and Lewis, 1962) and delayed the appearance of red color pigmentation in tomatoes (Dostal and Leopald, 1967). Even after 15 days of storage of pineapple fruits at room temperature, there were no full color development of fruit skin, when the fruits treated with MH at 500 mg L^{-1} (average score: 5.2, three quarter yellow) or SA at 5. m M (average score: 5.4, three quarter yellow). Hakim *et al.* (2013) opined that GA_3, MH has the ability to retain the total chlorophyll a and chlorophyll b, which caused delaying in color

development in banana fruit. Influence of SA on color development was reported by Nemeth *et al.* (2002).

Table 1. Effect of different post-harvest treatments on the skin color of pineapple during storage

Treatments	Skin color at different days after storage (DAS)					
	0	**3**	**6**	**9**	**12**	**15**
T_1	1.0	3.2	4.6	5.0	5.4	-
T_2	1.0	1.0	1.2	1.4	3.0	3.4
T_3	1.0	1.8	2.2	3.0	4.6	5.4
T_4	1.0	2.6	3.2	3.8	4.6	5.2
T_5	1.0	3.4	4.8	5.2	5.6	-
T_6	1.0	3.6	4.8	5.4	5.8	-
T_7	1.0	3.4	4.6	5.2	5.6	-
T_8	1.0	4.0	4.8	5.4	5.8	-
T_9	1.0	4.2	4.8	5.8	6.0	-

[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

[1 = Mature green; 2 = Breaking (beginning to yellow at the base); 3 = Quarter yellow; 4 = Half yellow; 5 = Three quarter and 6 = Fully yellow]

4.2. Crown condition

It was observed that crown condition was good with slight development of yellow color at tip in most of the treatments up to 6 DAS. Crown condition score of the fruits was found maximum for control (average score: 5.0, severe yellowing) at 12 DAS, whereas it was relatively low (average score: 2.2, good with slight tip yellowing) in case of fruits at T_2 even at 15 DAS (Table 2). However, fruits treated with salicylic acid (T_3) and maleic hydrazide (T_4) showed relatively higher crown condition score (average score: 3.0 and 3.2; respectively) during the storage period. Othman (2008) got similar observation and reported that reduction in crown quality in Gandul

pineapple was hastened by paraffin and semper fresh coatings. However, it was opined that crown deterioration is a natural process of senescence and is not a physiological disorder of pineapple. Storage temperature also affected the freshness of crown; the higher the storage temperature, the faster the discoloration of the crown (Abdullah *et al.,* 1986).

Table 2. Effect of different post-harvest treatments on crown condition of pineapple during storage at ambient condition

Treatments	Crown condition at different days after storage (DAS)					
	0	**3**	**6**	**9**	**12**	**15**
T_1	1.0	1.4	1.8	3.0	3.6	-
T_2	1.0	1.0	1.0	1.2	1.8	2.2
T_3	1.0	1.0	1.2	1.8	2.2	3.2
T_4	1.0	1.2	1.4	1.6	2.2	3.0
T_5	1.0	1.4	1.8	2.8	3.6	-
T_6	1.0	1.6	2.4	3.4	4.8	-
T_7	1.0	1.6	2.4	3.2	4.6	-
T_8	1.0	1.6	2.2	3.2	4.0	-
T_9	1.0	1.8	2.6	3.8	5.0	-

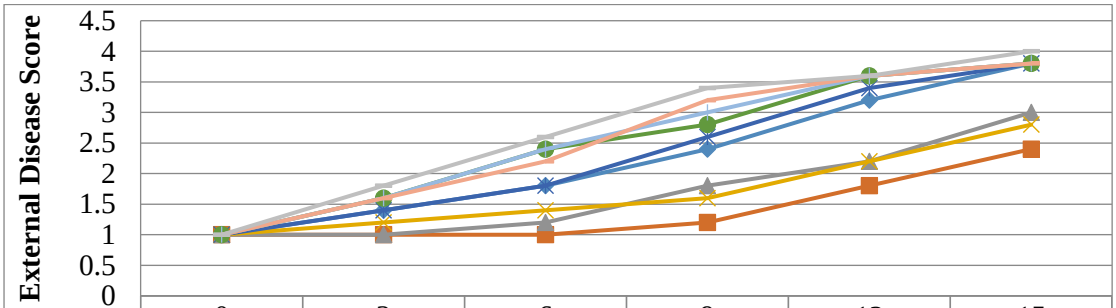
[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

[1 = Good fresh and green; 2 = Good with slightly yellow at the tips; 3 = Moderate, dry tips and yellowing; 4 = Bad, dry tips and more yellowing; and 5 = Severe yellowing]

4.3. Incidence of external disease

At 15 DAS, incidence of external diseases (average score: 4) was found maximum in fruit at control (T_9). Fruits which were covered either with polythene/newspaper bag or straw or hot water showed severe external infection (Figure 1). Both the fruits treated with GA_3 100 mg L^{-1} or MH 500 mg L^{-1} showed significantly slightly infected even at 15 DAS. Mandal *et al.* (2015) also found similar result and found that fruits

treated with GA_3 or SA showed significantly less or no external disease infections even at 15 DAS. Sudha *et al.* (2007) reported that GA_3 arrest the growth and spread of microorganisms in Sapota. It was claimed that exogenous application of SA could enhance resistance to pathogen (Asghari and Ashdam 2010; Babalar *et al.*, 2007).



	0	3	6	9	12	15
T1	1	1.4	1.8	2.4	3.2	3.8
T2	1	1	1	1.2	1.8	2.4
T3	1	1	1.2	1.8	2.2	3
T4	1	1.2	1.4	1.6	2.2	2.8
T5	1	1.4	1.8	2.6	3.4	3.8
T6	1	1.6	2.4	2.8	3.6	3.8
T7	1	1.6	2.4	3	3.6	3.8
T8	1	1.6	2.2	3.2	3.6	3.8
T9	1	1.8	2.6	3.4	3.6	4

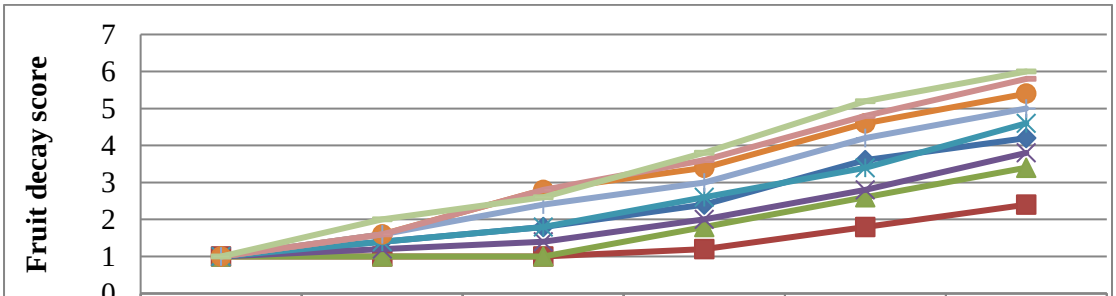
[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

Figure 1. Incidence of external disease of pineapple fruit during storage at ambient condition

4.3. Fruit decay during storage

At 15 DAS, fruit decay percentage was found maximum (average score: 6) in fruit at control (T_9). Fruits which were covered either with polythene/newspaper bag or straw or hot water showed high fruit decay score (average score: 5 to 6) at 15 DAS (Figure 2). But the fruits treated with GA_3 100 mg L^{-1} showed significantly 10% decay even at 15 DAS. Mandal *et al.* (2015) reported that fruits treated with GA_3 or SA showed

significantly less or no fruit decay even at 15 DAS. It was claimed that exogenous application of SA could enhance resistance to pathogen and delay post harvest decay (Asghari and Ashdam 2010; Babalar *et al.*, 2007).



	0	3	6	9	12	15
	Fruit decay at different days after storage (DAS)					
T1	1	1.4	1.8	2.4	3.6	4.2
T2	1	1	1	1.2	1.8	2.4
T3	1	1	1	1.8	2.6	3.4
T4	1	1.2	1.4	2	2.8	3.8
T5	1	1.4	1.8	2.6	3.4	4.6
T6	1	1.6	2.8	3.4	4.6	5.4
T7	1	1.6	2.4	3	4.2	5
T8	1	1.6	2.8	3.6	4.8	5.8
T9	1	2	2.6	3.8	5.2	6

[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

Figure 2. Fruit decay of pineapple during storage at ambient condition

4.4. Percentage of weight loss

The different postharvest treatments showed evidence of more evident effect on weight loss of pineapple during storage. Variation among the treatments was highly significant during each days of storage (Table 3). Total weight loss on treated and untreated pineapple was increased with the duration of storage. The maximum weight loss of pineapple (6.48%, 8.70%, 12.92% and 14.64%) was recorded in control treatment (T_9) at 3, 6, 9 and 12 DAS, respectively. Among the treated pineapple, T_2 (GA_3 at 100 mg L^{-1}) gave the best performance on percent weight loss and gave the minimum percent weight loss (1.62, 2.70, 6.88, 8.70 and 10.57%) at 3, 6, 9, 12 and 15

DAS, respectively which was followed by T_3 (SA at 5 m M L^{-1}) treatment. Kabir *et al.* (2010) reported that fruits treated with GA_3 at 200 mg L^{-1} were found to have minimum weight loss of pineapple fruits at 16 days of storage. Tabasum *et al.* (2019) reported that SA treated fruits have positive effects in maintaining membrane integrity. Abbasi *et al.* (2010) observed less chilling injury and less weight loss than other treatments in fruits of peach treated with 1mM SA. Brar *et al.* (2014) found that 200 ppm SA significantly reduced the weight loss in peach fruit under cold storage condition.

Table 3: Effect of post-harvest treatments on percentage of weight loss during storage

Treatments	Weight loss (%) at the different days of storage					
	0 DAS	**3 DAS**	**6 DAS**	**9 DAS**	**12 DAS**	**15 DAS**
T_1	0.00	3.36 f	6.55 d	10.77 c	12.66 c	-
T_2	0.00	1.62 h	2.70 h	6.88 g	8.07 g	10.57
T_3	0.00	2.84 g	3.63 g	8.71 f	9.20 f	12.57
T_4	0.00	4.04 e	5.25 f	8.85 f	9.97 e	13.07
T_5	0.00	4.30 e	5.33 f	9.27 e	11.10 d	-
T_6	0.00	5.07 d	6.33 e	10.44 d	12.54 c	-
T_7	0.00	5.83 c	6.77 c	10.77 c	12.86 bc	-
T_8	0.00	6.07 b	7.38 b	11.62 b	13.12 b	-
T_9	0.00	6.48 a	8.70 a	12.92 a	14.64 a	-
LSD (0.05)	**-**	**0.32**	**0.21**	**0.18**	**0.31**	**-**
CV %	**-**	**4.41**	**2.12**	**1.05**	**1.60**	**-**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

4.5. Percentage of Juice content

Juice content of the pineapple fruit increased along the period of storage in all the treatments. Dhar *et al.* (2008) got similar observation in pineapple cv. Giant Kew at Bangladesh. Though in the present study, juice content gradually increased, however, it remained low (70.23% and 70.32%) in case of fruits treated with GA_3 (T_2) and SA (T_3) compared with other treatments at 12 DAS (Table 4), which signified delaying of fruit ripening under this treatment, as ripening accelerates the juice content of pineapple fruit (Othman, 2008). But pineapple treated with NAA @100 mg L^{-1} have high % of juice content (73.48%). Mandal *et al.* (2015) reported that juice content of pineapple at storage was remained low in case of fruits treated with SA or GA_3 compared with other treatments.

Table 4: Effect of post-harvest treatments on percentage of juice content during storage

Treatments	Juice content (%) at the different days of storage	
	6 DAS	**12 DAS**
T_1	68.25 b	73.48 a
T_2	66.48 c	70.23 f
T_3	66.95 c	70.32 f
T_4	68.69 ab	70.90 d
T_5	69.14 ab	70.55 e
T_6	68.55 b	71.55 b
T_7	68.16 b	71.64 b
T_8	68.34 b	71.21 c
T_9	69.64 a	70.98 cd
CV %	**0.80**	**0.19**
LSD (0.05)	**0.92**	**0.23**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

4.6. Biochemical parameters

4.6.1. Total sugar content

The total sugars had significant difference among various treatments in the fruits. After 6 and 12 days of storage, highest total sugars (12.96% and 13.91%) was recorded in T_2 treatment which was statistically identical to T_3 treatemnt and the lowest total sugars (10.42% and 10.41%) was recorded in T_9 treatment. There was a sharp decline in total sugars in untreated fruits. Similar results were reported by Lu *et al.* (2010) in pineapple and Sayyari *et al.* (2009) in pomegranate. Kabir *et al.* (2010) also had similar kind of increase in total sugar content of pineapple fruit up to 12 DAS at ambient storage.

4.6.2. Ascorbic acid

The ascorbic acid had significant difference among various treatments in the fruits. After 6 and 12 days of storage, highest ascorbic acid (21.81% and 20.13%) was recorded in T_2 treatment and the lowest ascorbic acid (13.56% and 11.23%) was recorded in T_9 treatment. Beside this, it was also found that the quantity of ascorbic acid in pineapple was decreased with the increase of storage period. Adisa (1986) noticed that ascorbic acid content of pineapple gradually decreased with the increase in storage period. Joshi and Roy (1988) observed a continuous decrease of vitamin C during ripening, transportation and storage.

4.6.3. Total soluble solid (TSS) content

TSS is one of the most important quality factors for most of the fruits and for pineapple, a TSS of 13.9 to 17.0% indicates the highest quality of fruits to attain the optimum harvesting stage (Morton, 1987). In the study, highest Total soluble solids (18.64 ^{0}B and 20.25 ^{0}B) was recorded in the fruits treated with gibberellic acid at 100 mg L^{-1} (T_2) at 6 and 12 DAS. Lowest TSS (15.86 ^{0}B and 13.24 ^{0}B) was recorded in

control at 6 and 12 DAS. Increase in the TSS of fruits may be due to reduction of the activities of various enzymes and by delaying senescence, disorganization of cellular structure and checking of microbial activities (Lougheed *et al.,* 1979). The TSS and sugars increase during storage due to hydrolysis of starch into sugars as on complete hydrolysis of starch into sugars as on complete hydrolysis of starch into sugars as on complete hydrolysis of starch no further increase occurs and subsequently a decline in TSS is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al.,* 1980). Similar results were recorded by Fatema *et al.* (2013) in kiwi fruits, when the fruits treated with SA at 5 mM concentration had highest TSS. Hajilou *et al.* (2013) recorded highest TSS in 2.0 mM and 3.0 mM SA treatments in apricot.

Table 5: Effect of post-harvest treatments on percentage of total sugar, ascorbic acid and total soluble solid during storage

Treatments	Total sugar (%)		Ascorbic acid (mg/100 g pulp)		TSS (^{0}Brix) at DAS	
	6 DAS	12 DAS	6 DAS	12 DAS	6 DAS	12 DAS
T_1	12.09 bc	12.62 b	17.79 d	15.76 d	17.22 d	14.55 f
T_2	12.96 a	13.91 a	21.81 a	20.13 a	18.64 a	20.25 a
T_3	12.95 a	13.68 a	20.75 b	19.54 b	17.77 c	19.34 b
T_4	12.13 b	12.39 bc	19.66 c	17.13 c	17.75 c	17.37 c
T_5	12.11 bc	12.10 c	16.81 e	14.68 e	18.24 b	17.17 c
T_6	11.62 bcd	11.60 d	15.74 f	13.63 f	16.88 f	15.55 e
T_7	11.46 cd	10.88 e	15.22 g	12.88 g	17.06 de	14.22 g
T_8	10.43 d	10.48 e	14.75 h	12.37 h	16.96 ef	16.33 d
T_9	10.42 e	10.41 e	13.56 i	11.23 i	15.86 g	13.24 h
CV %	**3.00**	**2.43**	**0.75**	**0.68**	**0.59**	**0.75**
LSD (0.05)	**0.60**	**0.49**	**0.22**	**0.18**	**0.17**	**0.21**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

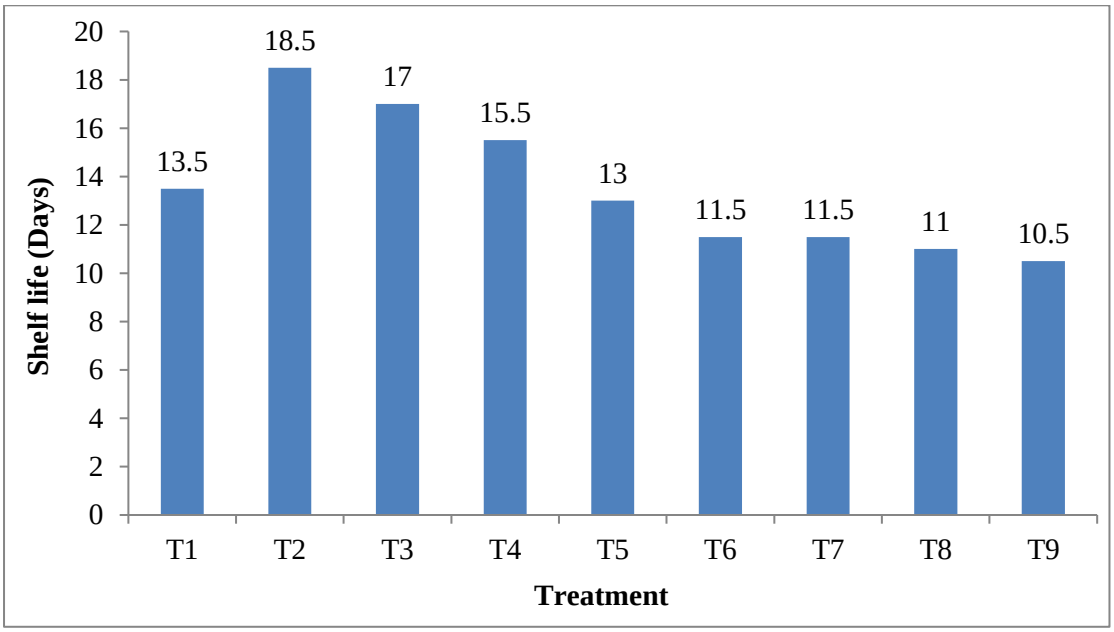
[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

4.7. Shelf life

Shelf life is the period from harvesting up to the last edible stage. The extension of shelf life of fruits has been one of the prime concerns of mankind throught the record of history (Salunkhe and Dcsai, 1984).

There were significant variation in shelf life of the pineapple due to different treatment under study (Figure 3). Maximum shelf life (18.50 days) was recorded in case of the fruits treated with GA_3 (T_2) followed by T_3 i.e. treated with SA at 5.0 m M (17.00 days) compared with control (10.50 days). Dhar *et al.* (2008) reported GA_3 (100 mg L^{-1}) treated pineapple fruits got 20.77 days of shelf life when kept under

room temperature. Gholami *et al.* (2010) reported that GA_3 treated sweet cherry fruit got delayed ripening as it decreased the ethylene production. Hakim *et al.* (2013) observed maximum shelf life (13.0 days) in banana fruit when treated with GA_3 at 400 ppm. Lu *et al.* (2010) observed that post harvest treatment with 5.0 m M SA delayed ripening and extended shelf life of pineapple cv. Comte de Paris. Mandal *et al.* (2015) observed that post harvest treatments with GA_3 delayed ripening and extended shelf life of pineapple up to 17.05 days.



[T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water)]

Figure 3. Shelf life of pineapple fruits under different post-harvest treatments

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out in the laboratories of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka during the period from 08 January 2020 to 26 January 2020. The objectives of the present study were to investigate the role of different chemicals in extending the shelf life of pineapple fruits and to improve the shelf life and quality of pineapple fruits at ambient storage condition. The materials used for the experiment were freshly harvested pineapple fruits of variety Honey Queen (*jaldubi*) from Rangamti. Nine different post harvest treatments used in the study are: T_1 = Fruit dipping in Napthalene Acetic Acid (NAA) at 100 mg L^{-1}; T_2 = Gibberellic Acid (GA_3) at 100 mg L^{-1}; T_3 = Salicylic Acid (SA) at 5 m M L^{-1}; T_4 = Maleic Hydrazide (MH) at 500 mg L^{-1}; T_5 = Covering with perforated polythene; T_6 = Covering with newspaper bag; T_7 = Dry straw; T_8 = Hot water treatment, and T_9 = Control (treated with normal water). There experiment was setup in randomized complete block design (RCBD) with three replications. The experiment was conducted based on observations, which were made on external and internal characters of fruits and physio-chemical properties such as total weight loss, length and diameter decrease, skin color, crown condition, disease severity, juice content, ascorbic acid, total sugar, total soluble solid content and shelf life. The results obtained in the study have been summarized below.

Summary

Skin color of pineapple fruits markedly changed during storage. It was observed that from mature green stage, fruit color gradually intensified through the time of storage. Out of the nine treatments under study, GA_3 at 100 mg L^{-1} (T_2) caused retardation of peel color change (average score: 3.4, quarter yellow; at 15 DAS). Even after 15 days

of storage of pineapple fruits at room temperature, there were no full color development of fruit skin, when the fruits treated with MH at 500 mg L^{-1} (average score: 5.2, three quarter yellow) or SA at 5. m M (average score: 5.4, three quarter yellow).

Crown condition score of the fruits was found maximum for control (average score: 5.0, severe yellowing) at 12 DAS, whereas it was relatively low (average score: 2.2, good with slight tip yellowing) in case of fruits at T_2 even at 15 DAS (Table 2). However, fruits treated with salicylic acid (T_3) and maleic hydrazide (T_4) showed relatively higher crown condition score (average score: 3.0 and 3.2; respectively) during the storage period.

At 15 DAS, incidence of external diseases and fruit decay percentage (average score: 4 and average score: 6, respectively) was found maximum in fruit at control (T_9). But the fruits treated with GA_3 100 mg L^{-1} or MH 500 mg L^{-1} showed significantly slightly infected and 10% decay even at 15 DAS.

Total weight loss on treated and untreated pineapple was increased with the duration of storage. The maximum weight loss of pineapple (6.48%, 8.70%, 12.92% and 14.64%) was recorded in control treatment (T_9) at 3, 6, 9 and 12 DAS respectively. Among the treated pineapple, T_2 gave the best performance on percent weight loss and gave the minimum percent weight loss (1.62, 2.70, 6.88, 8.70 and 10.57%) at 3, 6, 9, 12 and 15 DAS, respectively.

Juice content of the pineapple fruit increased along the period of storage in all the treatments. Though in the present study, juice content gradually increased, however, it remained low (70.23% and 70.32%) in case of fruits treated with GA_3 (T_2) and SA (T_3) compared with other treatments at 12 DAS, which signified delaying of fruit

ripening under these treatment, as ripening accelerates the juice content of pineapple fruit.

The total sugars, ascorbic acid and total soluble solids had significant difference among various treatments in the fruits. After 6 and 12 days of storage, highest total sugars (12.96% and 13.91%); highest ascorbic acid (21.81% and 20.13%) and highest TSS (18.64 ^{0}B and 20.25 ^{0}B) was recorded in T_2 treatment and the lowest total sugars (10.42% and 10.43%); lowest ascorbic acid (13.56% and 11.23%) and lowest TSS (15.86 ^{0}B and 13.24 ^{0}B) was recorded in T_9 treatment.

There were significant variations in shelf life of the pineapple due to different treatment under study. Maximum shelf life (18.50 days) was observed in case of the fruits treated with GA_3 (T_2) compared with control (10.50 days).

Conclusion

The changes in total weight loss, crown condition, disease severity and fruit decay during storage period were significantly influenced by different postharvest treatments. For all postharvest treatments, fruits showed a decline in weight, length and diameter with the increasing of storage duration. The result of the present experiment showed that GA_3 at 100 mg L^{-1} as the best post-harvest treatment to extend the shelf life while maintaining the fruit physico-chemical qualities of Pineapple cv. Honey Queen during storage at room temperature.

Recommendation

The following suggestions may be considered for further studies:

1. Different traditional techniques for storage needed to be studied thoroughly particularly in respect of efficiency and cost condition.
2. Detail study may be conducted with treatments like, cold storage, coating materials and porous packing in relation to microbial decay and storability of pineapple.

CHAPTER VI

REFERENCES

Abbasi, N. A., Hafeez, S., Tareen, M. J., Hewett, E. W., Johnston, J. W. and Gunson, F. (2010). Salicylic acid prolongs shelf life and improves quality of 'Maria Delicia' peach fruit. *Acta. Horticulturae,*, **880**: 91-97.

Abdullah, H., Rohaya, M. A. and Zaipun, M. Z. (1986). Storage study of pineapple (*Ananas comosus* cv. Sarawak) with special emphasis on black heart disorder. *Malaysian Agri. Res. Devel. Ins. Res. Bull.,* **14**(2): 132-138.

Adisa, V. A. (1986). The influence of molds and some storage factors on the ascorbic acid content of orange and pineapple fruits. *Food Chemistry.,* **22**: 139-146.

Ahmed, F. and Bora, P. C. (2004). Changes in quality of Kew pineapple fruit at different times. *J. Food Sci. Technol.,* **26**(1): 51-52.

Ahmmed, M. G. (2011). Effect of maturity and storage condition on shelf life and post harvest quality of pineapple. M.S. thesis. Dept. of food technology and rural industries. BAU. Mymensingh. pp. 1-13.

Asghari, M. and Ashdam, M. S. (2010). Impact of salicylic acid on post harvest physiology of horticultural crops. *Trends Food Sci. Tech.,* **21**: 502-509.

Babalar, M., Asghari, M., Talaei, A. and Khosroshahi, A. (2007). Effect of pre and post-harvest salicylic acid treatment on ethylene production, fungal decay and overall quality of selva strawberry fruit. *Food Chemis.,* **105**: 449-453.

BBS. (2018). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. of the Peoples' Republic of Bangladesh, Dhaka. pp. 201-202.

Brar, J. S., Gupta, N. and Gill, M. S. (2014). Effect of pre and post-harvest treatments of salicylic acid on quality characteristics of peach (*Prunus persica* L.) fruits during storage. *Progressive Horti.*, **46**: 217-21.

Chadha, K. L., Reddy, B. M. C. and Shikhamany, S. D. (1998). Pineapple. Directorate of information and publications of Agriculture Krishi Anusandhan Bhavan. New Delhi. pp. 79-81.

Coggins, C. W. and Lewis, L. N. (1962). Regreening of Valencia Orange as Influenced by Potassium Gibberellate. *Plant Physiol.*, **37**(5): 625-627.

Deka, B. C., Saikia, J. and Sharma, S. (2005). Standardization of maturity indices of 'kew' pineapple. *Acta. Hort.* (ISHS)., **682**: 2215-2220.

Dhar, M., Rahman, S. M. and Sayem, S. M. (2008). Maturity and post harvest study of pineapple with quality and shelf life under red soil. *Intel. J. Sustain. Crop Pro*., **3**: 69-75.

Dostal, H. C. and Leopold, A. C. (1967). Gibberellin delays ripening of tomatoes. *Science.*, **158**: 1579-1580.

FAO, 2004. Production Year Book 2002. Food and Agriculture Organization of the United Nations, Rome, Italy, **63**: 180-182.

Fatemi, H., Aminifard, M. and Samane, M. (2013). Effect of post harvest salicylic acid treatment on fungal decay and some post harvest quality factors of kiwi fruit. *Archi. Phytopa. Plant Prot.*, **46**(11): 1338-1345.

Gholami, M., Sedighi, A., Ershadi, A. and Sarikhani, H. (2010). Effect of pre and post harvest treatments of salicyclic and gibberellic acid on ripening and some physiochemical properties of 'Mashhad' sweet cherry (Prunus avium L.) fruit. *Acta. Horticulturae.*, **884**: 257-264.

Gomez, A. K. and Gomez, A. A. (1984). Staristical Procedures for Agricultural Research. Second Edition. John Wiley and Sons! New York, U.S.A.

Gortner, W. A., Dull, G. G. and Krauss, B. H. (2006). Fruit development, maturation, ripening and senescence; A biochemical basis for horticultural terminology. *Hort. Abst*., **68**(12): 1457-1998.

Hajilou, J. and Fakhimrezaei, S. (2013). Effect of post harvest calcium chloride or salicylic acid treatments on the shelf life and quality of apricot fruit. *J. Horti. Sci. Biotec.*, **88**(5): 600-601.

Hakim, K. A., Sarkar, M. A. R., Khan, M. Z. H., Rahman, S. M., Ibrahim, M. and Islam, M. K. (2013). Effect of post harvest treatments on physiochemical characters during storage of two banana (*Musa spp*.) cv. Sabri and Amritasagar. *Inter. J. Bio.,* 3: 168-179.

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. pp. 80.

Hu, H., Li, X., Dong, C. and Chen, W. (2011). Effect of wax treatment on quality and post harvest physiology or pineapple fruit in cold storage. *African J. Bio. Tec.,* **10**: 7592-7603.

Joshi, G. D. and Roy, S. K. (1988). Influence of maturity transport and cold storage on biochemical composition of Alphonso mango fruits. *J. Moharastra. Agril. Univ.,* **13**(1): 12-15.

Kabir, H., Howlader, J., Ghosh, T. K., Goswami, C. and Haque, M. A. (2010). Effect of different maturity phases and post harvest treatments on the shelf life of pineapple. *Inter. J. Bio. Res.,* **2**: 11-16.

Kamol, S. I., Howlader, J., Sutra Dhar, G. C. and Aklimuzzaman, M. (2014). Effect of different stages of maturity and postharvest treatments on quality and storability of pineapple. *J. Bangladesh Agril. Univ.,* **12**(2): 251-260.

Lodh, S. B., Diwaker, N. G., Chadha, K. L., Melanta, K. R. and Selvaraj, Y. (1973). Biochemical changes associated with growth and development of pineapple fruits var. Kew. III. *Indian J. Hort.,* **30**: 381-383.

Lougheed, E. S., Murr, D. P. and Miller, S. R. (1979). Effect of calcium and daminozide on ethylene production and softening of apple fruits. *Experimentia*., **35**: 43-44.

Lu, X. H., Sun. D. Q., Xi, Y. W. M. and Sun, G. M. (2010). Effect of post harvest salicylic acid treatment on fruit quality and anti-oxidant metabolism in pineapple during cold storage. *J. Horti. Sci. Biotech.,* **85**: 454-458.

Mandal, D., Lalremruata, Hazarika, T. K. and Nautiyal, B. P. (2015). Effect of post-harvest treatments on quality and shelf life of pineapple (*Ananas comosus* L. Merr.) fruits at ambient storage condition. *Inter. J. Bio. Stress. Manag.,* **6**(4): 490-496.

Mondal, M. F. (2000). Production and storage of fruits (in Bangla). Published by Mrs. Afia Mondal. BAU Campus, Mymensingh-2202. pp. 32.

Morton, J. F. (1987). Fruits of warm climates. Miami, USA. pp. 18-28.

Nemeth, M., Janda, T., Horvath, E., Paldi, E. and Szalai, G. (2002). Exogenous salicylic acid increase polyamine content but may decrease drought tolerance in maize. *Plant Sci.,* **162**: 569-574.

Obrero, I. Q., (2006). Yield response of queen pineapple to the application of Gibberellic Acid. *Pineapple News.,* **15**: 6-7.

Othman, Z. (2008). Effect of post harvest coatings and heat treatment on quality of stored pineapple fruits. Ph. D. Thesis. University of Putra, Malaysia. pp. 98-309.

Paull, R. E. and Rohrbach, K. G. (1985). Symptom development of chilling injury in pineapple fruit. *J. American Soci. Hort. Sci.,* **110**: 100-105.

Poignant, A. (1970). Effect of plant growth regulators on quality of pineapple fruits. *Fruit doutre Mer*., **25**: 877-885.

Prasad, M. M. and Singh, H. N. P. (1993). Effect of hormones on longevity of banana fruits. *National Aca. Sci. Lett.*, **16**: 59-62.

Rahman, M. A. (2003). Effects of growth regulators on the storage behavior of two varieties of pineapple. M.S. thesis. Department of Horticulture, BAU, Mymensingh. pp. 79-82.

Ranganna, S. (1997). Handbook of analysis and quality control for fruits and vegetable products. Tata McGraw Hill Publishing Co. Ltd., New Delhi. pp. 875-886.

Salunkhe, D. H. and Desai, B. B. (1984). Post Harvest Biotechnology of Fruits (Vol. 2). CRC Press Inc. Boca Roton, Florida. pp. 194.

Salunkhe, D. K. and Desai, B. B. (1984). Postharvest Biotechnology of Fruits. Vol. 2. CRC press, Inc., Roca Raton, Florida. p. 7.

Sayyari, M., Balabar, M., Kalantari, S., Serrano, M. and Valero, D. (2009). Effect of salicylic acid treatment on reducing chilling injury in stored pomegranates. *Post. Bio. Technol.,* **55**(3): 152-154.

Scapim, C. A. and Clemente, E. (2005). Cold storage of pineapple ‘smooth cayenne under different types of packaging. *J. Food Technol*., **3**: 242-246.

Sen, S. K., Roy, A. and Bose. T. K. (1980). Pineapple production and utilization. Jaydebpur University. Calcutta. pp. 13-23.

Sudha, R., Amutha, R., Muthulaksmi, S., Indira, K. and Mareeswari, R. (2007). Influence of pre and post harvest chemical treatments on physical characteristics of sapota. *Res. J. Agri. Bio. Sci*,. **3**: 450-452.

Tabasum, A., Goud, C. R., Joshi, V., Kumari, D. A. and Bhagwan, A. (2019). Effect of post harvest treatments on the shelf life and quality of guava (*Psidium guajava* (L.)) cv. Allahabad Safeda. *Int. J. Curr. Microbiol. App. Sci*., **8**(1): 2686-2697.

Teisson, C., Combres, J. C., Martin-Pervel, P. and Marchal, J. (1979). Internal browning of pineapple: 11-symptoms, iv-biochemical approach. *Fruits*., **34**(5): 315-338.

Uddin, M. N. and Hossain, A. K. M. A. (2000). Study on the storage of pineapple. *Bangladesh Hort.,* **21**(2): 7-12.

Wijesinghe, W. A. J. P. and Sarananda, K. H. (2002). Post harvest quality of 'Mauritius' pineapple and reasons for reduced quality. *Inter. J. Trop. Agri. Res. Exten.,* **5**: 53-56.

Wills, R. B. H., Bembridge, P. A. and Scott, K. J. (1980). Use of flesh firmness and other objective tests to determine consumer acceptability of delicious apples. *Australian J. Experi. Agri. Ani. Husb.,* **20**: 252-56.

APPENDICES

Appendix I: Average room temperature and relative humidity during the experimental period from 08 January to 26 January 2020

Days	Room temperature (^{0}C)		Relative humidity (%)
	Maximum	Minimum	
08 January 2020	25.4	22.5	68
09 January 2020	25.2	22.3	68
10 January 2020	25.7	23.0	67
11 January 2020	26.0	23.3	62
12 January 2020	25.8	22.9	63
13 January 2020	25.5	22.5	65
14 January 2020	25.1	22.0	64
15 January 2020	24.7	22.0	61
16 January 2020	24.4	22.0	63
17 January 2020	25.0	22.6	60
18 January 2020	25.4	22.8	60
19 January 2020	25.6	22.8	62
20 January 2020	25.8	22.8	65
21 January 2020	25.6	22.6	65
22 January 2020	26.0	22.8	66
23 January 2020	25.8	22.6	69
24 January 2020	25.8	22.8	70
25 January 2020	25.8	22.8	68
26 January 2020	22.5	22.4	66

Appendix II: Analysis of variance of the data on weight loss (%) of pineapple as influenced by different postharvest treatment

At 3 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	61.130	7.641	205.084	0.0000
Within	18	0.671	0.037		
Total	26	61.801			
At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	82.454	10.307	671.371	0.0000
Within	18	0.276	0.015		
Total	26	82.731			
At 9 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	77.407	9.676	868.806	0.0000
Within	18	0.200	0.011		
Total	26	77.608			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	108.587	13.573	397.398	0.0000
Within	18	0.615	0.034		
Total	26	109.202			

Appendix III: Analysis of variance of the data on length decrease (%) of pineapple as influenced by different postharvest treatment

At 3 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	29.992	3.749	308.421	0.0000
Within	18	0.219	0.012		
Total	26	30.211			
At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	54.566	6.821	621.321	0.0000
Within	18	0.198	0.011		
Total	26	54.763			
At 9 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	42.783	5.348	356.529	0.0000
Within	18	0.270	0.015		
Total	26	43.053			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	42.595	5.324	368.893	0.0000
Within	18	0.260	0.014		
Total	26	42.855			

Appendix VI: Analysis of variance of the data on diameter decrease (%) of pineapple as influenced by different postharvest treatment

At 3 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	36.321	4.540	532.747	0.0000
Within	18	0.153	0.009		
Total	26	36.475			
At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	28.880	3.610	466.135	0.0000
Within	18	0.139	0.008		
Total	26	29.019			
At 9 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	39.596	4.950	859.398	0.0000
Within	18	0.104	0.006		
Total	26	39.700			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	40.372	5.047	757.398	0.0000
Within	18	0.120	0.007		
Total	26	40.492			

Appendix V: Analysis of variance of the data on juice content of pineapple as influenced by different postharvest treatment

At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	23.592	2.949	9.791	0.0000
Within	18	5.422	0.301		
Total	26	29.014			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	22.350	2.794	153.597	0.0000
Within	18	0.327	0.018		
Total	26	22.677			

Appendix VI: Analysis of variance of the data on total sugar content of pineapple as influenced by different postharvest treatment

At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	15.124	1.891	14.850	0.0000
Within	18	2.292	0.127		
Total	26	17.416			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	39.792	4.974	58.208	0.0000
Within	18	1.538	0.085		
Total	26	41.330			

Appendix VII: Analysis of variance of the data on ascorbic acid content of pineapple as influenced by different postharvest treatment

At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	196.406	24.551	1453.664	0.0000
Within	18	0.304	0.017		
Total	26	196.710			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	237.318	29.665	2742.041	0.0000
Within	18	0.195	0.011		
Total	26	237.513			

Appendix VIII: Analysis of variance of the data on total soluble solid content of pineapple as influenced by different postharvest treatment

At 6 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	23.592	2.949	9.791	0.0000
Within	18	5.422	0.301		
Total	26	29.014			
At 12 DAS					
Sources of variances	**df**	**SS**	**MS**	**F**	**P**
Between	8	22.350	2.794	153.597	0.0000
Within	18	0.327	0.018		
Total	26	22.677			

Plate:

Pineapple after three days of storage

Pineapple after six days of storage

Pineapple after nine days of storage

Pineapple after twelve days of storage

Pineapple after fifteen days of storage

Plate 1: Pineapple after different days of storage

Plate 2: Data collection