# PHYSIOLOGICAL CHANGES AND SHELF LIFE OF MANGO INFLUENCED BY PREHARVEST BAGGING AND VARIOUS POSTHARVEST TREATMENTS

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*Dedicated to*

*My sister*

*Tohfa Kabir,*

*the person who cares for me the most in this world*

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## *CERTIFICATE*

*This is to certify that the thesis entitled* ***"PHYSIOLOGICAL CHANGES AND SHELF LIFE OF MANGO INFLUENCED BY PREHARVEST BAGGING AND VARIOUS POSTHARVEST TREATMENTS"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***HORTICULTURE,*** *embodies the results of a piece of bona fide research work carried out by* ***NAHIDA KABIR,*** *Registration. No.* ***16-07543*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

*I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.*

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## ABSTRACT

The experiment was carried out at the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka. The experiment was laid out in a Completely Randomized Design with three replications. The present research was conducted on the aspect of shelf life and quality of mango through pre-harvest bagging, ten postharvest treatments and two postharvest bagging. Two pre-harvest bagging namely, B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging were assigned to different post-harvest treatments, e.g. $T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin and postharvest bagging P: Post-harvest bagging and $P_0$: Without Post-harvest bagging were used in the present study. Results revealed that the lowest disease incidence (9.6%, 16.55% and 22.85%) was found in pre-harvest bagging mangoes when treated with Bavistin and hot water dips ($BT_3$) at 9th, 12th and 15th days after harvest respectively where the longest shelf life was observed in BP treatment combinations. The best performance was observed in mangoes when treated with pre-harvest bagging, postharvest hot water and bavistin dips and postharvest bagging with perforated poly bags for long term storage quality control, transportation and marketing.

## LIST OF CONTENTS

## LIST OF CONTENTS (Contd.)

## LIST OF TABLES

## LIST OF TABLES (Contd.)

## LIST OF TABLES (Contd.)

## LIST OF FIGURES

## LIST OF FIGURES (Contd.)

## LIST OF PLATES

## LIST OF APPENDICES

## LIST OF ACRONYMS

| | | |
|---|---|---|
| BARI | = | Bangladesh Agricultural Research Institute |
| $^0$C | = | Degree Centigrade |
| DAH | = | Days after harvest |
| *et al.* | = | and others (*at elli*) |
| Kg | = | Kilogram |
| Kg/ha | = | Kg/hector |
| CRD | = | Completely Randomized Design |
| LSD | = | Least Significant Difference |
| $P^H$ | = | Fertilizer Recommendation Guide |
| LER | = | Land Equivalent Ratio |
| LSD | = | Least Significant Difference |
| $P^H$ | = | Hydrogen ion conc. |
| % | = | Percent |
| DMRT | = | Duncan's Multiple Range Test |
| LDP | = | Low Density Polybag |

# CHAPTER I

# INTRODUCTION

Mango (*Mangifera indica* L.) from Anacardiaceae family, is recognized as one of the choicest and is well accepted fruit all over the world and also acknowledged as the king of fruit (Shahjahan *et al*., 1994). In Bangladesh mango is considered to be the best of all indigenous fruits because of its excellent flavour, attractive fragrance, beautiful shades of color, delicious taste and nutritional value. Mango is native to South Asia, from where it has been distributed worldwide to become the most cultivated fruits in the tropics. Mango has been cultivated for more than 4000 years (Candole, 1984). It is commercially grown in more than 40 countries. Asia accounts for approximately 77% of global mango production and the America and Africa accounts for approximately 13% and 9%, respectively. It grows in native to South-East Asia and consists of 62 species (Anonymous, 2013). The Mango of Rajshahi and Chapai Nawabgonj is popular in home and abroad. The main mango producing countries of the world are India, Pakistan, Mexico, Brazil, Haiti, Philippines etc. India is the largest mango producer country who alone can produce 9.30 million tons followed by Brazil, Pakistan, Mexico, Philippines, Indonesia, Haiti, China, Bangladesh, Egypt, Sudan, Srilanka and Cuba (Bhuyan, 1995).

Its food value is greatly dependent on its chemical composition, such as dry matter, titrable acidity, total sugar, total soluble solid and ascorbic acid which facilitates development of postharvest quality, intrinsic quality such as flavor and taste, transportability and processing. Besides, mango contains appreciable quantity of provitamin A, vitamin C and soluble sugar. The unripe fruits contain nearly 50% more vitamin C than the ripe ones and in mineral content, mango holds an average position among fruits and in containing iron, unripe mango is the first than ripe fruit, about the 16th position among all major fruits (Salunkhe and Desai, 1984).

The postharvest loss in terms of quality and quantity of fruits occur all stages in the postharvest system from harvesting to consumption. Mango showed highly prominent postharvest loss because of its high perishability and climacteric pattern of respiration. There are a number of fungi (*Colletotrium gloeosporoides, Botryodiplodia theobromae* etc.) attack mango fruits at maturity after collection from tree. These fungi cause infection during storage and transfer, and losses sustained due to fungal infections during those periods are quite heavy. Srinivas *et al.,* (2002) reported that the total postharvest losses of mango to be 17.9% (3.5% Orchard field), 4:9% transportation, 4.1% storage and 5.4% retail level and 14.4% (1.9% Orchard 3.7% transportation, 3.7% storage and 5.3% retail level) respectively. Therefore, a critical area of examination would be how to reduce these postharvest losses in mango and other fresh fruits and to make a better situation of food balance in Bangladesh.

The fruit may require 3-9 days to ripen and this short period seriously limits its commercialization in distant markets. A major and often neglected problem to greater volume of nutritious food is to prevent the losses between the time of harvesting and consumption. Mango fruit has poor storage qualities and technologies for long term storage such as controlled or modified atmosphere have not been applied successfully to this fruit.

The losses occur all along the value chain, beginning from the time of harvesting right up to packaging, storage, transportation, retailing and consumption. As a result of postharvest losses of fruits the nutritional status of the population and the economy of developing countries are deeply affected.

With conceiving the above scheme in mind, the present research work was undertaken in order to fulfilling the following objectives:

i. To identify the impacts of different bagging systems on physiological changes and shelf life of mango.
ii. To identify the impacts of different postharvest treatments on physiological changes and shelf life of mango.

# CHAPTER II

# REVIEW OF LITERATURE

In Bangladesh, the fruit begin to ripen in May and the peak ripening months are June and July. From the end of July the yield of the fruit decreases and at August the mango season ends. Producers incur losses of the fruit at harvesting and distribution is due to short shelf life of the fruit. To minimize the losses, it is important to find methods of preserving the fruit or postharvest treatment which can be a way to delay the ripening. The purpose of the present study was to find out the most suitable postharvest treatments for preservation of mango by using available resources.

The mango enjoys wide popularity among millions of people all over the world and has received much attention to the researchers. A large number of research works on shelf life and quality as influenced by different postharvest treatments has been extensively investigated by a number of scientists in different parts of the world. Storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distances. The mature green fruits can be kept at room temperature for about 4 to10 days depending upon the variety. Shelf life of fruits could be extended by pre-cooling, chemical treatments, low temperature, etc. The harvested fruits are pre-cooled to 10 to 12$^{o}$C and then stored at an appropriate temperature. The fruits could be stored for 3 to 4 weeks in good condition at low temperature. It is a general practice to harvest fruits early in the season (premature stage) to capture early market. Mature fruits can similarly be ripened with lower doses of ethrel for uniform color development. Green mangoes, harvested in India for commercial preparation of chutneys and pickles as well as for table use, are stored for as long as 40 days at 5.6 to 7.2$^{o}$C with relative humidity of 85 to 99 percent. Some of these may be diverted for table use after 2 week ripening period at 16.7 to 18.1°C (Median, 2002).

The present study can be divided into two categories in case of post-harvest of mango storage operation viz. mechanical process and chemical process. Some of the available research findings pertaining to the present study have been reviewed and presented below under the following heads:

## 2.1 Non-chemical/mechanical treatment

### 2.1.1 Pre-harvest bagging

Literature is not available that deals with preharvest fruit bagging in mango. However, An investigation was undertaken by Haldankar et al. (2015) in 2013 and 2014 for two consecutive fruiting seasons entitled studies on influence of bagging of fruits at marble stage on quality of mango cv. Alphonso. The fruits were bagged at marble stage (30 days from fruit set) with different types of bags which constituted the various treatments *viz*: T1: Newspaper bag; T2: Brown paper bag; T3: Scurting bag; T4: Polythene bag; T5: Butter paper bag; T6: Muslin cloth bag; T7: Brown paper bag with polythene coating; T8: control (no bagging). Bagging with newspaper bag and brown paper bag improved fruit retention, weight of fruit, diameter of fruit, pulp weight, total soluble solids and reducing sugars at ripe stage and produced spongy tissue free fruits. The brown paper bag with polythene coating improved fruit retention, weight of fruit, pulp weight and decreased occurrence of spongy tissue and incidence of mealy bag. The butter paper bag, muslin cloth bag and scurting bag improved fruit retention, reduced occurrence of spongy tissue and incidence of mealy bag. Preharvest bagging with different types of bag did not change the sensory qualities of ripe fruits mango cv. Alphonso.

An experiment was conducted by Sarker et al. (2009) where Different bagging materials (black polybag, transparent polybag, brown paper bag) were evaluated for the control of mango fruit fly attacking Langra and Khirshapat variety at the mango orchards of Mango Research Station and Lac Research Station, Chapai Nawabganj during May to June 2001 and 2003.

Though all bagging materials gave 100% protection of mango fruits against the fruit fly infestation, bagging of fruits with brown paper bag was found to be the best in protecting mango fruits and provides almost similar % total soluble solid (TSS) and physical fruit quality (expressed by % black spots) in bagged fruits when compared with the un-bagged healthy fruits of the control treatment.

### 2.1.2 Hot water treatment

Benitez et al. (2006) conducted an experiment on mango cv. Namdokmai' where fruits were treated in hot water at 55°C for 5 minutes. They observed that hot water treated fruits remarkably delayed the onset of disease infection, reduced the number of infected fruits and lowered the severity of infection. They reported that hot water treated fruits showed lower disease severity than untreated fruits during storage.

Hu et al. (2005) carried out an experiment on mango where fruits were kept in hot water at 52 to55°C for 10 minutes. They observed that hot water treated fruits made peel coloration uniform, improved quality and prolonged fruit storage, but could not inhibit fruit ripeness and reduce weight loss due to increased respiration.

Zhu et al. (2002) recommended hot water treatment as commercial postharvest technology of mango. They observed that hot water treatment made the color of both peel and pulp homogenous. The soluble solids content and pH values were very high in hot water treated fruits than those of non-hot treated fruits. Another experiment was carried out by Rosa (2002) on mangoes (cv. Keitt) where fruits were treated with hot water (50°C for 10 minutes). The results showed that hot water treatment had a bad effect on firmness and colour.

Feng et al. (1991) conducted an experiment on mango cv. 'Kensington Pride' where mangoes were treated in hot water at 46-480C for 10 minutes.

They observed that hot water treated fruits reliably increased respiration rate, ethylene production, physiological weight loss, total soluble solids during storage.

Manzano et al. (1997) experimented to find out an efficient handling method for mango cultivars 'Arumanis and Manalagi' by using different treatments viz. (i) fruits packed using carton boxes with Wit cells, (ii) fruits washed with 75 ppm chlorine, dipped in hot water (53°C) for 5 minutes, packed in boxes with fruitcells or fruit nets, (iii) fruits were washed with fruit cells or fruit nets: Results showed that there were no significant differences in physical and chemical characteristics among the three treatments but treatment (ii) showed longer storage life than other treatments.

Gofur et al. (1997) stated that the shelf life of mango fruit without applying any treatment was short because fruits exhibited a rapid rate of ripening. But the mango fruits treated with hot water at 52±2°C for 5 minutes containing 1% $CaCl_2$ delayed ripening by 5 to 8 days and their spoilage was reduced.

Johnson et al. (1994) suggested that heating of fruit at temperature of 52°C for 5 minutes followed by benomyl dip or 30 second unheated overhead spray of prochloraze gave rise to best control of anthracnose disease in mango. Hot water treatment at 47°C temperature for 7.5 to 30 minutes shortened fruit softening and caused extensive external and internal injury as reported by Jacobi and Wang (1992). Joseph and Awrof (1992) observed that mature green mango fruits dipped in hot water at 55°C delayed ripening, controlled decay, minimized weight loss and extend shelf life of fruits without any adverse effects.

Feng et al. (1991) reported that hot water treatment of mature hard mango fruits at 52 to 54°C temperature for 8 to 10 minutes controlled mango anthracnose disease during storage and. prolonged shelf life.

Jhonson et al. (1990) observed that immersion of mango cv. 'Kingston Pride' in hot water at 52°C for 5 minutes provided good control of stem end rot of mangoes during storage for 14 days at 25 to 30°C temperature.

### 2.1.3 Postharvest bagging

Fawaz (2006) conducted an experiment on mango cv. `Bullock's heart' where fruits were individually wrapped in low density polyethylene film before packing them in one layer in carton boxes. They reported that individual wrapping of fruits in low density, polyethylene film has the highest carotene content and the lowest weight loss.

A study on mango was carried out by Mortuza et al. (2002) where fruits were wrapped with polyethylene bag, newspaper or tissue paper and packed in wooden box, bamboo basket and hard paper carton. He observed that polyethylene bag wrapping caused maximum reduction in incidence of anthracnose (*Colletotrichum gloeosporioides*) which was followed by newspaper, arid tissue paper. Polyethylene wrapping delayed ripening considerably.

The qualities of mango fruits were investigated by Srinivasa et al. (2002) on modified atmosphere packaging. On the other hand fruits stored in plastic film covered boxes showed an extension of shelf life up to 19 days and without any microbial growth and off flavor.

An experiment was carried out by Alves et al. (1998) on mango cv. `Tommy and Atkins' where fruits were stored in a modified atmosphere (MA) obtained by packing the fruits in a low density polythene bag. They observed that NIA stored fruits showed delayed ripening but these fruits developed off flavors, did not develop sweetness and remain more acid than control fruits when held under ambient conditions.

Fruits stored in polythene bags resulted in increased respiration and earlier fruits rotten worked with mango fruit cv. `Keitt' and found lower loss of fruit packed in both heat shrinkable polythene film (D-955) arid a low density polythene film (LDPF) for 0 to 5 weeks at 20°C temperature' Bagging reduced postharvest diseases of mango and increased skin color at the ripe stage.

The intensity of red colour decreased with the increasing duration of bagging (Hofinan et al.; 1997).

Shrivarma and Thimmaraju (1989) conducted an experiment with mango cv. ‘Alphonso’ and reported that fruits stored in perforated polythene bags had the lowest weight loss and spoilage during storage and ripening. Another experiment was conducted on mango cv. ‘Alphonso’ and observed that fruits stored in perforated polythene bags had the lowest weight loss and spoilage during storage and ripening.

## 2.2 Chemical treatment

### 2.2.1 Bavistin

An investigation was carried out by Islam et al. (2016) with the postharvest mangoes (viz. Langra and Khirshapat) treating with different levels of Bavistin DF solution (namely, 250, 500, and 750 PPM ) for obtaining results on the reduction of postharvest losses, pattern of physical, biochemical changes as well as storability of postharvest mango. The Khirshapat along with Bavistin DF at 750 PPM performed better in retardation of rapid augmentation of these compositions resulting in prolongation of shelf life. Langra using 750 ppm of Bavistin DF was found to be excellent in lower diminishing tendency in terms of dry matter, ash and vitamin C.

Waskar and Gaikwad (2005) undertaken an experiment to study the effect of various postharvest treatments on extension of shelf-life of Kesar mango fruits.

For this purpose, the mango fruits were harvested at proper stage of maturity and subjected to various postharvest dip treatments such as calcium chloride (2%), waxing (6%) and fungicides *viz.,* Bavistin (0.1%) and Captan (0.2%) either alone or in combination. The mango fruits were then packed in corrugated fibre board box and stored in three storage environments viz., at room temperature (28.12 to 36.18°C temperature and 46.18 to 71.25 % RH), in cool chamber (21.47 to 27.10°C temperature and 91 to 95 % RH) and cool store (10"C temperature and 90 to 95 % RH). It was found that the shelf life of mango fruits couId be extended upto 65 days when treated with a Ifombination of CaCI2 (2 %) + wax (6 %) + Bavistin (0.1 %) and stored in cool store, upto 35 days when stored in cool chamber and upto 24 days when stored at room temperature. On the contrary, the shelf life of untreated fruit was found to be hardly 18 days at room temperature. It was also observed that this treatment recorded lower physiological loss in weight and high organoleptic score when stored In cool store and cool chamber as compared to room temperature storage. The untreated (control) fruits were found to be infected with *Colletotrlchum gloeosporioides, Diploidia nataIensis* and *Rhizopus* sp.

### 2.2.2 Calcium chloride

In recent years, significant advances have been made in fruit storage by the use of Calcium Chloride dipping alone or combined with other treatments. Therefore, in present study different concentrations of Calcium chloride salts were used to ascertain their effects on delaying the ripening and eating quality of mango fruits. Due to perishability, farmers are losing a bulk of produce each year. Calcium is relatively divalent action that readily enters the apoplast and is bound in exchangeable from to cell wall and exterior surface of plasma membrane. Nontoxic even at high concentrations it serves as a detoxifying agent. In the cell walls calcium serves as a binding agent in the form of calcium pectates.

Calcium has received considerable attention in recent years due to its desirable effects; particularly it can delay ripening and senescence, reduce respiration, extend shelf life and reduce the physiological disorders (Sharma et al. 1996).

Postharvest quality of a product after harvest can be improved; it is possible to reduce the rate of quality loss. Surface treatments delay physiological decay in fruit tissues, stabilize the fruit surface and prevent degradation that affect the ($Ca_2^+$) has been extensively reviewed as both an essential element and its potential role in maintaining postharvest quality of fruit and vegetable crops. The role of calcium in stabilizing cellular membranes and delaying senescence in horticultural crops is well known (Poovaiah et. al., 1988). Dhillon and Sukhjit Kaur (2013) conducted an experiment to assess the effect of postharvest application of Calcium Chloride on the storage life of mango (*Mangifera indica* L.) var. Dushehari fruits. The fully mature mango fruits were harvested and treated with different concentrations of $CaCl_2$ viz. 0%, 2%, 4%, 6% and 8% and stored for different days viz. 3, 6, 9, and 12 days at room temperature. The results showed that postharvest application of Calcium Chloride (6%) had proved quite effective in enhancing the shelf life of Dushehari mango fruits up to 12 days at room temperature.

The role of calcium in the physiology of plant tissue is well established (Chaplin and Scott, 1980). In addition to its involvement in cell wall membrane and chromosome, metabolism it contributes to the maintenance of configuration of specific enzymes (Jones and Lunt, 1967). Addition of calcium improves rigidity of cell walls and obstruct enzymes such as polygalcturonase from reaching their active sites (John, 1987), thereby retarding tissue softening and delaying ripening. Calcium inhibits the ripening of tomato and pineapples (Goncalves et al., 2000 and Wills et al., 1977). Its role in physiological disorders is related to shelf life, ripening and fruit quality (Wilnwright and Burbage, 1989).

Calcium as postharvest treatment has been used as firming agents to extend postharvest shelf life in whole and fresh cut fruits. Rosen and Kader (1989) found that $CaCl_2$ treated strawberries by dipping resulted in higher calcium content and were firmer than water dipped. Agar et al. (1999) also found $CaCl_2$ maintained the firmness throughout storage for kiwifruits dipped in 0.5 or 1% $CaCl_2$. It was also reported that the rate of fruit softening depends on fruit calcium status.

Postharvest calcium dips can increase calcium content considerably compared to pre-harvest sprays, without causing fruit injury, depending on salt type and calcium concentration. Postharvest calcium application maintains cell turgor, membrane integrity, tissue firmness and delays membrane lipid catabolism thus extending storage life of fresh fruits (Chaplin and Scott, 1980 and Picchion et al., 1998).

Most early workers applied calcium by dipping fruits in solutions of calcium salts, but more recent works have shown that vacuum infiltration of these solutions may be a more effective method of getting calcium into the fruits (Lara et al., 2004 and Saftner et al., 1998). Infiltrated solutions also retain much of their effectiveness when the fruits are rinsed with water following treatment to reduce the possibility of injury to the fruit or damage (Scott and Wills, 1979). Although most efforts in treating fruit with calcium solutions have been directed towards reducing losses due to physiological disorders, it has been reported that increased calcium content of fruit may also reduce losses due to decay causing organisms (Lara et al., 2004).

In India, few researches have been done on papaya using calcium dip application on storage life and some aspects of quality. There was positive effects on prolonging storage life and maintained the quality aspects using dip treatment (Krishna and Purushotham, 2005 and Rajkumar and Manivannan, 2005).

Mahmud et al. (2008) conducted an experiment with papaya (*Carica Papaya* L.) fruits index 2 were treated with 1.5%, 2.5% and 3.5% solutions of calcium chloride by dipping and vacuum infiltration (-33 Kpa) or untreated (0%) as control. Effects of these treatments were evaluated on storage life and postharvest quality characteristics of papaya. After 21 days of storage at 13±1°C, the fruits were removed from storage for physicochemical analysis. Following additional five days holding in the storage condition for fruits used for evaluation of the rate of disease incidence and storage life. Postharvest dip treatments at different concentrations of calcium prolonged storage life, slowed down the ripening processes and maintained the quality of papaya.

Whereas, it was effectively greater with calcium infiltration treatments than that of dip treatments. Calcium infiltration extended the storage life and retained the quality as calcium concentrations increased up to 2.5% and then declined. The desired effect was obtained at 2.5% infiltration compared with other treatments. The least disease incidence was found in those fruits infiltrated with 2.5% calcium. Hence, it can be concluded that postharvest infiltration of calcium at 2.5% has the potential to control disease incidence, prolong the storage life and preserve valuable attributes of postharvest papaya, presumably because of its effects on inhibition of ripening and senescence process and loss of the fruit firmness of papaya.

Calcium carbide has been frequently used since long times to enhance ripening process of mango fruits (Paj, 1998). The calcium salts in different concentrations have either been used as pre-harvest sprays or infiltrated into harvested fruits, while some workers treated the harvested fruits by immersing in calcium solution for varying times. Three fortnightly sprays of 1% calcium nitrate, commencing 6-8 weeks before harvesting, delayed colour change and ripening in storage (Sive and Resnizky 1985).

Wills et al. (1988) dipped mature fruits of 3 mango cultivars in 4% (w/v) Ca solution under sub-atmospheric pressure ranging from 20-80 kpa (cv. Cengkir) or 20–100 kpa (cvs. Arumanis and Gedong) for 4.5 min. and stored at 23$^{o}$C. Colour changes were delayed by 1 – 2 days in fruits dipped in Ca at 20 and 40 kpa. In another study, mature green mango cv. Kensington Pride fruits were infiltrated with 2%, 4%, 6% and 8% calcium chloride solution under a positive pressure of 115 kpa for 2 min or in an artificial vacuum of 32 kpa. After treatment, fruits were stored at 20$^{o}$C in boxes lined and covered with polyethylene film. Pressure and vacuum infiltration with $CaCl_2$ delayed fruit ripening by approximately 12 and 8 days respectively, compared with fruits infiltrated with water. Few differences in the effects of different $CaCl_2$ concentrations on ripening were also observed (Yuen et al. 1993).

Mango (cvs. Manila and Tommy Atkins) fruits were stored at 4 or 8oC, 85% RH for 7 or 25 days. Half of the fruits were dipped in 5% $CaCl_2$ for 10 min. prior to storage. The fruits were ripened at ambient temperature (20$^{o}$C) after storage.

$CaCl_2$ at 2% in the fungicide dip raised the Ca level and delayed ripening (Sive and Resnizky 1985). Hot water treatment containing 1% $CaCl_2$ has been found the most effective treatment to retard ripening and spoilage of mango fruits (cvs. Fazli and Ashwina). Ripening was delayed by 5-8 days (Gofure et al. 1997).

Calcium ammonium nitrate application did not increase shelf-life of mango fruits when immersed for 90 min in 0.2 or 4% solution. However, the external appearance of the fruits was better at a concentration of 4% but this did not guarantee export quality (Freire and Chitarra 1999). These results seem to be quite confusing. Therefore, in the present study different concentration of various calcium salts (i.e. calcium chloride, calcium sulphate and calcium ammonium nitrate) were used to ascertain their effects on delaying the ripening and eating quality of mango fruits.

Anjum and Ali (2004) conducted an experiment with green mature fruits of mango cv. SS-1 (Kala Chaunsa) were immersed for 10 minutes in 2.5%, 5.0% or 7.5% calcium chloride ($CaCl_2.2H_2O$), calcium sulphate ($CaSO_4.2H_2O$) or calcium ammonium nitrate $\{Ca(NH_4NO_3)_2\}$ solutions. A control was also included in which fruits were dipped in fresh water for 10 minutes. The fruits were ripened at ambient temperature ($25\pm3^oC$) in boxes lined and covered with newspaper. Calcium chloride delayed the fruit ripening about 3 days as compared to control and resulted in better aroma of the fruits, however, it induced skin shrivelling. Calcium sulphate treatments resulted in improved pulp colour. The increase in concentration of calcium salts resulted in delayed ripening but had negative effect on fruit quality by increasing skin shriveling and lowering flavour and taste of the fruits.

Calcium chloride at 5.0% delayed the ripening for 4 days and resulted in better skin and pulp colour but with increased skin shriveling and poor flavour and taste, indicating poor eating quality.

The method of Esguerra and Bautista (1984) is often applied where the mangoesare submersed in a cold calcium chloride solution for 2 hours after harvest. In studies of 'Julie' (Mootoo, 1991) and 'Willard' (Suntharalingam, 1996) mangoes, treatments of 4% to 6% calcium chloride extended the shelf-life of the fruit by 5 to 7 days. Both Tirmazi and Wills (1981) and Suntharalingam (1996) observed skin injury to 'Kensington Pride'and 'Willard' mangoes, respectively, when treated with 8% calcium chloride solutions.

## 2.3 Different changes during storage

### 2.3.1 Color development and ripening of fruit

Color is an important mango quality characteristic. For the consumer color development is an important indicator for ripening of mango for edible purpose. Some more information on change in color is cited below -

Jayawickrama et al. (2006) conducted an experiment to find out the effect of ethrel on papaya ripening. They observed that fruits at ambient temperature (28±1°C) took 7 days to ripe, but on the other hand when the fruits were treated with ethrel solution (250 ppm) under similar condition it was found to ripen in 4 days.

Kumar and Dhawan (1995) conducted an experiment with different concentrations of ethrel solution (250, 500, 1000 ppm) on mango fruit ripening. They found that the ripening rate progressively increased with the increase in concentration.

Gonzalez *et al.* (1990) performed an experiment with hot water treatment at 46°C for 0, 60 and 90 minutes and evaluated after 7, 14 and 21 days. They observed that hot water treatment increased the speed of ripening but did not cause injuries in keitt mangoes.

In Sydney Postharvest Laboratory, Kumar and Dhawan (1995) showed that the concentration of ethylene required for the ripening of different products varies. The concentration applied is within the range of 1 and 100 ppm. The time and temperature of treatment also influences the rate of ripening with fruit being ripened at temperatures 15 to 21 °C and relative humidity of 85 to 90%.

An experiment was conducted by Kumar and Dhawan (1995) to study the effect of postharvest treatment on the enhancement of ripening of mango fruit (cv. Dashchari).

Fruits were harvested at the green mature stage and were treated with hot water (50°C ± 5°C for 10 minutes).

Fruits were then packed in cardboard boxes that are stored at room temperature. Data revealed that fruits treated with hot water maintained good texture that is color even up to 8 days of storage.

Experiments with ethrel (ethylene releasing chemical) on different cultivars of banana have indicated that 100 to 250 ppm of ethrel is required to get optimum qualities in the ripe banana fruit (Krishnamurthy, 1993).

### 2.3.2 Total weight loss

Weight loss reduced when mango fruits were stored in polythene bag as reported by Wavhal and Athale (1989), Shrivarma and Thimmaraju (1989). Gonzalez (1990) also reported that modified atmosphere packaging with polythene bags were delayed ripening and reduced weight loss. Manzano et al. (1997) observed that 6.2 percent fresh weight loss of mango occurred when stored at 25°C temperature for 20 days. Reddy and Haripriya (2002) reported that mango fruits treated with GA3 and stored in polythene bags with ethylene absorbent significantly reduced physiological' weight loss. Physiological weight loss were reduced in mango fruits cv. 'Kensington pride' which were wrapped with polythene bags and stored in 13°C (Zora, 2001).

### 2.3.3 Moisture content

Srivastava (1967) reported that the green mango contained higher percentage of moisture as compared to ripe mangoes. Shahajahan (1994) reported that the moisture content of pulp of mature hard 'Fazli' mango was 79.95% but found it as 91% and in ripe mango 78-86%. Salunkhe and Desai (1984) observed that mango pulp contain 81% moisture.

Absar et al. (1993) reported that moisture content at the early stage of development varied from 87.4% to 90.1%, gradually decreased as the maturity advanced and at ripening stage it varied from 71.22 to 79.4%.

They also observed that the decreasing tendency of moisture content with the advancement of maturity of varieties Gopalbagh (82.13 to 79.23%), Khirsapat (82.1 to 79.25%), Langra (81.75 to 78.29%) and Fazli (82.30 to 79.95%).

Mollah and Siddique (1973) conducted an experiment with 12 varieties of mango and found that moisture content of the pulp of all the varieties of mango ranged from 81.03 to 87.12%. They also studied the fruits of ten varieties of mango. The moisture percentage was the highest (87.55) in Ranibhog whereas it was the lowest (78.96%) in Misribhog. This trait for the different varieties under consideration ranged from 78.96 to 87.55%.

### 2.3.4 Dry matter content

Literature is not available that deals with the changes in dry matter content of mango fruits during storage: However, Paramanik (1995) found that the dry matter content in Fazli increase from 17.14 to 28.86% during storage of ambient temperature. It is also evident that as ripening progress some carbohydrate is completely oxidized to $CO_2$ and as a result of respiration (Palmer, 1971). This indicated an actual decrease in dry matter content.

### Disease incidence and severity on shelf life and quality of mango

Hofinan et al. (1997) examined that the treated fruits performed less disease incidence compared to without treated fruits. Non-treated fruits were attacked by the sunken black spots on the surface of the fruits as well as anthracnose (*Colletotrichum gloeosporioides*). In case of packaging technique, fruits packed in different packaging materials (like corrugated fiber board carton, plastic crate, perforate and nonperforated polyethylene bag) had the maximum shelf life, lower physiological loss in weight and less disease incidence than without package.

Among the different packaging materials, fruits packed in corrugated fiber board carton had the maximum shelf life (13.02 days), lower physiological loss in weight (4.11%) and less disease incidence (1.12%) without excessive deterioration compared to others.

The shelf life of mango could be extended up to 5 days by hot water treatment and packed in corrugated fiber board carton compared to others. The color and quality of mango was very better in treated fruits compared to non-treated fruits. Hofinan et al. (1999) observed that the effect of bagging of mango (*Mangifera indica* L.) fruit was evaluated in order to improve fruit quality of late maturing cultivars. Fruit calcium concentrations were reduced by bagging for 56 days or less in the 1994/1995 trial, but not by longer bagging times (82-131 days). Percent dry matter (% DM) was higher, and days to ripen shorter, in bagged fruit from one orchard during 1993/1994. Fruit-mass, flesh color, total soluble solids, acidity and eating quality were generally not affected by bagging. These results indicate that bagging can improve fruit quality through reduction in disease, and this benefit outweighs the negative effects of bagging on skin color in the 'Keitt' cultivar.

Absar et al. (1993) this study investigated treatment of mango (*Mangifera indica* L.) fruit with 2 host deference promoting compounds for suppression of anthracnose disease (*Colletotrichum gloeosporioides*). Cultivar 'Kensington Pride' fruit were treated at concentrations of up to 1000 mg/L with either potassium phosphonate or salicylic acid. Applications were by various combinations of pre and postharvest dips and vacuum infiltration.

The major causal agent for this group of rots varies among different production areas. One of the most destructive mango diseases is anthracnose, caused by *Colletotrichum gloeosporioides*, a fungal pathogen. It infects new flushes of leaves or may occur at the various stages of development from fruit set to maturity. The disease is common during wet season as it spreads and reproduces rapidly specially in warm areas. At present, pesticide is the most widely recommended and adopted method of controlling the pest.

However, the increasing concern on health and environment risks associated with pesticide use has led to the exploration of insecticidal properties of botanical pesticides. Hofinan et al. (1999) evaluated the efficacy of promising botanical materials against anthracnose of Hawaiian and native mango seedlings.

The botanical materials evaluated were neem (*Azadirachta indica* A. Juss), 'Malunggay' (*Moringa oleifera* L.), and garlic (*Allium sativum*). The effect of the botanical extracts was compared with those of untreated plants and fungicide-treated plants. The botanical plants were weighed and washed with 10% sodium hypoclorite for 5 minutes and rinsed thrice with distilled water. These were placed in Waring blender and for every kilogram of plant materials; 1 L of water was added until a homogenous mixture was attained. The crude extract was filtered using a clean muslin cloth. Ten healthy mango seedlings per treatment with three replications were assigned. Seedlings were sprayed with the appropriate treatments when they started to produce new leaves. Each seedling was sprayed with 40 ml botanical extract and for the fungicide; manufacturer's recommendation was followed using an atomizer.

**2.4 Postharvest physiochemical changes of mango**

The need to develop the best off vine mango ripening technique for both consumption and processing was investigated. Some physical and chemical measurements were performed on mature Green Dodo mangoes before and during a 3-day and 6-day ripening period by smoked pit ripening (SPR), ethylene (fruit generated) pit ripening (EPR), untreated pit ripening (UPR) and room temperature ripening (RTR) as a control method.

The postharvest ripening changes in the quality characteristic of ripe mangoes were correlated among treatments and compared with similar changes in other mango varieties. Changes such as formation of sugars, decreased acidity, and increased carotene reflected the most significant chemical changes in ripeness stage (Peter et al., 2007).

Fruit flesh taste is highly dependent on the balance between organic acids and soluble sugars, which are predominantly represented in mango by citric and malic acids, and sucrose, fructose and glucose, respectively (Medlicott and Thompson, 1985).

The patterns of these compounds during mango development and maturation are well described, even if many studies deal with the evolution of fruit flesh composition during ripening according to harvest date. To our knowledge, only a few results of pre harvest factor effects on mango taste have been reported.

Aina (1990) reported that the some physical and chemical measurements were applied to mature green African mango fruits (*Irvingia gabonensis Baill*) during a 7- day storage ripening period at tropical ambient conditions (27-30°C and 68- 70% relative humidity). Changes in fruit weight, texture and colour reflected the most significant chemical changes in the fruit such as starch degradation, formation of sugars and increase in total carotenoids. The postharvest ripening changes observed are discussed and compared with similar changes in other mango varieties.

From the above reviews, it is clear that quite large volumes of works have been done in different parts of the world. Different issues related to the physiochemical changes, shelf life extension, and diseases have been cited above. Similar reports are scanty in Bangladesh. Very little information is available in Bangladesh regarding to the use of botanical extracts as a postharvest treatment on physiochemical changes, shelf life and diseases during storage and ripening.

Hence, the present study attempts to investigate the physiochemical changes, shelf life and quality of bagging and non-bagging type of Langra variety using different promising postharvest treatments.

### 2.4.1 Vitamin C

Mango is a good source of vitamin C at early stages of development, which decreases rapidly 5-7 weeks after fruit set as reported by Gofur et al. (1994). They also reported that at 12 weeks after fruit set ascorbic acid content was 105.2, 65.7 and mg/100 g in Langra, Ashwini and Fazli varieties, respectively. They also reported that ascorbic acid decreased with increased of storage duration.

The green fruits stored at 10-12°C temperature for 7 weeks had little change on vitamin C content. Maximum portion vitamin C was lost when the fruits were stored at room temperature (20-30°C). In addition, reduction in vitamin C with progress of fruit maturity and ripening was found in cv. Gopalbhog', Khirshapat', Langra' and Fazli' described by Shahjahan et al. (I994).

There was a tendency for ascorbic acid content to be higher in cold storage. El and Ahmed (2001) noted that the lower the temperature the higher the vitamin C content. The same, fact also verified. They reported that higher ascorbic acid content was obtained in the mango fruits stored in cool chamber.

Mango contained considerable amount of ascorbic acid (Vitamin C) when it was green and tender, with a value as high as 348.5 mg per 100g of edible portion of mango pulp. In ripe fruit it was much lower. Ascorbic acid generally decreased during ripening. When they were overripe the percentage of ascorbic acid decreased progressively.

An experiment was conducted by Singh et al. (1993) with GA3 and ethrel and found to enhance the ripening and improve the quality of mango (cv.Amrapali).They found that ethrel at 500 ppm was very effective to improve the quality in terms of ascorbic acid content.

Reduction in ascorbic acid with advancement of maturity and ripening was observed in cv. Gopalbhog, Khirshapat, Langra and Fazli (Shahjahan et al. 1994).

Absar et al. (1993) studied ten varieties of mango at different stages of maturity. At ripe stage the highest vitamin C was obtained in Fonia (28.85) preceded by Ashwina (22.36), Langra (22.0), Fazli (20.40), Himsagar (15.24), Jalibanda (12.60), Kanchamitha (10.81), Khirsapat (10.65) and Gopalbhog (8.66 mg/l00g).

### 2.4.2 Vitamin A

Literature is not available that deals with vitamin A content in mango. However, The vitamin A content of the fresh fruits was determined by the extraction and quantitative determination of the pro-vitamin A carotenoid-β-carotene. The Retinol Equivalent (RE) was then obtained using standard conversion formula. The result indicated that the fruit with the minimum vitamin A content and percentage among the six samples was found in mango 301.61 ± 1.03 (7%), which was followed closely by watermelon 350.12 ± 19.01 (8%), guava 504.1 ± 0.75 (11%), tomato 542.86 ± 20.20 (12%), pawpaw 683.93 ± 5.15 (16%) (Aremu and Nweze, 2017).

### 2.4.3 Titratable acidity

Freshly harvested mango fruits (*Mangifera indica* cv. Nam Doc Mai), were heated at 38°C for 3 days or heated and then stored at 4°C for 3 weeks before ripening at 25°C, then compared with non-heated fruits for quality changes. When not refrigerated, heated and non-heated fruits ripened within 7 days to a comparable quality, although titratable acidity were remained higher in heated fruits. The peel of heated fruits was initially yellower in cold-stored fruits, and soluble solids content was initially greater, whereas firmness and titratable acidity were less than that of non-heated fruits during ripening at 25°C. After cold storage and ripening, heated fruits had a lower incidence of disease and developed less chilling injury than non-heated fruits.

Non-heated fruits stored at 4°C also developed off-flavor whereas the heated fruits did not. Heat treatment did not inhibit ripening Tripathi (1985).

Titratable acidity was declined slowly when mango fruits were stored at 13°C temperature. Similarly, Tripathi (1985) reported that titratable acidity decreased during storage in a refrigerated room. According to Hossain et al., (1999) titratable acidity was decreased during storage and ripening. Medlicott et al., also observed similar results. According to them acidity was reduced during later growth stage on attainment of maturity and ripening.

Shahjahan et al., (1994) revealed that acidity of mango was decreased gradually at the time of storage and ripening. Shahjahan et al., (1994) also performed an experiment to find out the effect of ethrel concentrations (250, 500, 1000, and 1500 ppm) on shelf life of mango. They reported that ethrel treatments significantly reduced the acid content compared to untreated fruits.

Jana et al. (1998) studied the 20 mango varieties of West Bengal, India and found that variety Daudia had the highest titrable acids (0.58%). They also carried out an experiment with 21 mango cultivars and chemical analysis was performed. They narrated that titrable acidity of mango varieties differed greatly. It was the maximum (0.59%) in Himsagar and the minimum (0.14%) in Jahangir.

### 2.4.4 Total soluble solids content

The soluble solids in mango flesh mainly consisted of sugars, soluble protein, starch, soluble pectin, organic acids, vitamin C etc. Studies on changes in most of these parameters have already been reviewed. Some more information on change in total soluble solid are cited below.

Nyanjage et al. (1998) observed that mango treated with hot water at 46.5°C for 45 minutes in combination with intermittent warming (34°C) during 12 days of cool storage (13°C) showed higher TSS and better general appearance than those of non-hot treated fruits. Singh (1998) carried out an experiment on mango cv.Amrapali' and found that TSS contents at mature and ripe stage were 8.12 and 20.05 percent respectively.

Hossain and Ahmed (1994) recorded 18.3% TSS in Aswina'. Absar et al. (1993) reported that the total soluble solid content was increased with maturity of fruit. They found that Langra' showed the highest (22.2%) and Fonia' the lowest (16.8%) TSS content at ripen stage.

Mollah and Siddique (1973) reported that Fazli' and Langra' showed to 14.8 % and 12.15 to 18.00 % TSS respectively. They also noticed that TSS varied from cultivar to cultivar.

Mollah and Siddique (1973) reported that TSS of mango cultivars Fazli and Langra were 7.70 to 14.8% and 12.15 to 18.00%, respectively. Popenoe (1964) made a report on the chemical composition of different varieties of mango and noted that TSS was more than 20%.

Mohamed and Abu-Goukh (2003) conducted an experiment with different concentrations of ethrel solution (250, 500, 1000 ppm) on mango fruit. They analyzed three varieties of mango for chemical composition and reported that ethrel treatments significantly increased TSS compared to untreated fruits.

Pinaki et al. (2002) conducted an experiment with hot water treatment and artificial ripening of mango. They observed that the differences between treated and controlled mangoes in taste and the appearance are large and TSS content is higher than the non-treated fruit.

Absar et al. (1993) reported that TSS in ripe stage of mango varieties ranged from 16.80-22.20%. They observed the highest TSS (22.2) in Langra, while Fonia the lowest (16.80%) one.

Increase in the percentage of total soluble solids during storage was recorded in mango (19.68) by Srivastava (1967). He found that total soluble solids increased while the acidity of the fruit generally decreased.

**Shelf life**

Romphophak et al. (2004) mentioned that the shelf life of mango determined by senescent peel spotting was 6 to 7 days in PVC packing compared with 3 to 4 days. Pinaki et al. (1997) found that matured banana fruits of uniform sites were dipped into gibberellic acid (GA3) at 150 ppm were most effective treatment for prolonging the shelf life of mango.

Kumar and Singh (1993) conducted an experiment with GA3and found that the quality and shelf life of mango cv. Amrapali were improved.

In a study Romphophak et al. (2004) determined the shelf life of banana by senescence peel spotting was 6-7 days in PVC packaging, compared with 3-4 days in the control. Packaging bananas with modified atmosphere (MA) using polythene bags (0.03) at 22°C was unsuitable for prolonging shelf life because it inhibited ripening and resulted in a flavor of fermentation.

Giami and Ali (1994) conducted an experiment on the unripe fruit had relatively low polyphenol oxidase (catechol oxidase) activity and low total polyphenol content but had huge ascorbic acid and carotenoid contents and showed the least browning potential. Shelf life is the most important aspect in loss reduction biotechnology of fruits. There is a natural tendency of fruits to degrade to the simpler inorganic compound ($CO_2$, $HO_2$, and $NH_3$) from which they were synthesized in the first place through spontaneous bio-chemical reaction which occur with the decreased in free energy and increase in the randomness (entrophy) of the system, consequently reduce the shelf life as well as other qualities of fruits.

The fruit, mango is very popular due to its wide range of adaptability, high nutritive value and richness in variety.

Long time storage is essential for extending the consumption period of mango, regulating their supply to market and also for transformation. MA packaging with postharvest treatments can delay ripening and reduces water loss of mango.

Many research works have been done on mango, but only very are related to the varieties in our country few works had done. Therefore, this research has been done so that we can find out the proper postharvest treatments to extend shelf life of some mango varieties of Bangladesh. Shelf life is the most important aspect in loss reduction biotechnology of fruits and vegetables. There is a natural tendency for the perishable fruits and vegetables to degrade to simpler inorganic compounds ($CO_2$, $H_2O$, $NH_3$) (Salunkhe and Desai, 1984).

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted during the period from June 2017 to July 2017 to study the physiological changes and shelf life of Mango due to bagging and different postharvest treatments. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, climate condition of the experimental area, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

## 3.1 Location of the experimental site

The experiment was conducted at SAU postharvest Laboratory, Horticulture Department, Sher-e-bangla Agricultural University, Dhaka. It was located in 24.09$^{o}$/N latitude and 90.26$^{o}$/E longitudes. The altitude of the location was 8 m above from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207.

## 3.2 Experimental materials

The experimental materials were mature hard fruits of mango variety, namely, Langra. Two types of Langra mangoes were used where one type was treated with preharvest brown paper bagging after 40 days of fruit setting and another type was without bagging treatment. Mangoes used in the experiment were collected from the orchard of mango grower, Chapai Nawabgongon 16, June 2017. Maturity of mangoes was indicated when the shoulders were in line with the stem end and the color was olive green. Maturity was also judged by the grower's recommendation.

### 3.3 Treatment of the experiment

The experiment consisted of three factors:

**Factor A:** Preharvest Bagging

i. $B_0$ = Non Bagging Mango
ii. B = Bagging Mango (Brown papper bagg)

**Factor B:** Postharvest Treatments

i. $T_0$ : Control
ii. $T_1$ : Hot water dips
iii. $T_2$ : Hot water + Bavistin dips
iv. $T_3$ : Bavistin + Hot water dips
v. $T_4$ : Bavistin dips
vi. $T_5$ : Hot water + $CaCl_2$ dips
vii. $T_6$ : $CaCl_2$ + Hot water dips
viii. $T_7$ : $CaCl_2$ dips
ix. $T_8$ : Bavistin + $CaCl_2$ dips
x. $T_9$ : $CaCl_2$ + Bavistin dips

**Factor C:** Postharvest Bagging

i. $P_0$ = Postharvest non bagging
ii. P = Postharvest bagging (Perforated LDP bag)

There were 40 (2 × 10×2) treatments combination.

### 3.4 Design and layout of the experiment

The three factors experiment was laid out in the completely randomized design with three replications of 5 fruits. A total of 600 fruits of more or less similar shape and size and free of visible disease symptoms were harvested. The skin adherences, dots and latex were cleaned by gently wiping the fruits with moist and clean towel. There were 2×10×2 treatments combinations. Each treatment combination comprised 15 fruits.

### 3.4 Methods

The postharvest treatments were randomly assigned to the experimental fruits. Half of the treated fruits were kept in perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

#### 3.4.1 Control

Fruits of each type bagging and nonbagging were randomly selected from the lot and half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition (Plate 1).

#### 3.4.2 Fruit treated with hot water

Normal tap water was heated in hot water bath-tube at a temperature of 52°C. A thermometer was used to measure the temperature. Mango fruits were dipped into hot water for 5 minutes and then half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

#### 3.4.3 Fruit treated with hot water and Bavistin

After hot water treatment fruits were dipped into 0.1% Bavistin solution for 10 minutes. 0.1% Bavistin solution was prepared by adding 10g of commercial bavistin powder into 10L of water and mixed it well and finally it was 0.1% bavistin solution prepared for postharvest mango treatment. Half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.4 Fruit treated with Bavistin and hot water

After dipping into 0.1% Bavistin solution for 10 minutes fruits were treated with hot water following the previous procedure. Half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.5 Bavistin dips

Fruits were dipped into 0.1% Bavistin solution for 10 minutes. After the treatment half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.6 Fruit treated with hot water and Calcium chloride

After hot water treatment fruits were dipped into 1.5% Calsium chloride solution for 10 minutes. 1.5% Calsium chloride solution was prepared by adding 150g of Calsium chloride into 10L of water and mixed it well and finally it was 1.5% Calsium chloride solution prepared for postharvest mango treatment. Half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.7 Fruit treated with Calcium chloride and hot water

After dipping into 1.5% Calsium chloride solution for 10 minutes fruits were treated with hot water following the previous procedure. Half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.8 Calsium chloride dips

Fruits were dipped into 1.5% Calsium chloride solution for 10 minutes. Half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.9 Bavistin and Calsium chloride dips

Firstly fruits were dipped into 0.1% Bavistin solution for 10 minutes and then into 1.5% calsium chloride solution for 10 minutes. Finally half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

### 3.4.10 Calsium chloride and Bavistin dips

Firstly fruits were dipped into 1.5% calsium chloride solution for 10 minutes and then into 0.1% Bavistin solution for 10 minutes. Finally half of the treated fruits were kept into perforated LDP bag where another half were kept without LDP bag and placed on laboratory table at ambient condition.

## 3.5 Parameters studied

In this experiment the following parameters were studied:

### 3.5.1 Physical parameters

1. Color
2. Weight loss
3. Moisture content
4. Dry matter content

### 3.5.2 Chemical parameters

1. TSS (Total soluble solids.)
2. TA ( Titratable acidity)
3. Vitamin A

4. Vitamin C

**3.5.3 Microbial characters (**Disease incidence percent)

**3.5.4 Shelf life** (Days)

**3.6 Observation**

During the entire period of storage, the fruits used in this experiment were observed every day. Data were recorded at an interval of 3 days during storage is influenced by different postharvest treatments and bagging.

**3.7 Methods of studying parameters listed earlier**

**3.7.1 Physical parameters**

**3.7.1.1 Color**

Days required to reach different stages of color during storage and ripening were measured by using numerical rating scale of 1-7, where 1 = green, 2 =breaker, 3 = one-quarter-yellow (< 25%), 4 = two-quarter fruit skin yellow (<50%), 5 = three quarter yellow (<75%), 6 = fully yellow (75-100%) and 7 = blackened/ rotten (fully yellow and black).

**3.7.1.2 Estimation of total weight loss**

The fruits of each treatment were individually weight by using electric balance andkept for storage. Percent total weight loss was calculated at an interval of 3 daysduring storage by using the following formula:

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

Where,

IW = Initial fruit weights (g) and

FW= Final fruit weight (g)

### 3.7.1.3 Estimation of moisture content

Ten gram of fruit pulp was weighed in a porcelain crucible (which was previously cleaned, dried and weighed) from each treatment and replications. The crucible was placed in electric oven at 80°C for 72 hours until the weight became constant. It was then cooled in desiccators and weighed again. Percent moisture content was calculated by using the formula:

Moisture content (%) $= \frac{\text{IW}-\text{FW}}{\text{IW}} \times 100$

Where,

IW = Initial weight of fruit pulp (g) and

FW= Final weight of fruit pulp (g)

### 3.7.1.4 Estimation of dry matter content

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

Dry matter (%) = 100 – % moisture content

### 3.7.2 Chemical parameters

### 3.7.2.1 Estimation of total soluble solids content

Total soluble solids content of mango pulp was estimated by using Abbes, Refractometer. A drop of mango juice squeezed from the fruit pulp on the prism of the refractometer. Percent TSS was obtained from direct reading of the instrument. Temperature corrections were made by using the methods described by Ranganna (1979).

### 3.7.2.2 TA (Titratable acidity)

Titratable acidity was estimated chemical analysis process by using mango pulp stored in refrigerator. Titratable acidity was declined slowly when stored in low temperature. The titratable acidity of mango pulp was determined by

method of Ranganna (1979). The procedure of lab test for Titratable acidity content was done and obtained results were recorded.

### 3.7.2.3 Vitamin C content

Ascorbic acid content was determined according to the method of Ranganna (1979). The procedure of lab test for vitamin C content was done and obtained results were recorded.

### 3.7.2.3 Vitamin A content

The β-carotene was determined by soaking 1 g of the sample (that is the paste or pulp of the fresh fruits) in 5 ml of methanol for 2 h at room temperature under dark condition in order to get a complete extraction. The β -carotene layer was separated using hexane through separating funnel. The volume was made up to 10 ml with hexane and then this layer was again passed through sodium sulphonate through a funnel in order to remove any moisture from the layer. The absorbance of the layer was measured at 436 nm using hexane as a blank (Ranganna, 1999).

## 3.7.3 Microbial characters

### 3.7.3.1 Assessment of disease incidence

The fruits were critically examined one day later for the appearance of rot. The incidence of fruit rot was recorded after one day. The first count was made at the 3 days after storage. Diseases incidence means percentage of fruits infected with disease. This is measured by calculating the percentage of fruits infected in each replication of each treatment. The diseased fruits were identified symptomatically.

The disease incidence was calculated as follow:

$$\%\ \text{Disease incidence} = \frac{\text{Number of infected fruits in each replication}}{\text{Total number of fruits in each replication}} \times 100$$

### 3.7.4 Estimation of shelf life

Shelf life of mango fruits as influenced by bagging and different postharvest storage treatments was calculated by counting the days required to ripe fully as to retaining, maximum marketing and eating qualities.

### 3.7.5 Statistical analysis

The collected data were statistically analyzed by Analysis of Variance (ANOVA)tests. The mean of different parameters was compared by DMRT (Duncans' Multiple Range Test). The collected data on various parameters were statistically analyzed using Tukey's Test. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was performed by F-test. The significance of difference between the pairs of means was compared by least significant difference (LSD) test at the 1% and 5% levels of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

This chapter comprises the presentation of the results obtained from the present study. The data were recorded at 3 days interval after storage (DAS) on physical, chemical and microbial properties and also shelf life of mango. These results are presented under the following headings:

## 4.1 Color

Significant influence was observed in respect of color of both bagging and non-bagging mangoes with different postharvest treatments and also their combined application under the present study at different days after storage (Appendix 1).

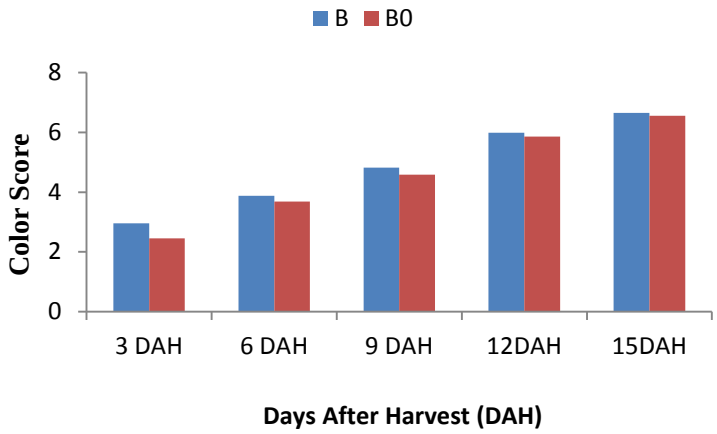
Longer period was required for non-bagging Langra than bagging Langra as pre-harvest bagging treatment to reach different stages of ripening (Plate 2). Significant variation was found at 3, 6, 9, 12 and 15 days after harvest.

The highest color score (3.88, 4.82, 5.99 and 6.65) was observed in bagging Langra and lowest color score (3.68, 4.59, 5.86 and 6.56) in non-bagging Langra at 6th, 9th, 12th and 15th days after harvest respectively (Figure 1).

Postharvest treatments had also significant variation on the changes of peel color of mango. The highest color scores (2.90, 4.35,4.90, 6.70 and 6.85) were observed in calcium chloride and bavistin dips treatment ($T_9$) and lowest color score (2.47, 3.30, 4.60,4.95 and 6.35) in hot water and bavistin dips treatment ($T_2$) at 3rd, 6th, 9th, 12th and 15th days after harvest respectively followed by T6 (calcium chloride and hot water) and $T_3$ (bavistin and hot water) at different days after harvest (Figure 2).

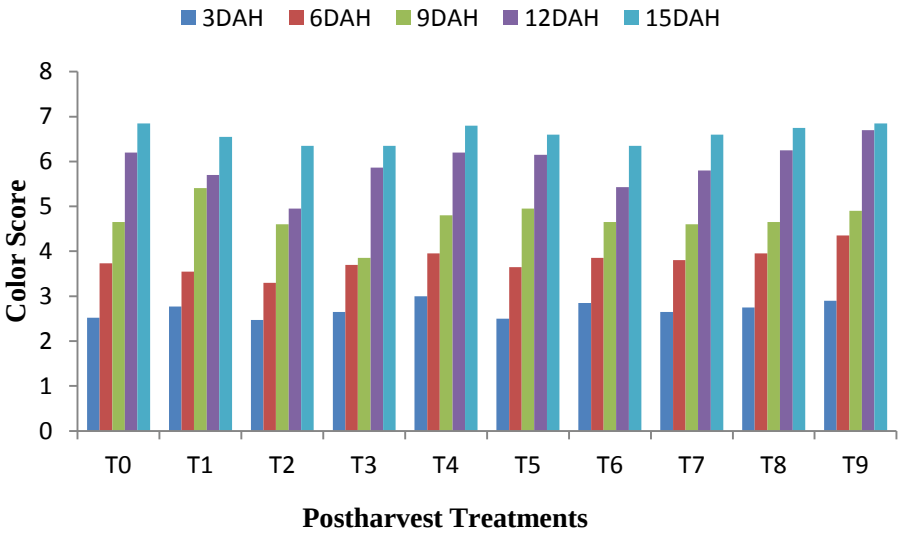
Postharvest bagging using low density polybag (LDP) had significant variation on the changes of peel color of mango.

The highest color score (3.79, 4.79, 6.04 and 6.63) was observed in non-bagging Langra and lower color score (3.77, 4.62, 5.81 and 6.58) in bagging Langra at 6th, 9th, 12th and 15th days after harvest respectively (Figure 3).



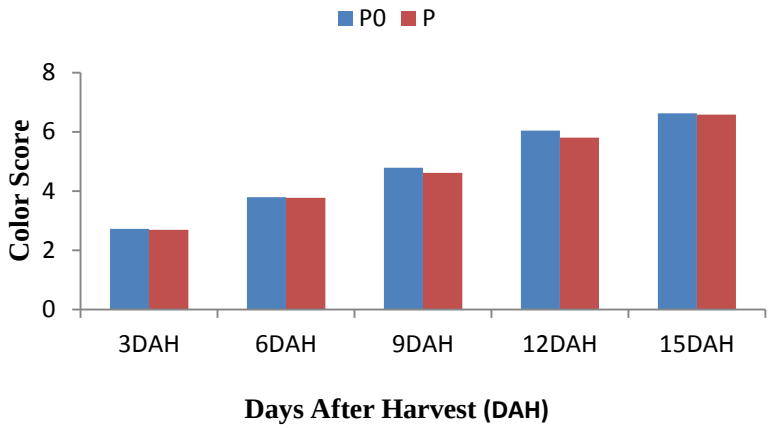

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 1: Effect of pre-harvest bagging on color of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 2: Effect of postharvest treatments on color of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 3: Effect of postharvest bagging on color of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant effect on color changes of mango at different day after harvest. The highest color score (4.60, 5.60, 6.80 and 7.00) was observed in bagging mangoes when treated with calcium chloride and bavistin dips ($BT_9$) and lowest color score (3.00, 4.00, 4.5 and 6.10) was found in without bagging mangoes when treated with hot water and bavistin dips ($B_0T_2$) at 6th, 9th, 12th and 15th days of harvest respectively (Table 1).

**Table 1. Interaction effect of pre-harvest bagging and post-harvest treatments on color of mango**

| Treatments | Color at Different Days After Harvest (DAH) | | | | |
|---|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH | 15 DAH |
| $BT_0$ | 2.35 | 3.10 | 4.00 | 5.60 | 6.70 |
| $BT_1$ | 3.15 | 4.10 | 5.20 | 5.70 | 6.50 |
| $BT_2$ | 2.55 | 3.60 | 3.70 | 5.40 | 6.60 |
| $BT_3$ | 2.80 | 3.60 | 4.60 | 6.03 | 6.50 |
| $BT_4$ | 3.40 | 4.40 | 5.20 | 6.50 | 7.00 |
| $BT_5$ | 2.70 | 3.70 | 5.00 | 5.90 | 6.40 |
| $BT_6$ | 3.00 | 3.70 | 4.50 | 5.46 | 6.20 |
| $BT_7$ | 2.80 | 3.80 | 5.10 | 6.00 | 6.60 |
| $BT_8$ | 3.40 | 4.20 | 5.30 | 6.50 | 7.00 |
| $BT_9$ | 3.50 | 4.60 | 5.60 | 6.80 | 7.00 |
| $B_0T_0$ | 2.70 | 4.36 | 5.30 | 6.80 | 7.00 |
| $B_0T_1$ | 2.40 | 3.00 | 4.00 | 5.70 | 6.60 |
| $B_0T_2$ | 2.40 | 3.00 | 4.00 | 4.50 | 6.10 |
| $B_0T_3$ | 2.50 | 3.80 | 5.00 | 5.70 | 6.20 |
| $B_0T_4$ | 2.60 | 3.50 | 4.70 | 5.90 | 6.60 |
| $B_0T_5$ | 2.30 | 3.60 | 4.30 | 6.40 | 6.80 |
| $B_0T_6$ | 2.70 | 4.00 | 4.70 | 5.40 | 6.50 |
| $B_0T_7$ | 2.50 | 3.80 | 4.20 | 5.60 | 6.60 |
| $B_0T_8$ | 2.10 | 3.70 | 4.50 | 6.00 | 6.50 |
| $B_0T_9$ | 2.30 | 4.10 | 5.23 | 6.60 | 6.70 |
| SE(±) | 0.096 | 0.102 | 0.103 | 0.106 | 0.086 |
| CV% | 6.16 | 4.70 | 3.81 | 3.12 | 2.26 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Interaction effects of postharvest treatments and postharvest bagging with LDP bags had also significant effect on color changes of mango at different day after harvest. The highest color score (4.40, 5.50, 6.80 and 7.00) was observed in bavistin dips when stored with LDP bagging ($T_4P$) and lowest color score (3.70, 4.70, 5.26 and 6.10) was found in Calcium chloride dips followed by hot water dips and stored with LDP bagging ($T_6P$) at 6th, 9th, 12th and 15th days of harvest respectively (Table 2).

These findings were observed by Doreyappa-Gowda and Huddar (2001) who reported that the green peel color of mature Alphanso and other varieties of mango turned from light green or green or dark green to light yellow or yellow or orange yellow due to the breakdown of chlorophyll due to a series of physicochemical changes during ripening, leading to disappearance of green color.

**Table 2. Interaction effect of post-harvest treatments and post-harvest bagging on color of mango**

| Treatments | Color at Different Days After Harvest (DAH) | | | | |
|---|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH | 15 DAH |
| $T_0$ $P_0$ | 2.70 | 4.20 | 5.20 | 6.50 | 6.80 |
| $T_0P$ | 2.35 | 3.26 | 4.10 | 5.90 | 6.90 |
| $T_1P_0$ | 2.80 | 3.60 | 5.00 | 5.90 | 6.70 |
| $T_1P$ | 2.75 | 3.50 | 4.20 | 5.50 | 6.40 |
| $T_2P_0$ | 2.55 | 3.20 | 3.40 | 4.70 | 6.30 |
| $T_2P$ | 2.40 | 3.40 | 4.30 | 5.20 | 6.40 |
| $T_3P_0$ | 2.80 | 3.90 | 4.90 | 5.83 | 6.30 |
| $T_3P$ | 2.50 | 3.50 | 4.70 | 5.90 | 6.40 |
| $T_4P_0$ | 3.00 | 3.50 | 4.40 | 5.60 | 6.60 |
| $T_4P$ | 3.00 | 4.40 | 5.50 | 6.80 | 7.00 |
| $T_5P_0$ | 2.20 | 3.40 | 4.50 | 6.00 | 6.60 |
| $T_5P$ | 2.80 | 3.90 | 4.80 | 6.30 | 6.60 |
| $T_6P_0$ | 2.50 | 4.00 | 4.50 | 5.60 | 6.60 |
| $T_6P$ | 3.20 | 3.70 | 4.70 | 5.26 | 6.10 |
| $T_7P_0$ | 2.90 | 4.20 | 5.10 | 5.70 | 6.60 |
| $T_7P$ | 2.40 | 3.40 | 4.20 | 5.90 | 6.60 |
| $T_8P_0$ | 2.80 | 3.70 | 4.60 | 5.90 | 6.60 |
| $T_8P$ | 2.70 | 4.20 | 5.20 | 6.60 | 6.90 |
| $T_9P_0$ | 2.70 | 4.00 | 4.60 | 6.40 | 6.70 |
| $T_9P$ | 3.10 | 4.70 | 6.23 | 7.00 | 7.00 |
| SE(±) | 0.096 | 0.102 | 0.103 | 0.106 | 0.086 |
| CV% | 6.16 | 4.70 | 3.81 | 3.12 | 2.26 |

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + Calcium chloride, $T_6$: Calcium chloride + Hot water, $T_7$: Calcium chloride dips, $T_8$: Bavistin + Calcium chloride dips and $T_9$: Calcium chloride + Bavistin
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

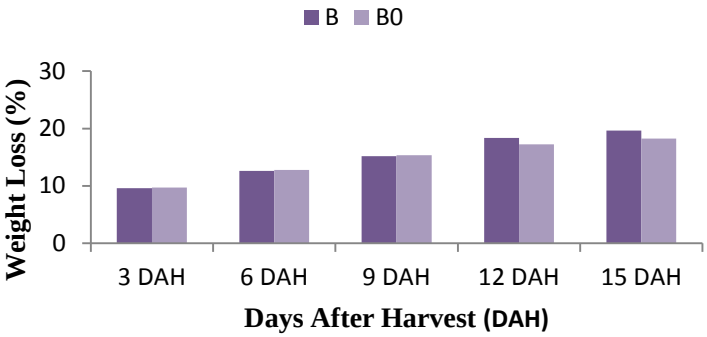
## 4.2 Weight loss of mango

Significant variation was observed in respect of total weight loss between pre-harvest bagging and non-bagging mangoes (Appendix 2).

It was observed that the weight loss trended to increase with the advancement of storage period in both bagging and non-bagging mangoes. The weight loss was greater in non-bagging mango compared to bagging one up to 9th day of storage but after that greater weight loss was found in bagging than the non-bagging mangoes (Figure 4).

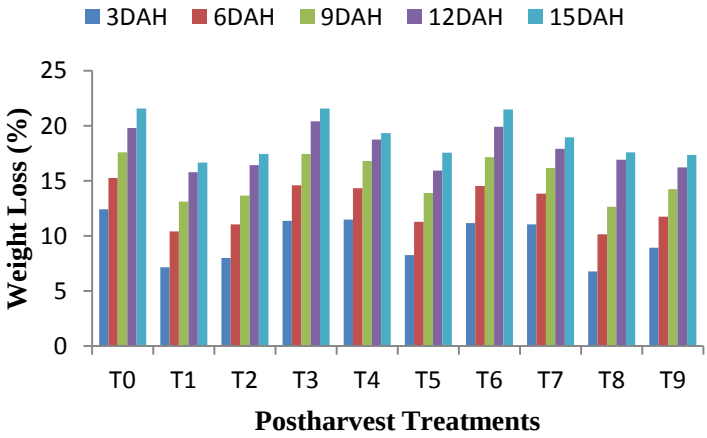
The present investigation showed that the postharvest treatments of mango harvest had significant effects on total weight loss (Appendix 2). Here, it was also observed gradually increased weight loss was happened with the advancement of storage duration. The total weight loss was found to be the highest (12.42%, 15.27%, 17.6%, 19.80% and 21.57% at3rd, 6th, 9th, 12th and 15th days of harvest respectively) at all stages in case of Control treatment ($T_0$) where the treatment of Hot water dips ($T_1$) represented the lowest weight loss (7.17%, 10.40%, 13.12%, 15.80% and 16.67% at 3rd, 6th, 9th, 12th and 15th days of harvest respectively) (Figure 5). Among the treatments Hot water dips ($T_1$) was the best in terms of controlling weight loss followed by $T_9$(Calcium chloride and Bavistin dips) and $T_2$ (Hot water and Bavistin dips).

Postharvest bagging had a great influence on total weight loss of mango (Appendix 2). Total weight loss was found to be the lowest when mangoes were stored in perforated polybags (LDP) rather than the non-polybag mangoes (Figure 6).



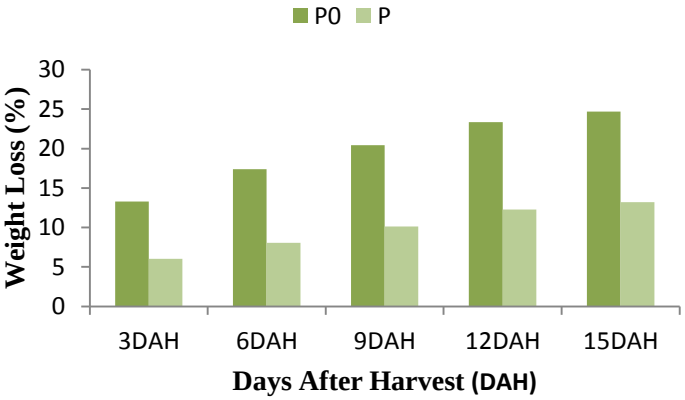

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 4: Effect of pre-harvest bagging on weight loss of mango




T0: Control, T1: Hot water dips, T2: Hot water + Bavistin, T3: Bavistin + Hot water, T4 : Bavistin dips, T5: Hot water + calcium chloride, T6: calcium chloride + Hot water, T7: calcium chloride dips, T8: Bavistin + calcium chloride dips and T9: calcium chloride + Bavistin

Figure 5: Effect of postharvest treatments on weight loss of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 6: Effect of postharvest bagging on weight loss of mango

The combined effect of postharvest treatments and postharvest bagging using perforated LDP bags on total weight loss was highly significant in all stages of observation (Appendix 2). Gradually increase in weight loss was found with increased duration. The control treatment without postharvest bagging ($T_0P_0$) gave the highest weight loss at all stages of harvest observation. Alternatively, the lowest weight loss was found in mango treated with Calcium chloride and Hot water dips treatment and stored in perforated polybag ($T_6P$) (Table 3).

**Table 3. Interaction effect of post-harvest treatments and post-harvest bagging on Weight loss (%) of mango**

| Treatments | Weight loss (%) at Different Days After Harvest (DAH) | | | | |
|---|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH | 15 DAH |
| $T_0 P_0$ | 14.50 | 18.35 | 21.20 | 23.65 | 24.55 |
| $T_0P$ | 10.35 | 12.20 | 14.10 | 15.95 | 18.60 |
| $T_1P_0$ | 6.60 | 11.25 | 14.70 | 18.05 | 19.40 |
| $T_1P$ | 7.75 | 9.55 | 11.55 | 13.55 | 13.95 |
| $T_2P_0$ | 10.55 | 14.95 | 18.35 | 22.10 | 23.50 |
| $T_2P$ | 5.45 | 7.15 | 9.00 | 10.75 | 11.40 |
| $T_3P_0$ | 16.75 | 20.90 | 24.10 | 27.95 | 29.85 |
| $T_3P$ | 5.98 | 8.30 | 10.80 | 12.85 | 13.30 |
| $T_4P_0$ | 17.90 | 21.35 | 24.30 | 26.45 | 27.30 |
| $T_4P$ | 5.10 | 7.35 | 9.35 | 11.10 | 11.40 |
| $T_5P_0$ | 12.95 | 17.15 | 20.40 | 22.60 | 24.25 |
| $T_5P$ | 3.55 | 5.40 | 7.40 | 9.30 | 10.85 |
| $T_6P_0$ | 21.25 | 25.35 | 28.20 | 31.48 | 33.70 |
| $T_6P$ | 1.10 | 3.75 | 6.10 | 8.35 | 9.30 |
| $T_7P_0$ | 15.95 | 19.55 | 22.20 | 24.20 | 25.60 |
| $T_7P$ | 6.15 | 8.15 | 10.15 | 11.60 | 12.30 |
| $T_8P_0$ | 5.45 | 9.85 | 13.10 | 17.50 | 18.05 |
| $T_8P$ | 8.10 | 10.45 | 12.20 | 16.35 | 17.15 |
| $T_9P_0$ | 11.00 | 15.10 | 17.95 | 19.55 | 20.65 |
| $T_9P$ | 6.85 | 8.40 | 10.55 | 12.90 | 14.10 |
| SE(±) | 0.119 | 0.095 | 0.105 | 0.127 | 0.110 |
| CV% | 2.14 | 1.30 | 1.19 | 1.24 | 1.01 |

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Interaction between pre-harvest bagging, postharvest treatments and postharvest bagging had a great effect on total weight loss of mango. Data showed that the significant difference was observed in weight loss of mango (Table 4). Highest weight loss was observed from $BT_3$ $P_0$ treatment interaction compared to others interactions.

**Table 4. Interaction effect of pre-harvest bagging, post-harvest treatments and post-harvest bagging on Weight loss (%) of mango**

| Treatments | Weight loss (%) at Different Days After Harvest (DAH) | | | | |
|---|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH | 15 DAH |
| $BT_0$ $P_0$ | 9.00 | 13.00 | 16.00 | 18.80 | 20.00 |
| $BT_0$ P | 11.30 | 12.90 | 14.80 | 17.10 | 21.60 |
| $BT_1$ $P_0$ | 5.3 | 10.10 | 13.60 | 19.00 | 20.90 |
| $BT_1$ P | 8.00 | 9.90 | 11.90 | 13.80 | 14.00 |
| $BT_2$ $P_0$ | 9.10 | 13.90 | 17.60 | 23.20 | 25.00 |
| $BT_2$ P | 4.3 | 5.50 | 7.20 | 9.30 | 9.50 |
| $BT_3$ $P_0$ | 18.30 | 22.40 | 25.60 | 30.90 | 32.60 |
| $BT_3$ P | 6.06 | 8.10 | 10.90 | 13.60 | 13.70 |
| $BT_4$ $P_0$ | 15.6 | 19.10 | 22.10 | 24.90 | 26.10 |
| $BT_4$ P | 8.30 | 10.40 | 12.10 | 14.30 | 14.50 |
| $BT_5$ $P_0$ | 11.60 | 16.10 | 19.70 | 22.10 | 23.30 |
| $BT_5$ P | 7.10 | 9.00 | 10.80 | 13.90 | 16.60 |
| $BT_6$ $P_0$ | 20.60 | 25.00 | 28.00 | 30.66 | 34.10 |
| $BT_6$ P | 0.00 | 2.70 | 5.00 | 9.00 | 10.10 |
| $BT_7$ $P_0$ | 17.90 | 21.40 | 23.80 | 25.10 | 27.00 |
| $BT_7$ P | 9.80 | 11.50 | 13.50 | 14.30 | 15.00 |
| $BT_8$ $P_0$ | 7.100 | 11.30 | 14.40 | 20.60 | 21.00 |
| $BT_8$ P | 8.20 | 10.40 | 12.10 | 17.90 | 18.60 |
| $BT_9$ $P_0$ | 11.40 | 15.30 | 17.90 | 18.80 | 19.3 |
| $BT_9$ P | 3.60 | 4.90 | 7.10 | 9.70 | 10.40 |
| $B_0T_0$ $P_0$ | 20.00 | 23.70 | 26.40 | 28.50 | 29.10 |
| $B_0T_0$ P | 9.40 | 11.50 | 13.40 | 14.80 | 15.60 |
| $B_0T_1$ $P_0$ | 7.90 | 12.40 | 15.80 | 17.10 | 17.90 |
| $B_0T_1$ P | 7.50 | 9.20 | 11.20 | 13.30 | 13.90 |
| $B_0T_2$ $P_0$ | 12.00 | 16.00 | 19.10 | 21.00 | 22.00 |
| $B_0T_2$ P | 6.60 | 8.80 | 10.80 | 12.20 | 13.30 |
| $B_0T_3$ $P_0$ | 15.20 | 19.40 | 22.60 | 25.00 | 27.10 |
| $B_0T_3$ P | 5.90 | 8.50 | 10.70 | 12.10 | 12.90 |
| $B_0T_4$ $P_0$ | 20.20 | 23.60 | 26.50 | 28.00 | 28.50 |
| $B_0T_4$ P | 1.90 | 4.30 | 6.60 | 7.90 | 8.30 |
| $B_0T_5$ $P_0$ | 14.30 | 18.20 | 21.10 | 23.10 | 25.20 |

| | | | | | |
|---|---|---|---|---|---|
| $B_0T_5$ P | 0.00 | 1.80 | 4.00 | 4.70 | 5.10 |
| $B_0T_6$ $P_0$ | 21.90 | 25.70 | 28.40 | 32.30 | 33.30 |
| $B_0T_6$ P | 2.20 | 4.80 | 7.20 | 7.70 | 8.50 |
| $B_0T_7$ $P_0$ | 14.00 | 17.70 | 20.60 | 23.30 | 24.20 |
| $B_0T_7$ P | 2.50 | 4.80 | 6.80 | 8.90 | 9.60 |
| $B_0T_8$ $P_0$ | 3.80 | 8.40 | 11.80 | 14.40 | 15.10 |
| $B_0T_8$ P | 8.00 | 10.50 | 12.30 | 14.80 | 15.70 |
| $B_0T_9$ $P_0$ | 10.60 | 14.90 | 18.00 | 20.30 | 22.00 |
| $B_0T_9$ P | 10.10 | 11.90 | 14.00 | 16.10 | 17.80 |
| SE(±) | 0.168 | 0.135 | 0.148 | 0.180 | 0.156 |
| CV% | 2.14 | 1.30 | 1.19 | 1.24 | 1.01 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging
$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

The result of the present study is in support of the findings of Shahajahan (1994). He reported that the moisture content of pulp in Fazli was 79.95%. Shahajahan (1994) also recorded that the decreasing tendency of moisture content with the advancement of maturity of varieties Gopalbhogh (82.13 to 79.23%), Khirsa (82.1 to 79.25%), Langra (81.75 to 78.29%) Fazli (82.30 to 79.95%).

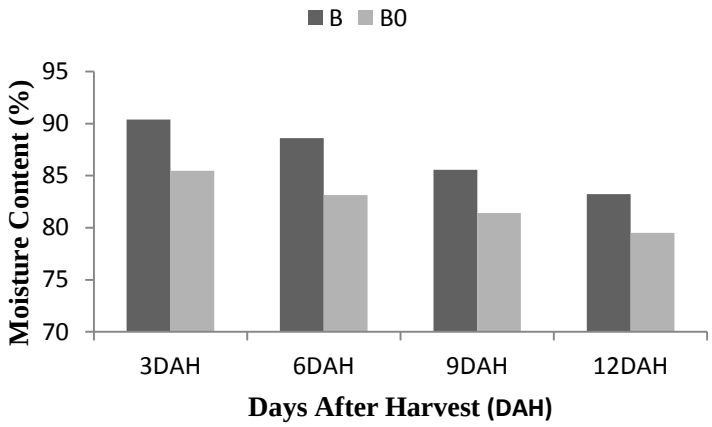
### 4.3 Moisture content of pulp

Significant variation was observed in respect of percent moisture content between pre-harvest bagging and non-bagging mangoes (Appendix 3). It was observed that the percent moisture content trended to decrease with the advancement of storage period in both bagging and non-bagging mangoes. The percent moisture content was greater in bagging mango compared to non-bagging one (Figure 7).

The present investigation showed that the postharvest treatments of mango harvest had significant effects on percent moisture content (Appendix 3). Here, it was also observed gradually decrease in percent moisture content was happened with the advancement of storage duration. The percent moisture content was found to be the highest (89.07%, 87.40%, 85.30% and 83.07%

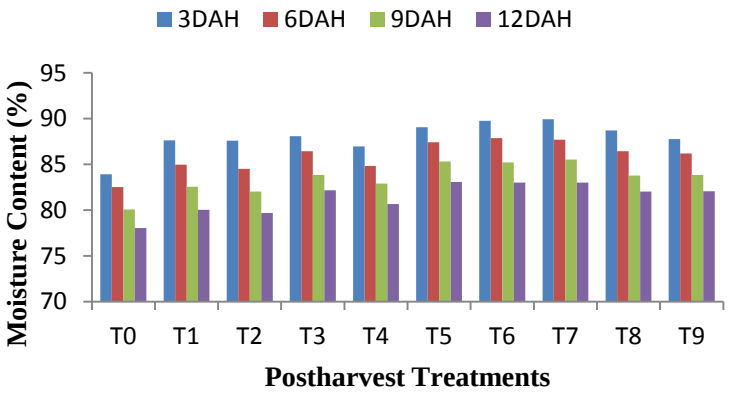
at3rd, 6th, 9th and 12th days of harvest respectively) at all stages in case of Hot water and Calcium chloride dips ($T_5$) where the control treatment ($T_0$) represented the lowest percent moisture content (83.90%, 82.50%, 80.05% and 78.05% at 3rd, 6th, 9th and 12th days of harvest respectively) (Figure 8).

Postharvest bagging had a influence too on percent moisture content of mango (Appendix 3). Percent moisture content was found to be the highest when mangoes were stored in perforated polybags (LDP) rather than the non-polybag mangoes (Figure 9).



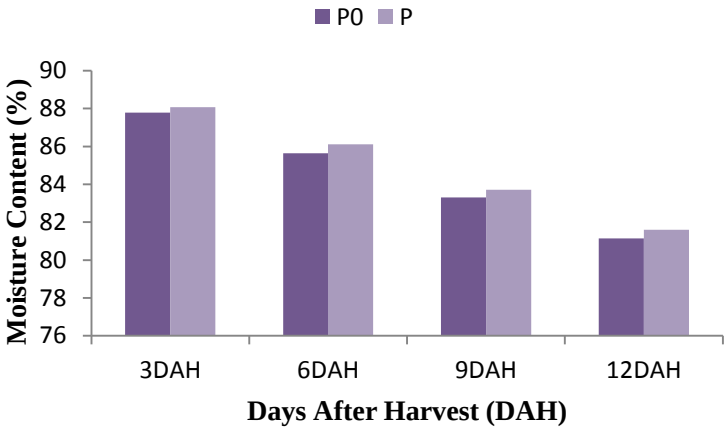

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 7: Effect of pre-harvest bagging on percent moisture content of mango




T0: Control, T1: Hot water dips, T2: Hot water + Bavistin, T3: Bavistin + Hot water, T4 : Bavistin dips, T5: Hot water + calcium chloride, T6: calcium chloride + Hot water, T7: calcium chloride dips, T8: Bavistin + calcium chloride dips and T9: calcium chloride + Bavistin

Figure 8: Effect of postharvest treatments on percent moisture content of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 9: Effect of postharvest bagging on percent moisture content of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant effect on percent moisture content of mango at different day after harvest. The highest percent moisture content (92.30%, 89.60%, 86.86% and 84.20%) was observed in pre harvest bagging mangoes when treated with calcium chloride dips ($BT_7$) and lowest percent moisture content (79.40%, 77.20%, 75.45% and 74.55%) was found in without pre harvest bagging mangoes with control treatment ($B_0T_0$) at 3th, 6th, 9th and 12th days of harvest respectively (Table 5).

**Table 5. Interaction effect of pre-harvest bagging and post-harvest treatments on Moisture Content (%) of mango**

| Treatments | Moisture Content (%) at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH |
| $BT_0$ | 88.40 | 87.80 | 84.65 | 81.55 |
| $BT_1$ | 92.00 | 89.45 | 86.35 | 83.35 |
| $BT_2$ | 90.60 | 88.65 | 85.75 | 82.85 |
| $BT_3$ | 89.40 | 87.65 | 84.11 | 83.40 |
| $BT_4$ | 88.00 | 86.85 | 84.25 | 82.75 |
| $BT_5$ | 90.85 | 89.25 | 86.75 | 84.5 |
| $BT_6$ | 92.05 | 89.90 | 86.10 | 83.95 |
| $BT_7$ | 92.30 | 89.60 | 86.86 | 84.20 |
| $BT_8$ | 90.75 | 88.50 | 85.35 | 82.85 |
| $BT_9$ | 89.55 | 88.55 | 85.60 | 82.90 |
| $B_0T_0$ | 79.40 | 77.20 | 75.45 | 74.55 |

| | | | | |
|---|---|---|---|---|
| $B_0T_1$ | 83.25 | 80.50 | 78.75 | 76.70 |
| $B_0T_2$ | 84.60 | 80.35 | 78.30 | 76.55 |
| $B_0T_3$ | 86.75 | 85.25 | 83.60 | 80.90 |
| $B_0T_4$ | 85.90 | 82.80 | 81.55 | 78.60 |
| $B_0T_5$ | 87.30 | 85.55 | 83.85 | 81.65 |
| $B_0T_6$ | 87.45 | 85.85 | 84.30 | 82.05 |
| $B_0T_7$ | 87.55 | 85.80 | 84.20 | 81.80 |
| $B_0T_8$ | 86.65 | 84.35 | 82.23 | 81.20 |
| $B_0T_9$ | 86.00 | 83.85 | 82.10 | 81.25 |
| SE(±) | 0.058 | 0.058 | 0.057 | 0.057 |
| CV% | 0.12 | 0.12 | 0.12 | 0.12 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Interaction between pre-harvest bagging and postharvest bagging had a great impact on percent moisture content of mango. Data showed that the significant difference was observed in percent moisture content of mango (Table 6). Highest percent moisture content was observed from $B_0P$ treatment interaction compared to others interactions.

**Table 6. Interaction effect of pre-harvest bagging and post-harvest bagging on Moisture Content (%) of mango**

| Treatments | Moisture Content(%) at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH |
| $BP_0$ | 88.40 | 87.80 | 84.65 | 81.55 |
| BP | 92.00 | 89.45 | 86.35 | 83.35 |
| $B_0P_0$ | 90.60 | 88.65 | 85.75 | 82.85 |
| $B_0P$ | 89.40 | 87.65 | 84.11 | 83.40 |
| SE(±) | 0.026 | 0.026 | 0.025 | 0.025 |
| CV% | 0.12 | 0.12 | 0.12 | 0.12 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

The result of the present study is in support of the findings of Shahajahan (1994). He reported that the moisture content of pulp in Fazli was 79.95%. Shahajahan (1994) also recorded that the decreasing tendency of moisture

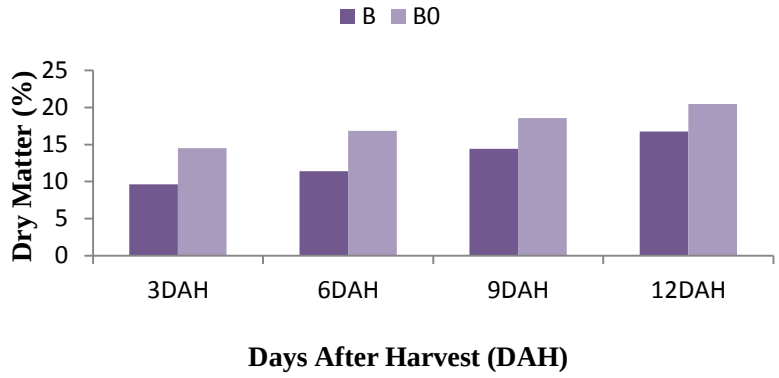
content with the advancement of maturity of varieties Gopalbhogh (82.13 to 79.23%), Khirsa (82.1 to 79.25%), Langra (81.75 to 78.29%) Fazli (82.30 to 79.95%).

### 4.4 Dry matter content

Significant variation was observed in respect of dry matter content between pre-harvest bagging and non-bagging mangoes (Appendix 4). It was observed that the dry matter content trended to inecrease with the advancement of storage period in both bagging and non-bagging mangoes. The dry matter was greater in non-bagging mango compared to bagging one (Figure 10).

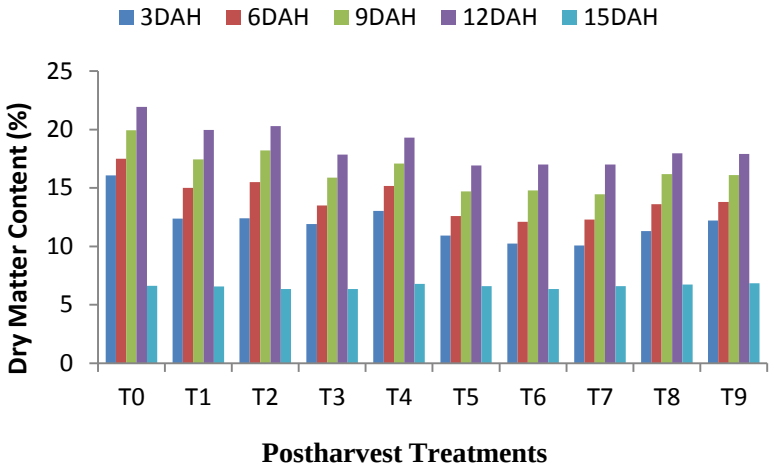
The present investigation showed that the postharvest treatments of mango harvest had significant effects on dry matter content (Appendix 4). Here, it was also observed gradually increase dry matter content was happened with the advancement of storage duration. Dry matter was found to be the lowest (10.92%, 12.60%, 14.70% and 16.92% at3rd, 6th, $9^{th}$ and 12th days of harvest respectively) at all stages in case of Hot water and Calcium chloride dips ($T_5$) where the control treatment ($T_0$) represented the highest dry matter (16.10%, 17.50%, 19.95% and 21.95% at 3rd, 6th, $9^{th}$ and 12th days of harvest respectively) (Figure 11).

Postharvest bagging had an influence too on dry matter content of mango (Appendix 4). Dry matter content was found to be the lowest when mangoes were stored in perforated polybags (LDP) rather than the non-polybag mangoes (Figure 12).



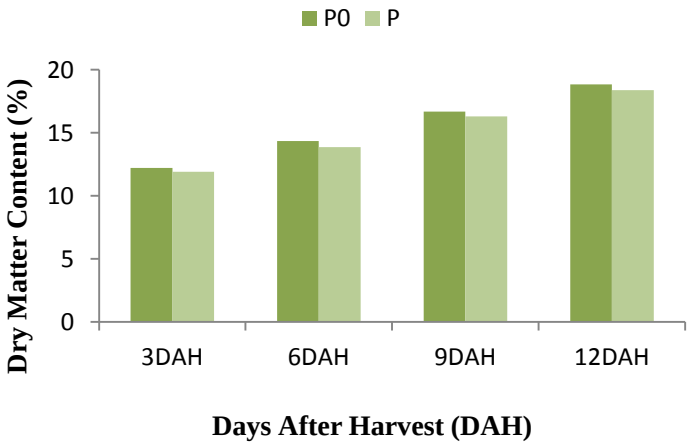

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 10: Effect of pre-harvest bagging on dry matter content of mango




T0: Control, T1: Hot water dips, T2: Hot water + Bavistin, T3: Bavistin + Hot water, T4 : Bavistin dips, T5: Hot water + calcium chloride, T6: calcium chloride + Hot water, T7: calcium chloride dips, T8: Bavistin + calcium chloride dips and T9: calcium chloride + Bavistin

Figure 11: Effect of postharvest treatments on dry matter content of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 12: Effect of postharvest bagging on dry matter content of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant impact on dry matter content of mango at different day after harvest. The highest dry matter content (20.56%, 22.80%, 24.55% and 25.45%) was observed in without pre harvest bagging mangoes with control treatment ($B_0T_0$) and lowest dry matter content (7.70%, 10.40.%, 13.15% and 15.80%) was found in pre harvest bagging mangoes when treated with calcium chloride dips ($BT_7$) at 3th, 6th, 9th and 12th days after harvest respectively (Table 7).

**Table 7. Interaction effect of pre-harvest bagging and post-harvest treatments on Dry matter (%) of mango**

| Treatments | Dry matter content at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH |
| $BT_0$ | 11.60 | 12.20 | 15.35 | 18.45 |
| $BT_1$ | 8.00 | 10.55 | 13.65 | 16.65 |
| $BT_2$ | 9.40 | 11.35 | 14.75 | 17.15 |
| $BT_3$ | 10.60 | 12.35 | 15.36 | 16.60 |
| $BT_4$ | 12.00 | 13.15 | 15.75 | 17.25 |
| $BT_5$ | 9.15 | 10.75 | 13.25 | 15.50 |
| $BT_6$ | 7.95 | 10.10 | 13.90 | 16.05 |
| $BT_7$ | 7.70 | 10.40 | 13.15 | 15.80 |
| $BT_8$ | 9.25 | 11.50 | 14.65 | 17.15 |
| $BT_9$ | 10.45 | 11.45 | 14.40 | 17.10 |
| $B_0T_0$ | 20.56 | 22.80 | 24.55 | 25.45 |
| $B_0T_1$ | 16.75 | 19.50 | 21.25 | 23.30 |
| $B_0T_2$ | 15.45 | 19.65 | 21.70 | 23.45 |
| $B_0T_3$ | 13.25 | 14.75 | 16.40 | 19.10 |
| $B_0T_4$ | 14.10 | 17.20 | 18.45 | 21.40 |
| $B_0T_5$ | 12.70 | 14.45 | 16.15 | 18.35 |
| $B_0T_6$ | 12.55 | 14.15 | 15.70 | 17.95 |
| $B_0T_7$ | 12.45 | 14.20 | 15.80 | 18.20 |
| $B_0T_8$ | 13.35 | 15.70 | 17.75 | 18.80 |
| $B_0T_9$ | 14.00 | 16.15 | 17.90 | 18.75 |
| SE(±) | 0.061 | 0.058 | 0.056 | 0.056 |
| CV% | 0.84 | 0.71 | 0.60 | 0.53 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Interaction between pre-harvest bagging and postharvest bagging had a great impact on dry matter content of mango. Data showed that the significant difference was observed in dry matter content of mango (Table 8). Highest dry matter content was observed from $B_0P_0$ treatment interaction compared to others interactions. The result of the present study is in support of the findings of Pramanik (1995). He stated that the dry matter content in Fazli increased from (17.14 to 28.86%) during harvest.

**Table 8. Interaction effect of pre-harvest bagging and post-harvest bagging on Dry matter (%) of mango**

| Treatments | Dry matter content at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH |
| $BP_0$ | 9.71 | 11.63 | 14.64 | 17.03 |
| BP | 9.51 | 11.13 | 14.20 | 16.51 |
| $B_0P_0$ | 14.71 | 17.09 | 18.75 | 20.67 |
| $B_0P$ | 14.32 | 16.62 | 18.38 | 20.28 |
| SE(±) | 0.026 | 0.026 | 0.025 | 0.025 |
| CV% | 0.84 | 0.71 | 0.60 | 0.53 |

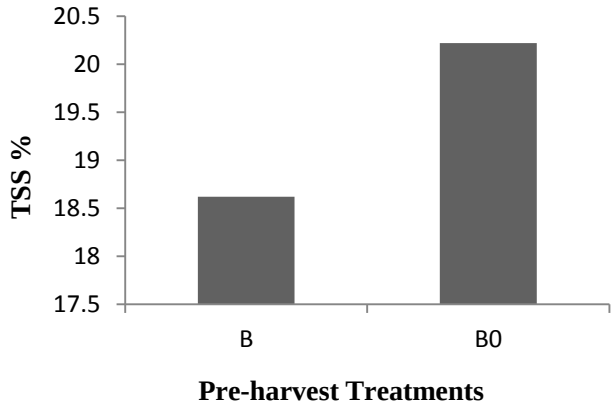
B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

### 4.5 Total soluble solids (TSS) content

Significant variation was observed in respect of total soluble solids (TSS) content between pre-harvest bagging and non-bagging mangoes (Appendix 5). The total soluble solids (TSS) content was greater in non-bagging mango compared to bagging one (Figure 13).

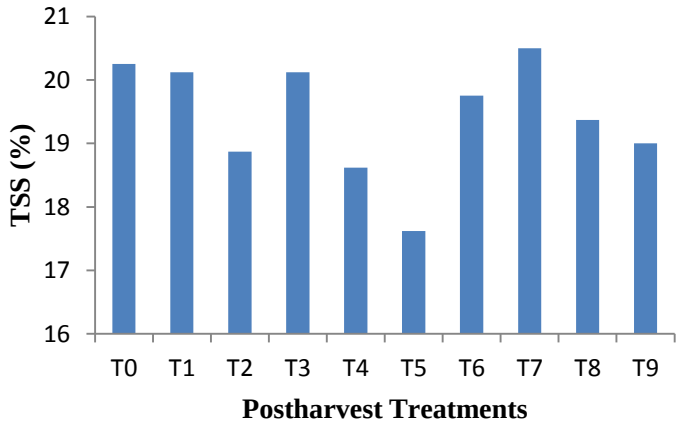
The present investigation showed that the postharvest treatments of mango had significant impact on total soluble solids (TSS) content (Appendix 5). Total soluble solids (TSS) content was found to be the highest (20.50%) at the end of shelf life in case Calcium chloride dips ($T_7$) where hot water and calcium chloride dips ($T_5$) represented the lowest total soluble solids (TSS) content (17.62%) (Figure 14).

Postharvest bagging had an influence on total soluble solids (TSS) content of mango (Appendix 5). Total soluble solids (TSS) content was found to be the lowest when mangoes were stored in perforated polybags (LDP) rather than the non-polybag mangoes (Figure 15).



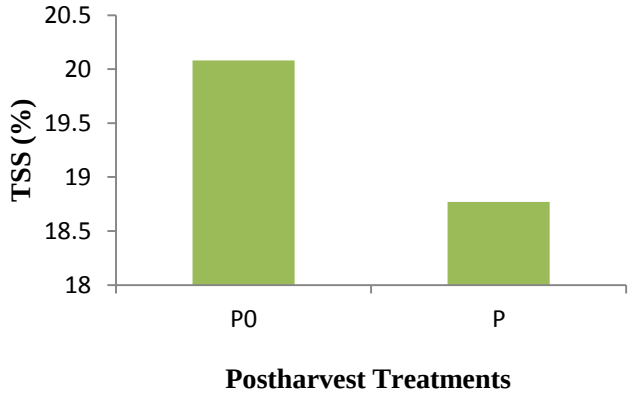

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 13: Effect of pre-harvest bagging on TSS (%) of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 14: Effect of postharvest treatments on TSS (%) of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 15: Effect of postharvest bagging on TSS (%) of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant impact on total soluble solids (TSS) content of mango at the end of shelf life. The highest total soluble solids (TSS) content (21.50%) was observed in without pre harvest bagging mangoes with control treatment ($B_0T_0$) and lowest total soluble solids (TSS) content (17.00%) was found in pre harvest bagging mangoes when treated with Bavistin dips ($BT_7$) at the end of shelf life (Table 9).

**Table 9. Interaction effect of pre-harvest bagging and post-harvest treatments on Total soluble solids (TSS %) of mango**

| Treatments | Total soluble solids (TSS %) at the end of Shelf Life |
|---|---|
| $BT_0$ | 19.00 |
| $BT_1$ | 19.50 |
| $BT_2$ | 18.75 |
| $BT_3$ | 19.25 |
| $BT_4$ | 17.00 |
| $BT_5$ | 16.25 |
| $BT_6$ | 19.25 |
| $BT_7$ | 19.75 |
| $BT_8$ | 19.50 |
| $BT_9$ | 18.00 |
| $B_0T_0$ | 21.50 |
| $B_0T_1$ | 20.75 |
| $B_0T_2$ | 19.00 |
| $B_0T_3$ | 21.00 |
| $B_0T_4$ | 20.25 |

| | |
|---|---|
| $B_0T_5$ | 19.00 |
| $B_0T_6$ | 20.25 |
| $B_0T_7$ | 21.25 |
| $B_0T_8$ | 19.25 |
| $B_0T_9$ | 20.00 |
| SE(±) | 0.517 |
| CV% | 4.61 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Interaction between pre-harvest bagging and postharvest bagging had a great impact on total soluble solids (TSS) content of mango. Data showed that the significant difference was observed in total soluble solids (TSS) content of mango (Table 10). Highest total soluble solids (TSS) content was observed from $B_0P_0$ treatment interaction compared to others interactions. Mollah and Siddique (1973) reported that 'Fazli' and 'Langra' showed (14.8%) and (18.00%) TSS respectively at the end of shelf life. They also found that TSS varied cultivar to cultivar.

**Table 10. Interaction effect of pre-harvest bagging and post-harvest bagging on Total soluble solids (TSS %) of mango**

| Treatments | Total soluble solids (TSS %) at the end of Shelf Life |
|---|---|
| $BP_0$ | 19.70 |
| BP | 17.55 |
| $B_0P_0$ | 20.45 |
| $B_0P$ | 20.00 |
| SE(±) | 0.231 |
| CV% | 4.61 |

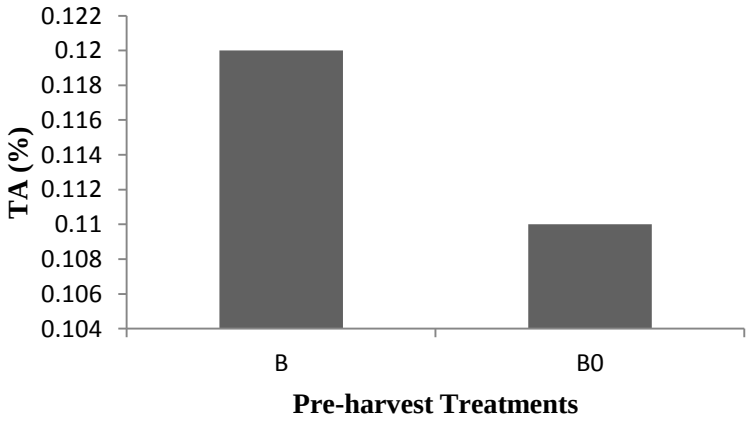
B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

## 4.6 Titratable acidity

Significant variation was observed in respect of titratable acidity (TA) between pre-harvest bagging and non-bagging mangoes (Appendix 5). The titratable acidity (TA) was greater in bagging mango compared to non-bagging one (Figure 16).

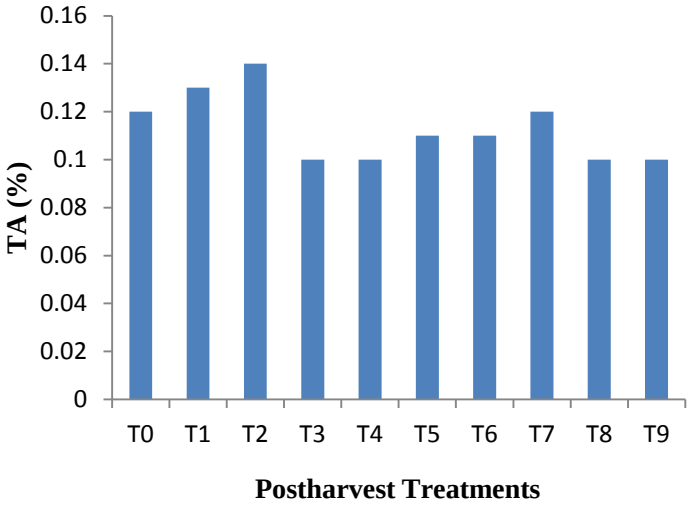
The present investigation showed that the postharvest treatments of mango had significant impact on titratable acidity (TA) (Appendix 5). Titratable acidity (TA) was found to be the highest (0.14%) at the end of shelf life in case hot water and Bavistin dips ($T_2$) (Figure 17).

Postharvest bagging had no significant effect on titratable acidity (TA) of mango (Appendix 5) (Figure 18)



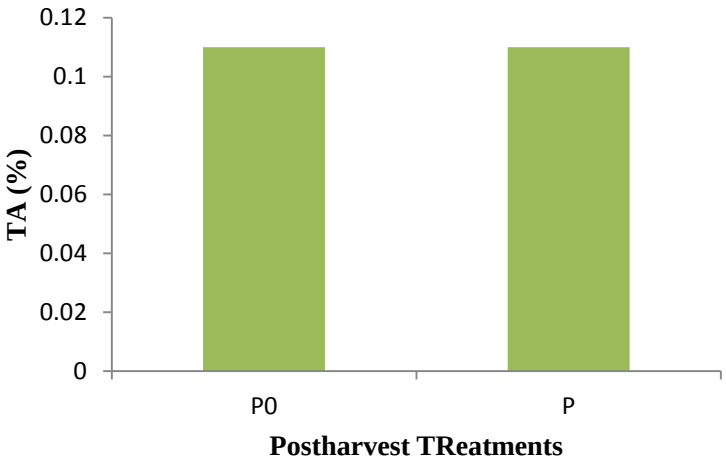

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 16: Effect of pre-harvest bagging on TA (%) of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 17: Effect of postharvest treatments on TA (%) of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 18: Effect of postharvest bagging on TA (%) of mango

Interaction between pre-harvest bagging, postharvest treatments and postharvest bagging had an effect on titratable acidity (TA) of mango. Data showed that the significant differences was observed in titratable acidity (TA) of mango (Table 11). Highest titratable acidity (TA) was observed from $BT_2$ $P_0$ treatment interaction compared to others interactions.

**Table 11. Interaction effect of pre-harvest bagging, post-harvest treatments and post-harvest bagging on Titrable acidity(%)of mango**

| Treatments | Titrable acidity(%)at the end of Shelf Life |
|---|---|
| $BT_0 P_0$ | 0.10 |
| $BT_0 P$ | 0.15 |
| $BT_1 P_0$ | 0.16 |
| $BT_1 P$ | 0.17 |
| $BT_2 P_0$ | 0.18 |
| $BT_2 P$ | 0.16 |
| $BT_3 P_0$ | 0.10 |
| $BT_3 P$ | 0.10 |
| $BT_4 P_0$ | 0.12 |
| $BT_4 P$ | 0.10 |
| $BT_5 P_0$ | 0.11 |
| $BT_5 P$ | 0.10 |
| $BT_6 P_0$ | 0.10 |
| $BT_6 P$ | 0.12 |
| $BT_7 P_0$ | 0.16 |
| $BT_7 P$ | 0.14 |
| $BT_8 P_0$ | 0.10 |
| $BT_8 P$ | 0.08 |
| $BT_9 P_0$ | 0.09 |
| $BT_9 P$ | 0.10 |
| $B_0T_0 P_0$ | 0.12 |
| $B_0T_0 P$ | 0.11 |
| $B_0T_1 P_0$ | 0.10 |
| $B_0T_1 P$ | 0.10 |
| $B_0T_2 P_0$ | 0.10 |
| $B_0T_2 P$ | 0.12 |
| $B_0T_3 P_0$ | 0.10 |
| $B_0T_3 P$ | 0.12 |
| $B_0T_4 P_0$ | 0.10 |
| $B_0T_4 P$ | 0.11 |
| $B_0T_5 P_0$ | 0.12 |
| $B_0T_5 P$ | 0.11 |
| $B_0T_6 P_0$ | 0.10 |
| $B_0T_6 P$ | 0.12 |
| $B_0T_7 P_0$ | 0.12 |
| $B_0T_7 P$ | 0.09 |
| $B_0T_8 P_0$ | 0.12 |

| | |
|---|---|
| $B_0T_8$ P | 0.12 |
| $B_0T_9$ $P_0$ | 0.12 |
| $B_0T_9$ P | 0.09 |
| SE(±) | 0.008 |
| CV% | 8.71 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

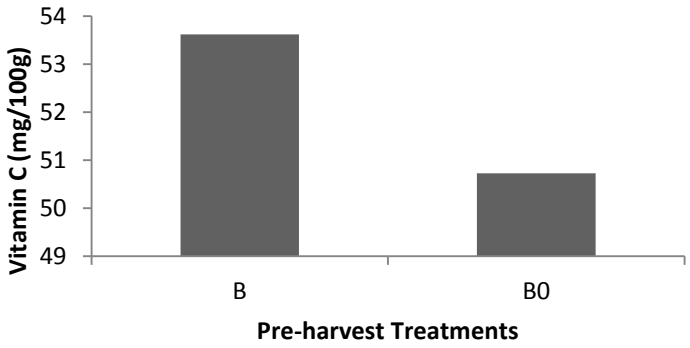
### 4.7 Vitamin C content

Significant variation was observed in respect of vitamin C content between pre-harvest bagging and non-bagging mangoes (Appendix 5). Vitamin C content was greater in bagging mango compared to non-bagging one (Figure 19).

The present investigation showed that the postharvest treatments of mango had significant impact on vitamin C content (Appendix 5).

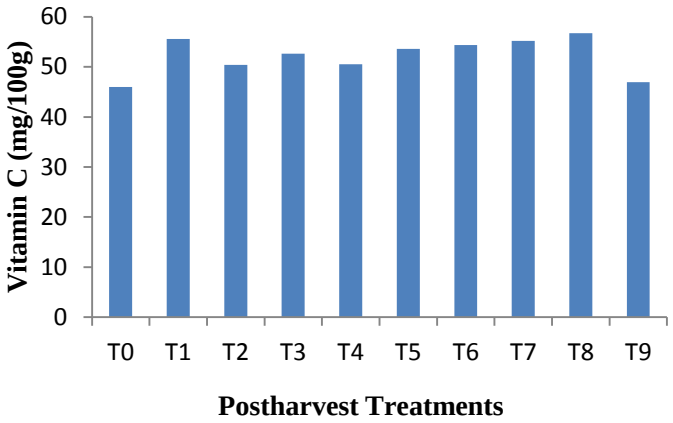
Vitamin C content was found to be the highest (56.70 mg/100g) at the end of shelf life in case Bavistin and Calcium chloride dips ($T_8$) where control treatment ($T_0$) represented the lowest vitamin C content (45.97 mg/100g) (Figure 20).

Postharvest bagging had an influence on vitamin C content of mango (Appendix 5). Vitamin C content was found to be lower when mangoes were stored in perforated polybags (LDP) than the non-polybag mangoes (Figure 21).



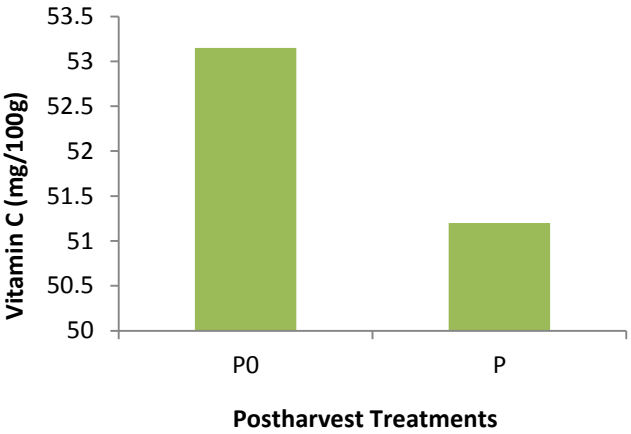

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 19: Effect of pre-harvest bagging on percent vitamin C of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 20: Effect of postharvest treatments on vitamin C content of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 21: Effect of postharvest bagging on vitamin C content of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant impact on Vitamin C content of mango at the end of shelf life. The highest Vitamin C content (57.06 mg/100g) was observed in bagging mango treated with hot water dips ($BT_1$) and lowest (44.80 mg/100g) was found in without pre harvest bagging mangoes with control treatment ($B_0T_0$) at the end of shelf life (Table 12). The result of the present study has got the support of Mondal et al. (1998) and Absar et al. (1993). They reported that vitamin C content decreased gradually during harvest, ripening and transport.

The decreased in vitamin content with harvest duration is attributed to the oxidation of ascorbic acid in to dehydro ascorbic acid by enzyme ascorbic acid oxidase (Singh and Abidi, 1986).

**Table 12. Interaction effect of pre-harvest bagging and post-harvest treatments on Vitamin C (mg/100g) Content of mango**

| Treatments | Vitamin C (mg/100g) Content at the end of Shelf Life |
|---|---|
| $BT_0$ | 47.15 |
| $BT_1$ | 57.06 |
| $BT_2$ | 51.70 |
| $BT_3$ | 54.40 |
| $BT_4$ | 51.95 |
| $BT_5$ | 55.60 |
| $BT_6$ | 55.50 |
| $BT_7$ | 56.75 |
| $BT_8$ | 58.00 |
| $BT_9$ | 48.10 |
| $B_0T_0$ | 44.80 |
| $B_0T_1$ | 54.05 |
| $B_0T_2$ | 49.10 |
| $B_0T_3$ | 50.80 |
| $B_0T_4$ | 49.05 |
| $B_0T_5$ | 51.55 |
| $B_0T_6$ | 53.25 |
| $B_0T_7$ | 53.60 |
| $B_0T_8$ | 55.40 |

| | |
|---|---|
| $B_0T_9$ | 45.75 |
| SE(±) | 0.056 |
| CV% | 0.19 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Interaction between pre-harvest bagging and postharvest bagging had a great impact on vitamin C content of mango. Data showed that the significant difference was observed in vitamin C content of mango (Table 13). Highest vitamin C content was observed from BP treatment interaction compared to other interactions.

**Table 13. Interaction effect of pre-harvest bagging and post-harvest bagging on Vitamin C (mg/100g) Content of mango**

| Treatments | Vitamin C (mg/100g) Content at the end of Shelf Life |
|---|---|
| $BP_0$ | 52.70 |
| BP | 54.54 |
| $B_0P_0$ | 49.70 |
| $B_0P$ | 51.77 |
| SE(±) | 0.025 |
| CV% | 0.19 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Combined effect of postharvest treatments and postharvest bagging using perforated LDP bags on vitamin C content had significant effect at the end of shelf life (Appendix 5). Calcium chloride dips with postharvest bagging ($T_7P$) gave the highest vitamin C content at the end of shelf life. Alternatively, the lowest vitamin C content was found in mango with control treatment and stored without polybag ($T_0P_0$) (Table 14).

**Table 14. Interaction effect of post-harvest treatments and post-harvest bagging on Vitamin C (mg/100g) Content of mango**

| Treatments | Vitamin C (mg/100g) Content at the end of Shelf Life |
|---|---|
| $T_0$ $P_0$ | 43.90 |
| $T_0P$ | 48.05 |
| $T_1P_0$ | 53.50 |
| $T_1P$ | 57.61 |
| $T_2P_0$ | 51.10 |
| $T_2P$ | 49.70 |
| $T_3P_0$ | 53.00 |
| $T_3P$ | 52.20 |
| $T_4P_0$ | 48.65 |
| $T_4P$ | 52.35 |
| $T_5P_0$ | 52.70 |
| $T_5P$ | 54.45 |
| $T_6P_0$ | 55.35 |
| $T_6P$ | 53.40 |
| $T_7P_0$ | 52.15 |
| $T_7P$ | 58.20 |
| $T_8P_0$ | 56.35 |
| $T_8P$ | 57.05 |
| $T_9P_0$ | 45.30 |
| $T_9P$ | 48.55 |
| SE(±) | 0.056 |
| CV% | 0.19 |

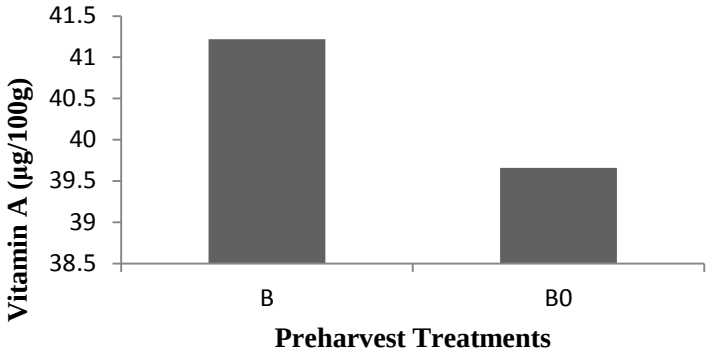
$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

### 4.8 Vitamin A content

Significant variation was observed in respect of vitamin A content between pre-harvest bagging and non-bagging mangoes (Appendix 5). Vitamin A content was greater in bagging mango compared to non-bagging one (Figure 22). The present investigation showed that the postharvest treatments of mango had significant impact on vitamin A content (Appendix 5).

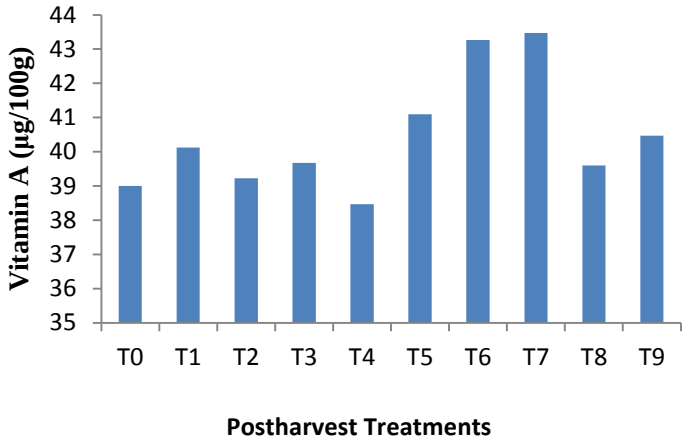
Vitamin A content was found to be the highest (43.47 µ/100g) at the end of shelf life in case of Calcium chloride dips ($T_7$) where control treatment ($T_0$) represented the lowest vitamin A content (39.00 µ/100g) (Figure 23).

Postharvest bagging had an influence too on vitamin A content of mango (Appendix 5). Vitamin A content was found to be lower when mangoes were stored in perforated polybags (LDP) than the non-polybag mangoes (Figure 24).



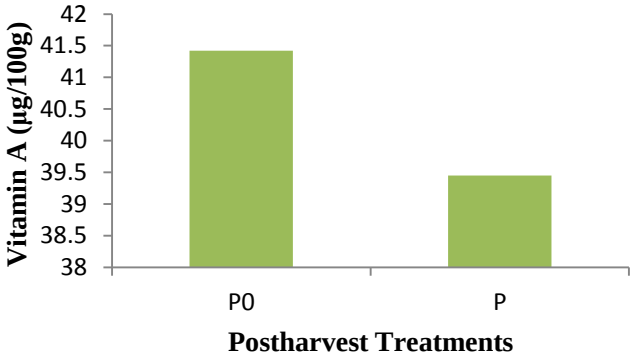

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 22: Effect of pre-harvest bagging on percent vitamin A of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 23: Effect of postharvest treatments on vitamin A content of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 24: Effect of postharvest bagging on vitamin A content of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant impact on Vitamin A content of mango at the end of shelf life. The highest Vitamin A content (44.40µ/100g) was observed in bagging mango treated with calcium chloride and hot water dips ($BT_6$) and lowest (38.15µ/100g) was found in without pre harvest bagging mangoes with control treatment ($B_0T_0$) at the end of shelf life (Table 15).

**Table 15. Interaction effect of pre-harvest bagging and post-harvest treatments on Vitamin A (µ/100g) Content of mango**

| Treatments | Vitamin A (µ/100g) Content at the end of Shelf Life |
|---|---|
| $BT_0$ | 39.85 |
| $BT_1$ | 41.05 |
| $BT_2$ | 39.94 |
| $BT_3$ | 40.60 |
| $BT_4$ | 38.85 |
| $BT_5$ | 41.65 |
| $BT_6$ | 44.40 |
| $BT_7$ | 44.00 |
| $BT_8$ | 40.53 |
| $BT_9$ | 41.40 |
| $B_0T_0$ | 38.15 |
| $B_0T_1$ | 39.20 |
| $B_0T_2$ | 38.50 |

| | |
|---|---|
| $B_0T_3$ | 38.75 |
| $B_0T_4$ | 38.10 |
| $B_0T_5$ | 40.55 |
| $B_0T_6$ | 42.15 |
| $B_0T_7$ | 42.95 |
| $B_0T_8$ | 38.70 |
| $B_0T_9$ | 39.5 |
| SE(±) | 0.056 |
| CV% | 0.24 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Combined effect of postharvest treatments and postharvest bagging using perforated LDP bags on vitamin A content had significant effect at the end of shelf life (Appendix 5). Calcium chloride dips without postharvest bagging ($T_7P_0$) gave the highest vitamin A content at the end of shelf life. Alternatively, the lowest vitamin A content was found in mango with control treatment and stored without polybag ($T_0P_0$) (Table 16).

**Table 16. Interaction effect of post-harvest treatments and post-harvest bagging on Vitamin A (µ/100g) Content of mango**

| Treatments | Vitamin A (µ/100g) Content at the end of Shelf Life |
|---|---|
| $T_0$ $P_0$ | 36.80 |
| $T_0P$ | 39.60 |
| $T_1P_0$ | 43.45 |
| $T_1P$ | 38.40 |
| $T_2P_0$ | 39.49 |
| $T_2P$ | 38.95 |
| $T_3P_0$ | 38.15 |
| $T_3P$ | 41.20 |
| $T_4P_0$ | 39.25 |
| $T_4P$ | 37.70 |
| $T_5P_0$ | 42.30 |
| $T_5P$ | 39.90 |

| | |
|---|---|
| $T_6P_0$ | 43.70 |
| $T_6P$ | 42.85 |
| $T_7P_0$ | 46.15 |
| $T_7P$ | 40.80 |
| $T_8P_0$ | 41.80 |
| $T_8P$ | 37.43 |
| $T_9P_0$ | 41.60 |
| $T_9P$ | 39.35 |
| SE(±) | 0.056 |
| CV% | 0.24 |

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

### 4.9 Disease incidence

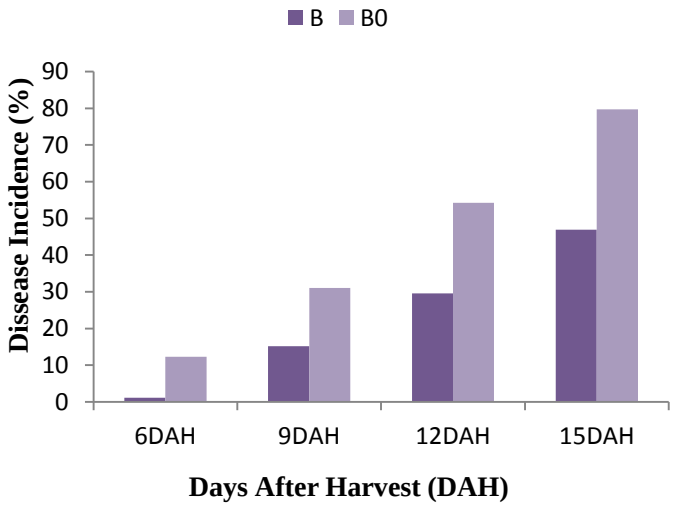
Significant variation was observed in respect of disease incidence between pre-harvest bagging and non-bagging mangoes (Appendix 6). It was observed that the disease incidence content trended to increase with the advancement of storage period in both bagging and non-bagging mangoes. Disease incidence was greater in non-bagging mango compared to bagging one (Figure 25).

The present investigation showed that the postharvest treatments of mango harvest had significant effects on disease incidence (Appendix 6).

Here, it was also observed a gradual inecrease in disease incidence with the advancement of storage duration. Disease incidence was found to be the highest (28.32% ,57.50% and 86.24% at 9th, 12th and 15th days of harvest respectively) at all stages in case of Bavistin and Calcium chloride dips ($T_8$) (Plate 3) where the Bavistin dips ($T_4$) represented the lowest disease incidence (11.55%, 24.35% and 36.95% at 9th, 12th and 15th days of harvest respectively) (Figure 26)

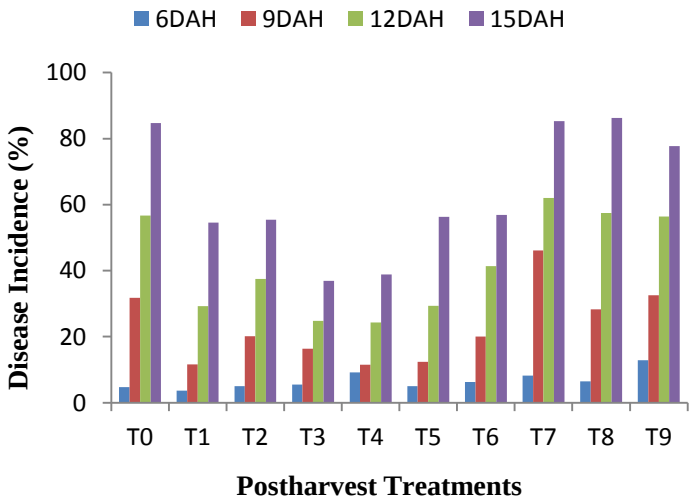
Postharvest bagging had an influence too on disease incidence of mango (Appendix 6). Disease incidence was found to be the lowest when mangoes

were stored in perforated polybags (LDP) rather than the non-polybag mangoes (Figure 27).



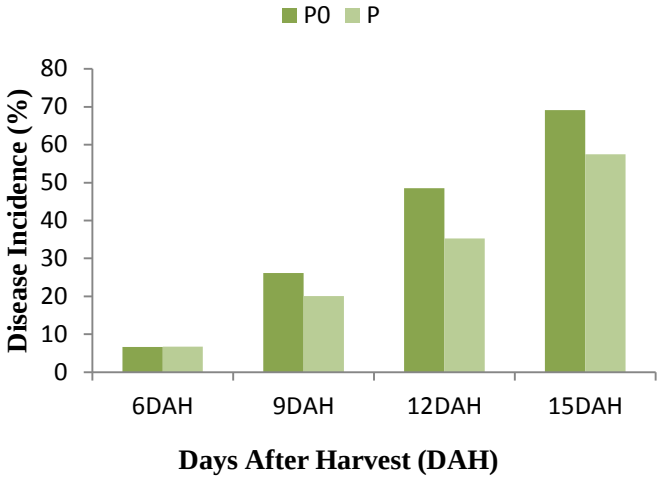

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 25: Effect of pre-harvest bagging on percent disease incidence of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 26: Effect of postharvest treatments on disease incidence of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 27: Effect of postharvest bagging on disease incidence of mango

Combined effects of pre-harvest bagging and postharvest treatments had also significant impact on disease incidence of mango at different day after harvest.

The highest disease incidence (40.45%, 77.40% and 100.00%) was observed in without pre-harvest bagging mangoes with Bavistin and Calcium chloride dips ($B_0T_8$) and lowest disease incidence (9.6.%, 16.55% and 22.85%) was found in pre-harvest bagging mangoes when treated with Bavistin and hot water dips ($BT_3$) (Plate 3) at 9th, 12th and 15th days after harvest respectively (Table 17).

**Table 17. Interaction effect of pre-harvest bagging and post-harvest treatments on Disease Incidence (%) of mango**

| Treatments | Disease Incidence (%) at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 6 DAH | 9 DAH | 12 DAH | 15 DAH |
| $BT_0$ | 0.00 | 32.75 | 56.80 | 80.55 |
| $BT_1$ | 0.00 | 2.80 | 20.95 | 38.95 |
| $BT_2$ | 0.00 | 13.45 | 25.15 | 30.90 |
| $BT_3$ | 0.00 | 9.6 | 16.55 | 22.85 |
| $BT_4$ | 11.00 | 4.15 | 8.65 | 19.20 |
| $BT_5$ | 0.00 | 4.10 | 19.95 | 41.60 |
| $BT_6$ | 0.00 | 8.65 | 17.35 | 30.45 |
| $BT_7$ | 0.00 | 40.95 | 48.65 | 76.60 |

| | | | | |
|---|---|---|---|---|
| $BT_8$ | 0.00 | 16.20 | 37.60 | 72.48 |
| $BT_9$ | 0.00 | 18.90 | 44.25 | 55.55 |
| $B_0T_0$ | 9.55 | 30.75 | 56.5 | 88.90 |
| $B_0T_1$ | 7.25 | 20.40 | 37.55 | 70.10 |
| $B_0T_2$ | 10.10 | 26.90 | 49.75 | 80.00 |
| $B_0T_3$ | 11.10 | 23.05 | 33.00 | 51.05 |
| $B_0T_4$ | 7.30 | 18.95 | 40.05 | 58.57 |
| $B_0T_5$ | 10.00 | 20.75 | 38.85 | 71.05 |
| $B_0T_6$ | 12.60 | 31.50 | 65.40 | 83.30 |
| $B_0T_7$ | 16.50 | 51.40 | 75.35 | 94.05 |
| $B_0T_8$ | 12.95 | 40.45 | 77.40 | 100.00 |
| $B_0T_9$ | 25.70 | 46.30 | 68.50 | 100.00 |
| SE(±) | 0.084 | 0.106 | 0.102 | 0.382 |
| CV% | 2.19 | 0.80 | 0.42 | 1.05 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Interaction between pre-harvest bagging and postharvest bagging had a great impact on disease incidence of mango. Data showed that the significant difference was observed in disease incidence of mango (Table 18). Highest disease incidence was observed from $B_0P_0$ treatment interaction compared to other interactions.

**Table 18. Interaction effect of pre-harvest bagging and post-harvest bagging on Disease Incidence (%) of mango**

| Treatments | Disease Incidence (%) at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH |
| $BP_0$ | 0.00 | 22.14 | 38.55 | 52.8 |
| BP | 2.20 | 8.18 | 20.63 | 40.95 |
| $B_0P_0$ | 13.29 | 30.21 | 58.55 | 85.373 |
| $B_0P$ | 11.32 | 31.88 | 49.93 | 74.030 |
| SE(±) | 0.037 | 0.047 | 0.045 | 0.171 |
| CV% | 2.19 | 0.80 | 0.42 | 1.05 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

The combined effect of postharvest treatments and postharvest bagging using perforated LDP bags on disease incidence was highly significant in all stages of observation (Appendix 2). Gradual increase in disease incidence was found with the increase of duration. The control treatment without postharvest bagging ($T_0P_0$) gave the highest disease incidence at all stages of harvest observation. Alternatively, the lowest disease incidence was found in mango treated with Bavistin dips and stored in perforated polybag ($T_4P$) (Table 19).

**Table 19. Interaction effect of post-harvest treatments and post-harvest bagging on Disease Incidence (%) of mango**

| Treatments | Disease Incidence (%) at Different Days After Harvest (DAH) | | | |
|---|---|---|---|---|
| | 3 DAH | 6 DAH | 9 DAH | 12 DAH |
| $T_0$ $P_0$ | 6.05 | 55.30 | 81.30 | 100.00 |
| $T_0P$ | 3.50 | 8.20 | 32.05 | 69.45 |
| $T_1P_0$ | 4.70 | 10.75 | 30.50 | 63.95 |
| $T_1P$ | 2.55 | 12.45 | 28.00 | 45.10 |
| $T_2P_0$ | 4.95 | 17.10 | 31.70 | 50.40 |
| $T_2P$ | 5.15 | 23.25 | 43.20 | 60.50 |
| $T_3P_0$ | 6.55 | 18.45 | 26.55 | 40.75 |
| $T_3P$ | 4.55 | 14.25 | 23.00 | 33.15 |
| $T_4P_0$ | 5.90 | 13.45 | 29.60 | 48.32 |
| $T_4P$ | 12.40 | 9.65 | 19.10 | 29.45 |
| $T_5P_0$ | 5.05 | 10.90 | 34.00 | 61.30 |
| $T_5P$ | 4.95 | 13.95 | 24.80 | 51.35 |
| $T_6P_0$ | 8.55 | 22.30 | 52.00 | 60.90 |
| $T_6P$ | 4.05 | 17.85 | 30.75 | 52.8 |
| $T_7P_0$ | 5.95 | 52.90 | 69.50 | 86.85 |
| $T_7P$ | 10.55 | 39.45 | 54.50 | 83.80 |
| $T_8P_0$ | 4.40 | 26.20 | 63.90 | 92.65 |
| $T_8P$ | 8.55 | 30.45 | 51.10 | 79.83 |
| $T_9P_0$ | 14.35 | 34.40 | 66.45 | 86.10 |
| $T_9P$ | 11.35 | 30.80 | 46.30 | 69.45 |
| SE(±) | 0.084 | 0.106 | 0.102 | 0.382 |
| CV% | 2.19 | 0.80 | 0.42 | 1.05 |

$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

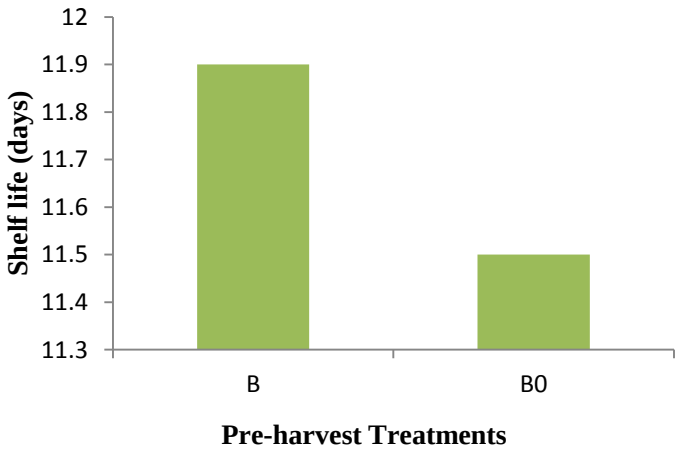
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

### 4.10 Shelf life

Postharvest treatments exerted significant effects in extending shelf life of mango (Appendix 5). Significant variation was observed in respect of shelf life between pre-harvest bagging and non-bagging mangoes (Appendix 5). Shelf life was greater in bagging mango compared to non-bagging one (Figure 28).

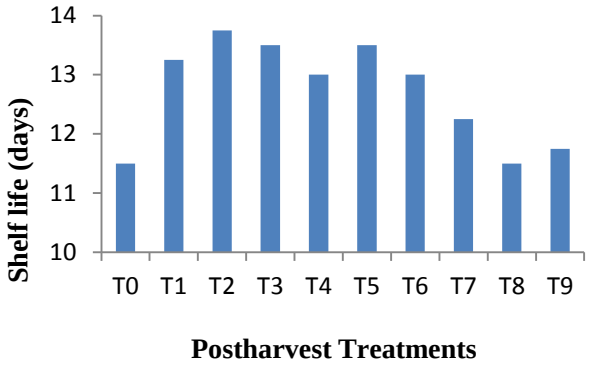
The results of the study revealed that the shelf life of mango fruits ranged from 9.00 to 15.00 days. The longest shelf life (13.75 days) was found in Hot water and Bavistin dips ($T_2$) followed by $T_3$ (Bavistin and Hot water dips), $T_6$ (Calcium chloride and Hot water dips) and $T_1$ (Hot water dips) where the shortest shelf life (11.50 days) was recorded in control (Figure 29).

Postharvest bagging had an influence too on shelf life of mango (Appendix 5). Shelf life was found to be higher when mangoes were stored in perforated polybags (LDP) than the non-polybag mangoes (Figure 30).



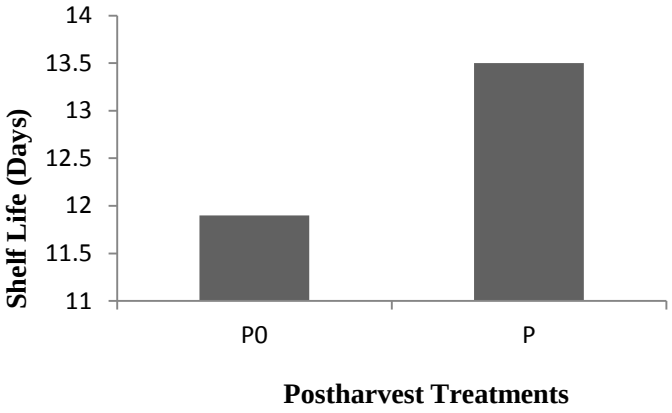

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging

Figure 28: Effect of pre-harvest bagging on shelf life of mango




$T_0$: Control, $T_1$: Hot water dips, $T_2$: Hot water + Bavistin, $T_3$: Bavistin + Hot water, $T_4$ : Bavistin dips, $T_5$: Hot water + calcium chloride, $T_6$: calcium chloride + Hot water, $T_7$: calcium chloride dips, $T_8$: Bavistin + calcium chloride dips and $T_9$: calcium chloride + Bavistin

Figure 29: Effect of postharvest treatments on shelf life of mango




P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

Figure 30: Effect of postharvest bagging on shelf life of mango

Interaction between pre-harvest bagging and postharvest bagging had a great effect on shelf life of mango. Data showed that the significant difference was observed in shelf life of mango (Table 20). Highest shelf life was observed from BP treatment interaction compared to other interactions.

The extension of shelf life of fruit has been one of the prime concerns of marketing throughout the record of history. Similar results were found by Salunkhe and Desai, 1984.

**Table 20. Interaction effect of pre-harvest bagging and post-harvest bagging on Shelf Life (Days) of mango**

| Treatments | Shelf Life (Days) |
|---|---|
| **$BP_0$** | 13.50 |
| **BP** | 14.30 |
| **$B_0P_0$** | 10.30 |
| **$B_0P$** | 12.70 |
| **SE(±)** | 0.258 |
| **CV%** | 7.87 |

B: Pre-harvest bagging and $B_0$: Without Pre-harvest bagging
P: Post-harvest bagging and $P_0$: Without Post-harvest bagging

# CHAPTER V

# SUMMARY AND CONCLUSIONS

The experiment was carried out at the Department of Horticulture, Sher-e-Bangla Agricultural University,Dhaka during June to July 2017. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. The present research was conducted on the aspect of physiological changes and shelf life of mango through pre-harvest bagging, various postharvest treatments and postharvest bagging. An important variety of mango namely, Langra was assigned to different pre and postharvest treatments (Control; Hot water dips; Calcium chloride dips; Bavistin dips) and postharvest bagging with LDP were used in the present study.

In this study observations were made on external and internal fruit attributes, physiochemical properties such as total weight loss, moisture content, dry matter content, total soluble solids content, vitamin C, vitamin A, disease incidence and shelf life. External fruit attributes were evaluated by unaided eye, and standard color chart was used for the determination of skin color. In this experiment mango of each treatment from three replications were collected randomly at 3, 6, 9, 12 and15 days after harvest for physiochemical studies. The data were statistically analyzed and interpreted. Marked variations were observed in relation to various fruit characters. The results of the experiment showed that almost all the parameters studied were significantly influenced by the above factors.

In case of pre-harvest bagging, results revealed that color score and percent moisture content were higher in bagging mango than non-bagging mango. However, dry matter content was greater in non-bagging mango than bagging one. Though TSS vary a little between bagging and non-bagging mango but titrable acidity, vitamin C and vitamin A content are higher in bagging mangoes treated with pre-harvest bagging. Again, pre-harvest bagging showed a significant effect on controlling disease incidence. As a result, percent disease

incidence was lower in bagging mango than the non-bagging one. Pre-harvest bagging gave a longer shelf life too.

Total ten postharvest treatments were applied in this experiment with control. Among all those treatments highest color scores (2.90, 4.35,4.90, 6.70 and 6.85) were observed in calcium chloride and bavistin dips treatment ($T_9$), Hot water dips ($T_1$) represented the lowest weight loss (7.17%, 10.40%, 13.12%, 15.80% and 16.67% at 3rd, 6th, 9th, 12th and 15th days of harvest respectively), the highest moisture content found (89.07%, 87.40%, 85.30% and 83.07% at3rd, 6th, $9^{th}$ and 12th days of harvest respectively) and the lowest dry matter content found (10.92%, 12.60%, 14.70% and 16.92% at3rd, 6th, $9^{th}$ and 12th days of harvest respectively) at all stages in case of Hot water and Calcium chloride dips ($T_5$). Again, Total soluble solids (TSS) content was found to be the highest (20.50%) at the end of shelf life in case Calcium chloride dips ($T_7$) where hot water and calcium chloride dips ($T_5$) represented the lowest total soluble solids (TSS) content (17.62%). Vitamin C content was found to be the highest (56.70 mg/100g) at the end of shelf life in case Bavistin and Calcium chloride dips ($T_8$) where control treatment ($T_0$) represented the lowest vitamin C content (45.97 mg/100g) where Vitamin A content was found to be the highest (43.47 μ/100g) at the end of shelf life in case of Calcium chloride dips ($T_7$). However, Bavistin dips ($T_4$) represented the lowest disease incidence (11.55%, 24.35% and 36.95% at 9th, 12th and 15th days of harvest respectively) compared to other treatments.

In case of postharvest bagging, total weight loss was found to be the lowest when mangoes were stored in perforated polybags (LDP) rather than the non-polybag mangoes when percent moisture content was higher in mangoes stored in perforated polybags (LDP). Whether, total soluble solids (TSS) content was found to be the lowest when mangoes were stored in perforated polybags (LDP), postharvest bagging had no significant effect on titratable acidity (TA) of mango. Disease incidence was found to be the lowest and higher shelf life when mangoes were stored in perforated polybags (LDP).

Between these three factors there were four treatment combinations. Among them combined effects of pre-harvest bagging and postharvest treatments had significant effect on color changes of mango where the highest color score (4.60, 5.60, 6.80 and 7.00) was observed in bagging mangoes when treated with calcium chloride and bavistin dips ($BT_9$), higher percent moisture content (92.30%, 89.60%, 86.86% and 84.20%) in pre-harvest bagging mangoes treated with calcium chloride dips ($BT_7$), the lowest dry matter content (7.70%, 10.40.%, 13.15% and 15.80%) in pre-harvest bagging mangoes treated with calcium chloride dips ($BT_7$) at 3th, 6th, 9th and 12th days after harvest respectively, the lowest total soluble solids (TSS) content (17.00%) in pre-harvest bagging mangoes treated with calcium chloride dips ($BT_7$) at the end of shelf life, the highest Vitamin C content (57.06 mg/100g) in bagging mango treated with hot water dips ($BT_1$), the highest Vitamin A content (44.40µ/100g) in bagging mango treated with calcium chloride and hot water dips ($BT_6$), the lowest disease incidence (9.6.%, 16.55% and 22.85%) was found in pre-harvest bagging mangoes when treated with Bavistin and hot water dips ($BT_3$) at 9th, 12th and 15th days after harvest respectively.

In case of pre and postharvest bagging, the highest percent moisture content was observed from $B_0P$ treatment interaction compared to others interactions, the highest dry matter , total soluble solids (TSS) content and disease incidence were observed from $B_0P_0$ treatment interaction compared to others interactions. However, the highest vitamin C content and shelf life were observed from BP treatment interaction.

Combined effect of postharvest treatments and postharvest bagging gave the highest color score (4.40, 5.50, 6.80 and 7.00) treated with Bavistin dips and stored in LDP bags ($T_4P$), control treatment without postharvest bagging ($T_0P_0$) gave the highest weight loss at all stages of harvest observation, calcium chloride dips with postharvest bagging ($T_7P$) gave the highest vitamin C content at the end of shelf life where calcium chloride dips without postharvest bagging ($T_7P_0$) gave the highest vitamin A content at the end of shelf life.

Again, control treatment without postharvest bagging ($T_0P_0$) gave the highest disease incidence at all stages of harvest observation where the lowest disease incidence was found in mango treated with Bavistin dips and stored in perforated polybag ($T_4P$).

Interaction between pre-harvest bagging, postharvest treatments and postharvest bagging had an effect on total weight loss of mango where the highest weight loss was observed from $BT_3$ $P_0$ treatment interaction, the highest titratable acidity (TA) was observed from $BT_2$ $P_0$ treatment interaction and

Finally, it can be concluded that mango should be treated with pre-harvest bagging, hot water and bavistin dips and stored in perforated polybags (LDP) for long term storage quality control, transportation and marketing.

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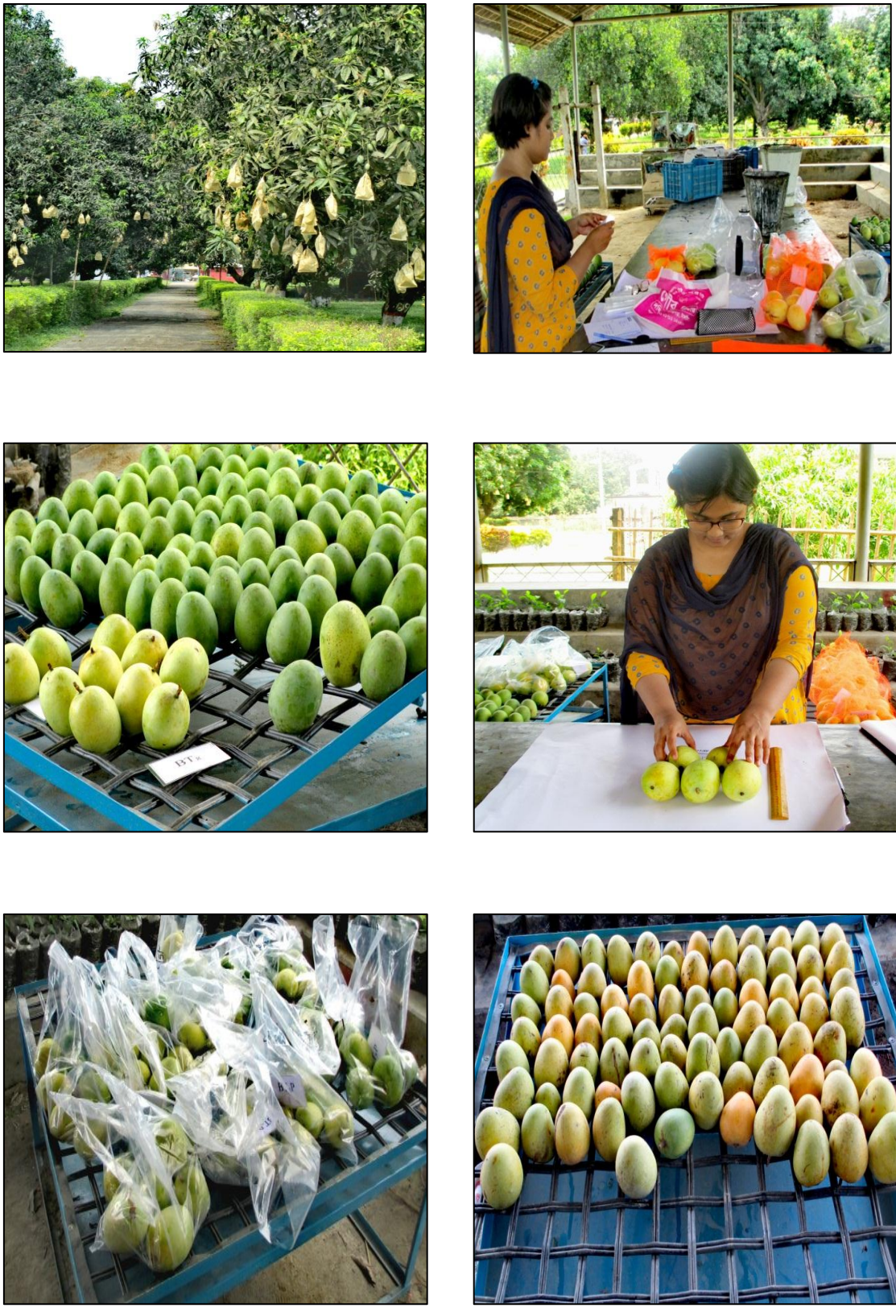


Plate 1. Preparation for postharvest treatments at the day of harvest

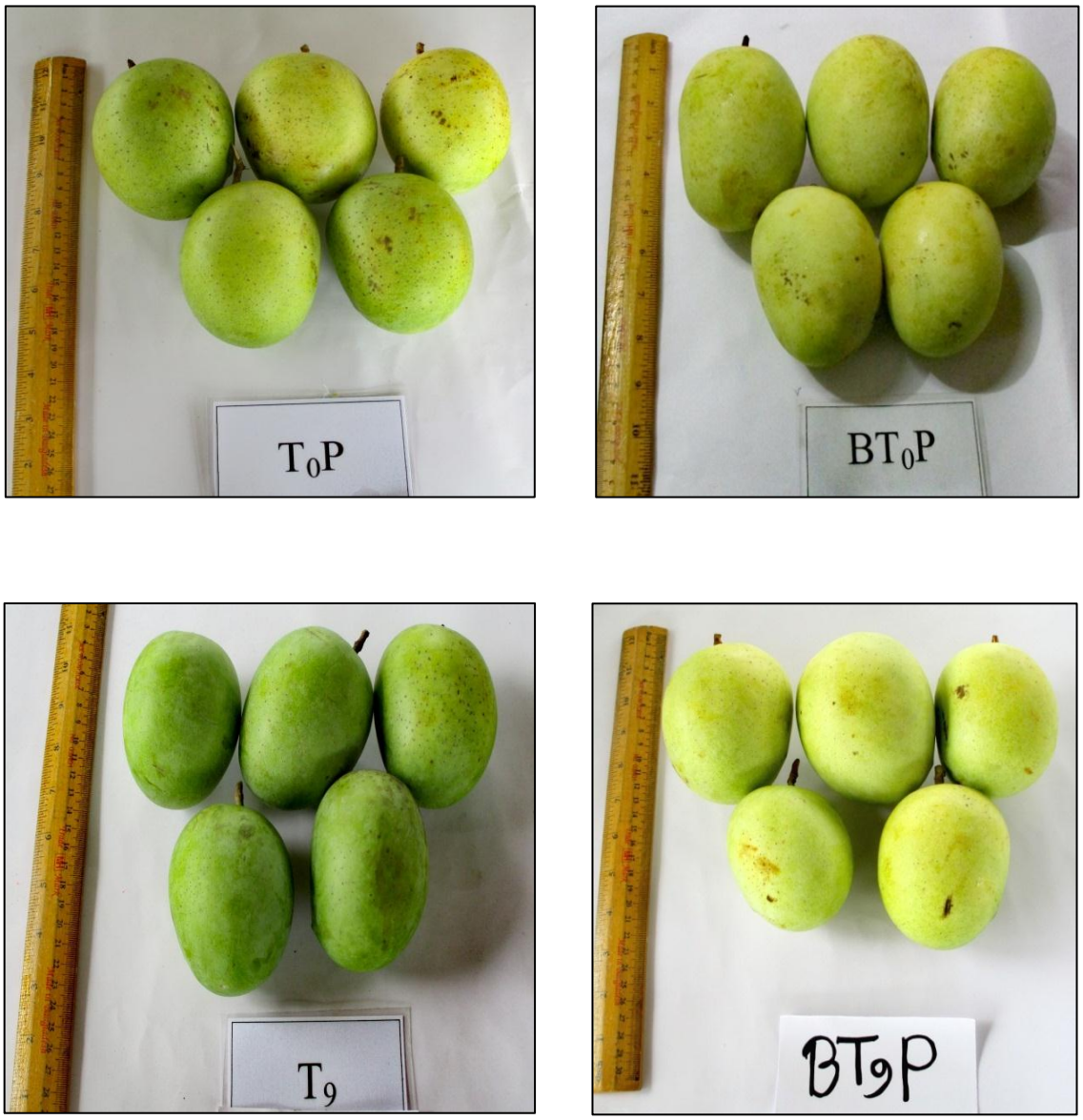



Plate 2. Comparison of color among the pre-harvest bagging and non-bagging mangoes at the day of harvest

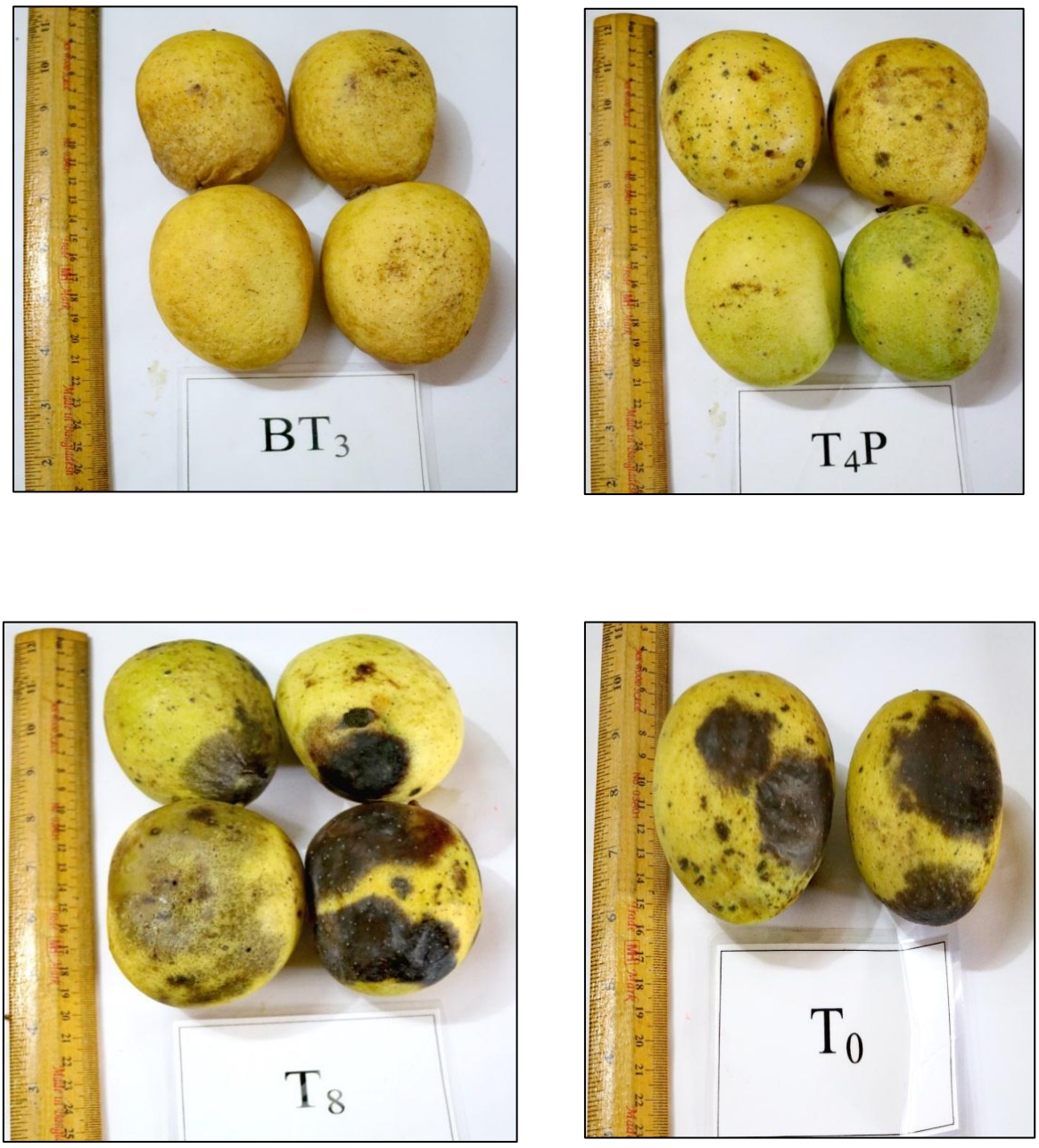
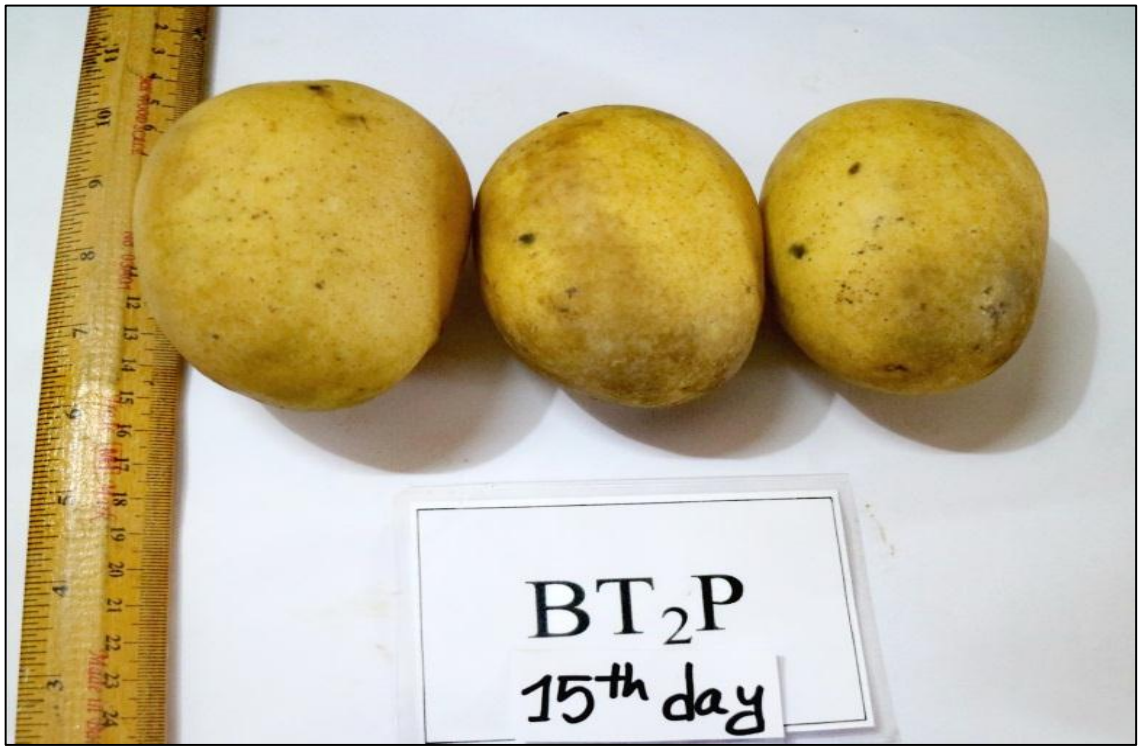



Plate 3. Comparison of disease incidence among the treatment interactions



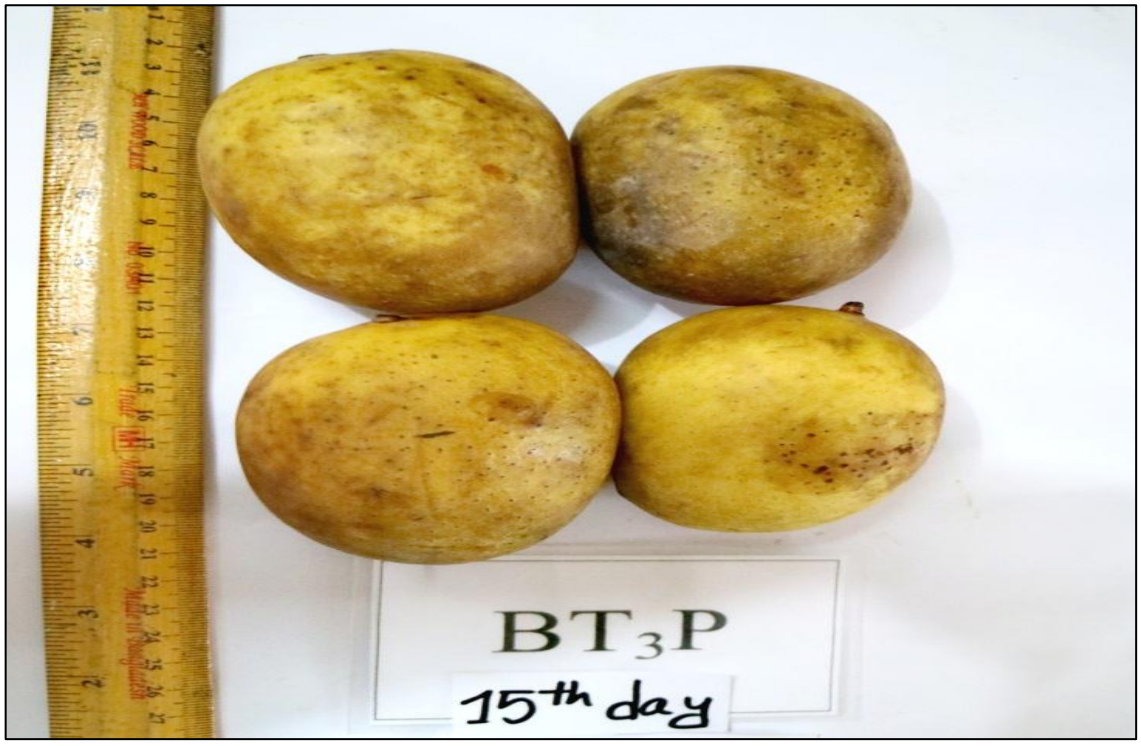




Plate 4. At the end of shelf life

# APPENDICES

## Appendix 1: Effect of pre-harvest bagging, postharvest treatments and postharvest bagging on color of mango

| Mean Square | Degrees of Freedom | Mean square of color at different days after harvest (DAH) | | | | |
|---|---|---|---|---|---|---|
| | | 3 | 6 | 9 | 12 | 15 |
| Replication | 2 | 0.19 | 0.02 | 0.04 | 0.02 | 0.009 |
| Factor A | 1 | 7.95** | 1.12** | 1.54** | 0.50** | 0.24** |
| Factor B | 9 | 0.38** | 0.92** | 1.83** | 2.89** | 0.50** |
| Factor C | 1 | 0.01** | NS | 0.90** | 1.49** | NS |
| AB | 9 | NS | 1.41** | 1.74** | 1.08** | 0.36** |
| AC | 1 | 0.46** | NS | NS | 2.64** | 0.67** |
| BC | 9 | 0.50** | 1.20** | 2.52** | 0.93** | 0.23** |
| ABC | 9 | 0.44** | 1.24** | 1.61** | 1.25** | 0.72** |
| Error | 78 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 |

** = Significant at 1% level of significance

NS Non significant

## Appendix 2: Effect of pre-harvest bagging, postharvest treatments and postharvest bagging on weight loss (%) of mango

| Mean Square | Degrees of Freedom | Mean square of weight loss at different days after harvest (DAH) | | | | |
|---|---|---|---|---|---|---|
| | | 3 | 6 | 9 | 12 | 15 |
| Replication | 2 | 0.002 | 0.29 | 0.35 | 0.17 | 0.01 |
| Factor A | 1 | NS | 0.77** | 0.77** | 34.56** | 59.64** |
| Factor B | 9 | 50.60** | 46.87** | 45.48** | 38.35** | 45.51** |
| Factor C | 1 | 15577.60** | 2600.28** | 3201.27** | 3685.21** | 3933.07** |
| AB | 9 | 27.47** | 26.66** | 25.70** | 29.06** | 28.26** |
| AC | 1 | 52.93** | 34.99** | 30.00** | 28.03** | 25.39** |
| BC | 9 | 137.70** | 123.13** | 113.08** | 119.98** | 140.91** |
| ABC | 9 | 33.89** | 32.94** | 29.56** | 33.62** | 46.91** |
| Error | 78 | 0.04 | 0.03 | 0.03 | 0.05 | 0.04 |

**= Significant at 1% level of significance

NS Non significant

**Appendix 3: Effect of pre-harvest bagging, postharvest treatments and postharvest bagging on moisture content (%) of mango**

| Mean Square | Degrees of Freedom | Mean square of moisture content at different days after harvest (DAH) | | | |
|---|---|---|---|---|---|
| | | 3 | 6 | 9 | 12 |
| Replication | 2 | 0.001 | 0.001 | 0.012 | 0.009 |
| Factor A | 1 | 721.77** | 897.62** | 515.38** | 411.81** |
| Factor B | 9 | 35.52** | 34.11** | 34.58** | 34.47** |
| Factor C | 1 | 2.43** | 6.91** | 5.006** | 6.21** |
| AB | 9 | 16.71** | 22.71** | 24.79** | 14.01** |
| AC | 1 | 0.21** | NS | 0.053* | 0.12** |
| BC | 9 | 0.07** | 0.265** | 0.17** | 0.26** |
| ABC | 9 | 0.103** | 0.112** | 0.089** | 0.42** |
| Error | 78 | 0.01 | 0.01 | 0.01 | 0.01 |

* = Significant at 5% level of significance

** = Significant at 1% level of significance

NS Non significant

**Appendix 4: Effect of pre-harvest bagging, postharvest treatments and postharvest bagging on dry matter content (%) of mango**

| Mean Square | Degrees of Freedom | Mean square of dry matter content at different days after harvest (DAH) | | | |
|---|---|---|---|---|---|
| | | 3 | 6 | 9 | 12 |
| Replication | 2 | 0.002 | 0.004 | 0.01 | 0.025 |
| Factor A | 1 | 713.131** | 899.26** | 515.01** | 411.81** |
| Factor B | 9 | 32.89** | 34.08** | 35.95** | 34.47** |
| Factor C | 1 | 2.54** | 7.05** | 4.88** | 6.21** |
| AB | 9 | 16.03** | 22.67** | 22.64** | 14.01** |
| AC | 1 | 0.25** | NS | NS | 0.12** |
| BC | 9 | 0.07** | 0.262** | 0.302** | 0.26** |
| ABC | 9 | 0.10** | 0.11** | 0.29** | 0.42** |
| Error | 78 | 0.01 | 0.01 | 0.01 | 0.01 |

** = Significant at 1% level of significance

NS Non significant

**Appendix 5: Effect of pre-harvest bagging, postharvest treatments and postharvest bagging on vitamin C, vitamin A, TSS, TA and shelf life of mango**

| Mean Square | Degrees of Freedom | Mean square at the end of shelf life | | | | |
|---|---|---|---|---|---|---|
| | | Vitamin C | Vitamin A | TSS | TA | Shelf life |
| Replication | 2 | 0.014 | 0.005 | 1.22 | 0.00004 | 1.075 |
| Factor A | 1 | 249.98** | 73.74** | 76.80** | 0.005 | 172.80** |
| Factor B | 9 | 1438.34** | 35.28** | 9.71** | 0.002 | 9.13** |
| Factor C | 1 | 114.86** | 116.56** | 50.70** | NS | 76.80** |
| AB | 9 | 9.28** | 0.65** | 3.59** | 0.003 | 3.13** |
| AC | 1 | 0.39** | 0.23** | 21.67** | NS | 19.20** |
| BC | 9 | 200.08** | 26.01** | 6.82** | 0.0006 | 2.80** |
| ABC | 9 | 4.22** | 0.33** | 2.05** | 0.0007 | 2.53* |
| Error | 78 | 0.76 | 0.01 | 62.55 | 0.0001 | 0.99 |

* = Significant at 5% level of significance

** = Significant at 1% level of significance

NS Non significant

**Appendix 6: Effect of pre-harvest bagging, postharvest treatments and postharvest bagging on disease incidence (%) of mango**

| Mean Square | Degrees of Freedom | Mean square of disease incidence at different days after harvest (DAH) | | | |
|---|---|---|---|---|---|
| | | 6 | 9 | 12 | 15 |
| Replication | 2 | 0.01 | 0.03 | 0.003 | 0.2 |
| Factor A | 1 | 3766.56** | 7570.00** | 18228.7** | 32252.2** |
| Factor B | 9 | 88.71** | 1556.94** | 2683.75** | 4265.4** |
| Factor C | 1 | 0.40** | 1132.83** | 5282.79** | 4056.5** |
| AB | 9 | 162.12** | 205.77** | 537.37** | 581.0** |
| AC | 1 | 130.42** | 1832.23** | 648.67** | 2.4* |
| BC | 9 | 41.64** | 718.21** | 752.35** | 355.6** |
| ABC | 9 | 93.20** | 776.44** | 1034.85** | 814.4** |
| Error | 78 | 0.02 | 0.03 | 0.03 | 0.4 |

* = Significant at 5% level of significance

** = Significant at 1% level of significance