POSTHARVEST MANAGEMENT OF 'HARIVANGA' MANGO VARIETY TO INCREASE SHELF LIFE AND QUALITY

TAMANNA YESMIN

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2018

POSTHARVEST MANAGEMENT OF 'HARIVANGA' MANGO VARIETY TO INCREASE SHELF LIFE AND QUALITY

BY

TAMANNA YESMIN

REGISTRATION NO. : 12-04734

A Thesis
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

SEMESTER: JANUARY-JUNE, 2018

Approved by:

Prof. Dr. Md. Nazrul Islam	**Prof. Md. Hasanuzzaman Akand**
Department of Horticulture	Department of Horticulture
Sher-e-Bangla Agricultural University	Sher-e-Bangla Agricultural University
Dhaka-1207	Dhaka-1207
Supervisor	**Co-supervisor**

Prof Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/HORT/……. Date: ……..

CERTIFICATE

This is to certify that the thesis entitled **'Postharvest Management of 'Harivanga' Mango Variety to Increase Shelf Life and Quality**' submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the results of a piece of bona fide research work carried out by **TAMANNA YESMIN**, Registration No.**12-04734** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: June, 2018
Dhaka, Bangladesh

Prof. Dr. Md. Nazrul Islam
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207

Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, the Supreme Ruler of the universe who enables the author to complete this present piece of work. Tthe author deems it a great pleasure to express her profound gratefulness to her respected parents, who entiled much hardship inspiring for prosecuting her studies, receiving proper education.

The author feels proud to express her heartiest sence of gratitude and sincere appreciation to her Supervisor Professor **Dr. Md. Nazrul Islam**, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, for his continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her Co-supervisor Professor **Md. Hasanuzzaman Akand**, Department of Horticulture, SAU, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author expresses her sincere respect and sence of gratitude to Professor **Dr. Mohammad Humayun Kabir,** Honorable Chairman, Departement of Horticulture, SAU, Dhaka for cordial cooperation during the study period.The author also expresses her heartfelt thanks to all the teachers of the Department of Horticulture, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author expresses her sincere appreciation to her relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

The Author

POSTHARVEST MANAGEMENT OF 'HARIVANGA' MANGO VARIETY TO INCREASE SHELF LIFE AND QUALITY

BY

TAMANNA YESMIN

ABSTRACT

The study was conducted at the laboratory of the Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from July 2018 to assess the postharvest management of 'Harivanga' mango variety to increase shelf life and quality. The popular Mango variety 'Harivanga' were used as experimental materials for the study. The experiment comprised of 19 different postharvest practices as treatment and T_1: Control condition (no postharvest treatments and stored in open condition). T_8 treatment given the highest result and T_8: Stored in low density perforated polybag after Bavistin dips treatment. Data were recorded on shelf life and different quality parameters and statistically significant differences were observed for different treatments. The highest shelf life (15.67 days) was observed from T_8 treatment, whereas the lowest shelf life (9.00 days) was recorded from T_1 treatment. At 3, 5, 7 and 9 days after harvest (DAH), the highest moisture content (85.44%, 83.36%, 82.18% and 80.14%, respectively) was found from T_8 treatment, whereas the lowest moisture content (81.76%, 80.22%, 78.66% and 75.85%, respectively) was observed from T_1 treatment. At 3, 5, 7 and 9 DAH, the highest total soluble solids (TSS) (16.34%, 20.83%, 23.55% and 26.12%, respectively) was recorded from T_8 treatment, whereas the lowest TSS content (13.02%, 16.82%, 19.46% and 21.55%, respectively) was observed from T_1treatment. At 5, 7 and 9 days after harvest (DAH), the highest disease incidence (33.33%, 58.33% and 100.00%, respectively) was recorded from T_1 treatment and the lowest disease incidence (0.00%, 0.00% and 8.33%, respectively) was observed from T_8 and T_9 treatments. So, consideration of shelf life and quality treatment T_8 as stored in polybag after Bavistin dips treatment were superior on other treatment for 'Harivanga' mango.

CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENT	**i**
	ABSTRACT	**ii**
	CONTENTS	**iii**
	LIST OF TABLES	**v**
	LIST OF PLATES	**vi**
	LIST OF APPENDICES	**vii**
1.	**INTRODUCTION**	**01**
2.	**REVIEW OF LITERATURE**	**04**
3.	**MATERIALS AND METHODS**	**23**
	3.1 Description of the study location	23
	3.1.1 Period of the study	23
	3.1.2 Description of the study site	23
	3.1.3 Physical condition of the storage room	23
	3.2 Details of the study	23
	3.2.1 Experimental materials	23
	3.2.2 Treatments of the experiment	25
	3.2.3 Design and layout of the study	25
	3.2.4 Application of post-harvest management practices	26
	3.3 Parameters studied	26
	3.4 Observation	26
	3.5 Methods of studying parameters listed earlier	27
	3.6 Statistical analyses	31

CHAPTER	TITLE	PAGE
4.	**RESULTS AND DISCUSSION**	**32**
	4.1 Shelf life	32
	4.2 Physical parameters	32
	4.2.1 Firmness score	32
	4.2.2 Color score	36
	4.2.3 Weight loss	36
	4.2.4 Moisture content	36
	4.2.5 Dry matter content	40
	4.3 Chemical parameters	40
	4.3.1 TSS (Total soluble solids)	40
	4.3.2 Titrable acidity	40
	4.3.3 Vitamin C content	44
	4.4 Microbial parameters	44
	4.4.1 Disease incidence	44
5.	**SUMMARY AND CONCLUSIONS**	**47**
	REFERENCES	**50**
	APPENDIX	**58**

LIST OF TABLES

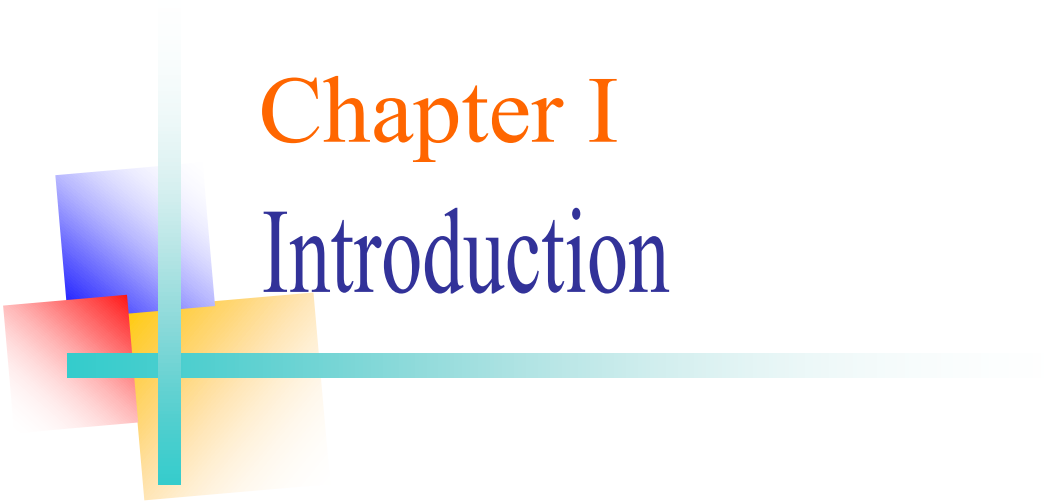
	Title	Page
Table 1.	Effect of different postharvest treatments on shelf life and firmness score at different days after harvest (DAH) of Harivanga mango	33
Table 2.	Effect of different postharvest treatments on color score at different days after harvest (DAH) of Harivanga mango	37
Table 3.	Effect of different postharvest treatments on weight loss at different days after harvest (DAH) of Harivanga mango	38
Table 4.	Effect of different postharvest treatments on moisture content at different days after harvest (DAH) of Harivanga mango	39
Table 5.	Effect of different postharvest treatments on dry matter content at different days after harvest (DAH) of Harivanga mango	41
Table 6.	Effect of different postharvest treatments on total soluble solids-TSS (%) at different days after harvest (DAH) of Harivanga mango	42
Table 7.	Effect of different postharvest treatments on titrable acidity (%) at different days after harvest (DAH) of Harivanga mango	43
Table 8.	Effect of different postharvest treatments on Vitamin C content at different days after harvest (DAH) of Harivanga mango	45
Table 9.	Effect of different postharvest treatments on disease incidence at different days after harvest (DAH) of Harivanga mango	46

LIST OF PLATES

	Title	Page
Plate 1.	Collection and Processing of mangoes	24
Plate 2.	Stored mango after application of different treatments	31
Plate 3.	Stored mangos with T_1 treatment (control condition)	34
Plate 4.	Stored mango with T_8 treatment (Low density perforated polybag at Bavistin dips treatment)	35

LIST OF APPENDIX

	Title	Page
Appendix I.	Analysis of variance of the data on shelf life and firmness score at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	58
Appendix II.	Analysis of variance of the data on color score at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	58
Appendix III.	Analysis of variance of the data on weight loss at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	58
Appendix IV.	Analysis of variance of the data on moisture content at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	59
Appendix V.	Analysis of variance of the data on dry matter content at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	59
Appendix VI.	Analysis of variance of the data on total soluble solids-TSS at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	59
Appendix VII.	Analysis of variance of the data on titrable acidity at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	60
Appendix VII.	Analysis of variance of the data on Vitamin C content at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	60
Appendix IX.	Analysis of variance of the data on disease incidence at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments	60



Chapter I

Introduction

CHAPTER I

INTRODUCTION

Mango (*Mangifera indicca* L.) belongs to the family Anacardiaceae is a widely cultivated fruits throughout the tropics and subtropics (Sethi *et al*., 2011). It is a popular fruit and also called the king of fruit (Salunkhe and Desai, 1984). The 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 of the world. The Asian countries 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 of Bangladesh is popular in home and abroad although 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). In Bangladesh, mango ranks first in terms of area and third in terms of production and occupies 34,000 hectares of land with the total production of 1,085,000 metric tons (BBS, 2013). Mango is decidedly the most popular fruit among millions of people in the orient and is considered to be the best of all the indigenous fruits of Bangladesh. Mango is acknowledged as the best fruits in the world market because of its great utility, excellent flavor and attractive fragrance, beautiful shades of color, delicious taste and healthful value. Nutritionally, mango is highly important because it has medium calorific value and high nutritional values. Carbohydrate content in ripe mango pulp is 16.9 (Salunkhe and Desai, 1984). Mango is a rich source of vitamins, minerals arid total soluble `solids and it helps to prevent many human diseases (Purohit, 1985).

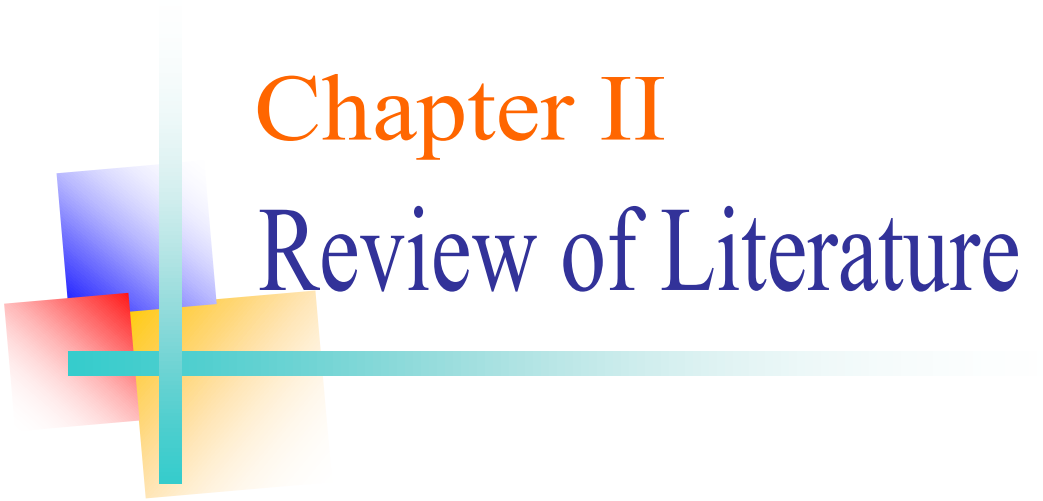
Nutritional value per 100 g energy 250 kcal, carbohydrates 15 g, dietary fiber 1.6 g, fat 0.38 g, protein 0.82 g, vitamin A equiv. 54 μg, beta-carotene 640 μg, Vitamin C 36.4 mg, vitamin E 0.9 mg, vitamin K 4.2 μg, calcium 11 mg, Iron 0.16 mg, Magnesium 10 mg, Manganese 0.063 mg, Phosphorus 14 mg, Potassium 168 mg, Sodium 1 mg. (USDA, 2013). The per capita fruit consumption in Bangladesh is far below the minimum requirement. The minimum dietary requirement of fruit/day/head is 85 g, whereas our availability is only 30-35 g, which is much lower than recommended daily requirement (Siddique and Scanlan, 1995). On the other hand, scientist claim that a considerable portion of the world's total food supply and that 30 to 40% at the crop produce harvested in the developing countries never reach to the consumer mainly because of pre and postharvest losses (Miller *et al*., 1986). As estimated by Lashley (1984), approximately 30 to 50% fruits go waste during postharvest handling, storage and ripening.

The magnitude of postharvest losses in fresh fruit was estimated to be 5 to 25% in developed countries and 20 to 50% in developing countries (Khader, 1985). According to Hassan (2010), the postharvest loss of mango in Bangladesh is 27.4%.Srinivasa*et al*. (2002) reported from India that the total post-harvest losses of mango cv. Totapuri and Alphonso 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. Quroshi and Meah (1991) found that post-harvest loss of mango fruits varied according to variety from 0 to 16.3% with an average loss 12.5%. It also depends on transport distance from production site to retail location. Mondal *et al*. (1995) estimated that postharvest loss of mango was in the range of 30 to 35% due to late ripening. Therefore, a critical area of examination would be how to reduce these postharvest losses in mango and other fresh fruits through so time ripening. Mango being one of the most important fruits, efforts towards reduction of postharvest losses should be of top priority through shortening ripening period.

Development of postharvest technologies related to quality maintenance and postharvest life extension is of great importance to consumer acceptability and marketing considerations (Zhong *et al*., 2006 and Chien *et al*., 2007). Proper postharvest treatments and packaging are required for maintaining better quality, extended shelf life and having access to international markets (Anwar and Malik, 2007). Shelf life of fruits could be extended by precooling, chemical treatments, low temperature, different botanical extracts, and so on. However, ventilated low-density polyethylene (LDPE) have also been found to be beneficial, as this material maintains humidity, which results in less shrinkage during storage (Tharanathan *et al*., 2006). Different botanical extracts viz. neem and garlic, and coating like sesame oil influence the shelf life and maintain quality of mango (Rodov *et al*., 1997). The combination of modified atmospheric packaging (MAP) with effective decay control measures can extend the postharvest life of mango fruit (Rodov *et al*., 1997).Growers and traders higher quantity of calcium carbide needed to ripen immature fruit, makes them tasteless (Mariappan, 2004, Subramanian, 2004; Medlicott, 1986; Padmini and Prabha, 1997). Various research literatures indicated that different chemicals which can be used to ripen mango fruit (Cua and Lizada, 1990; Medlicott *et al.,* 1990; Padmini and Prabha, 1997; Singh and Janes, 2001) But there are only few reports about the effectiveness of ethephon as a ripening agent (Nair and Singh, 2003; Mata *et al*. (2007)). Sergent *et al.* (1993) reported that immersed mangoes in hot water (52^0C for 2 minutes) and thereafter these mangos treated with chemicals which increased the production of soluble solids content that correlated with the improved flavor and color and softer texture of mango.

Considering the above mentioned perspectives this research work was undertaken with the following objectives:

- To minimize postharvest losses of ‘Harivanga’ mango variety through different management practices.
- To increase shelf life and quality through different postharvest treatments.



Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Mango is a nutritious and delicious popular fruit in Bangladesh as well as all over the world. There is no exaggeration to say that mango is now recognized as one of the best fruit in the world market because of its excellent flavor, attractive fragrance, beautiful color, delicious taste; however, it is a climacteric in nature and has short shelf life. A lot of work is going on to improve its quality and reduce its wastage by prolonging its shelf life. But research works related to quality and shelf life of mango due to different post-harvest treatment on different popular variety are limited in Bangladesh as well as the world. The research work so far done in our country and abroad is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related so far been done at home and abroad have been done on management of mango variety to increase shelf life and quality by using different post-harvest management practices presented below-

An investigation entitled the “Effect of containers and covering materials on quality and shelf life of Mango cv. Amrapali” was conducted by Ninama and Patel (2018) at P.G. Laboratory, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand having thirteen treatments. In experiment, the graded fruits of mango were packaged in various packaging containers (Bamboo basket, CFB box and Plastic crates, with or without covering material) and stored at ambient condition. On the basis of the above findings, it can be concluded that fruits packed in CFB box with newspaper covering proved to be effectively reduced the physiological loss in weight as well as spoilage loss and thereby maintain good balance between vitamin C and sugar content of fruits during storage and improved TSS, acidity, fruit firmness and ripening while decrease spoilage loss as compared to control and also extending the shelf life of mango fruits.

An investigation was carried out by Netravati *et al*. (2018) to evaluate the effectiveness of postharvest dip treatments on decay index of mango fruits cv. Alphonso. Freshly harvested and pre-cooled Alphonso mango fruits were treated with different post-harvest dip treatments and evaluated for the parameters like total soluble solids, decay index and visual skin color change. Among different treatments, minimum TSS (15.60%) was noted in hot water treated fruits, lower decay index (0.89%) and higher score for visual skin color (8.83) throughout the storage period was observed in azoxystrobin treated fruits as compared to untreated fruits.

Keywords An experiment was conducted by Hoque *et al*. (2017) to examine the efficacy of various post-harvest treatments namely control, hot water treatment, thin plastic film, chlorinated water, neem extract and garlic extract on shelf life and quality of mango. Parameters studied were color, firmness, disease severity, disease incidence, total soluble solids, total weight loss, moisture content, dry matter and shelf life of mango. The longest shelf life of 15.41 days was found in mango fruits wrapped with thin plastic film.

An experiment was conducted by Singh *et al*. (2017) on six thousand fruit collected from the mango cv. Langra at Fruit Research Station kuthulia, Rewa to study the post-harvest factors affecting on shelf-life and quality of mango cv. Langra. The postharvest treatments were: T_1-MH (1000 ppm), T_2-GA_3 (250 ppm), T_3- Hot water (50^0C), T_4- Potassium permanganate, T_5-silver nitrate (1%), T_6-Calcium nitrate (40 ppm), T_7- wax emulsion coating (6%), T_8- neem oil, T_9-perforated polythene and T_{10}- control. In this investigation, observations were recorded on the two parameters viz., physical and chemical at an interval of 4 days for a total period of 12 days during storage. The maximum fruit weight (232.90 g) and fruit length (10.47 cm) was observed in T_1. The maximum pulp thickness was show with T_4 (1.43 cm). The maximum Acidity (0.44%) and T.S.S. (19.510Brix) was showed in T_4, while maximum sugar acidity ratio (48.60) was noted in T_9. The maximum shelf life in (day) room temperature after ripening was recorded in

T_4 (13.87 day) while minimum shelf life in (8.00 days) room temperature after ripening was found in control (T_{10}).

Karemer and Habimana (2014) carried out an experiment on ripening, shelf-life, physico-chemical parameters and organoleptic evaluation of mango fruits Cv. Alphonso at the "A" block of mango orchard at UAS, GKVK Campus, Bangalore, Karnataka, India with the fallowing objectives: to evaluate the different concentrations of calcium chloride on ripening of certain varieties of mango; to study the effect of calcium chloride spray on shelf-life of different varieties of mango; to study the effect of calcium chloride spray on physico-chemical properties of mango and to study the effect of calcium chloride spray on organoleptic qualities of mango. The experiment was carried out were sprayed with $CaCl_2$ in the following treatments: T_1: Control (no spray), T_2: 0.50% spray of calcium chloride at 30 days before harvest, T_3: 1.00% spray of calcium chloride at 30 days before harvest, T_4: 1.50% spray of calcium chloride at 30 days before harvest, T_5: 0.50% spray of calcium chloride at 15 days before harvest, T_6: 1.00% spray of calcium chloride at 15 days before harvest, T_7: 1.50% spray of calcium chloride at 15 days before harvest. The results revealed that 1.50% $CaCl_2$ significantly increased the number of days taken for ripening of fruits, the shelf-life of fruits, physico-chemical parameters and organoleptic evaluation of mango fruits compared to control.

Abd El-Monem *et al*. (2013) conducted an experiment with Keitt mango fruits that harvested at maturity stage, then cold stored at$10 + 1^0$C and relative humidity of 85%, for forty days after being subjected to different concentrations of natural compounds known to be physiologically active. In this study, effects of sodium nitroprusside SNP (0.5, 1.0 and 2.0 mM L^{-1}) a nitric oxide donor, salicylic acid SA (0.5, 1.0 and 2.0 mM L^{-1}), hydrogen peroxide (H_2O_2) (10, 20 and 40 mML^{-1}) and chitosan (0.5, 1.0 and 2.0%) on cold stored mango fruits were studied. Results revealed that all treatments reduced total sugars, respiration rate, water loss, decay percentage and maintained fruit firmness compared with the control. On the other

hand, total soluble solids, titratable acidity, and fruit color showed less response to investigated treatments and concentrations.

Dissa *et al*. (2011) conducted an experiment to determine the impact of ripeness on drying characteristics of mango by considering different zones on the fruit. The total soluble solids/acidity ratio, color and texture of fruit flesh for each zone was considered and the ripeness was estimated. Results showed that the time required to reduce moisture content to any given level depended on the ripeness state, being highest for unripe samples and lowest for ripe samples. At each drying moment, temperature of ripe sample was higher than that of unripe sample. Mass diffusivity, thermal diffusivity and drying rates strongly increased with ripeness state. At 60^0C, unripe and ripe fruit mass diffusivities ranged respectively from 1.69 × 10-10 to 9.87 × 10-10 m²/s and 3.38 × 10-10 to 1.77 × 10-9 m²/s. Thermal diffusivities ranged from 2.12 × 10-11 to 6.44 × 10-10 m²/s and 2.74 × 10-10 to 8.05 × 10-10 m²/s, respectively for unripe and ripe samples. In natural convection, drying rates reached maximal values of 0.16 kg m^{-2}/s for unripe sample and 0.47 kg m^2/s for ripe sample whereas in forced convection they reached respectively 0.43 and 0.67 kg m^2/s.

A study was conducted by Jabbar *et al*. (2011) to differentiate the use of fungicides and hot water quarantine application on mango fruit cv. Samar Bahisht Chaunsa. The mangoes were stored for 21 days at (13±1^0C, 85±5% RH). The results showed that application of Topsin-M fungicide @ 1 g L^{-1} as field dip for 1 min (pre-transport) followed by HWQT @ 48^0C for 60 min., showed significantly suppression of postharvest diseases. The HWQT generally lead to increase the internal discoloration as compared with the control. NaOCl alone or with HWQT, caused higher internal discoloration of fruit. All physical treatments induced some degree of soft nose but combination of NaOCl with HWQT was found to accelerate the problem compared to control. The fruits treated with NaOCl @ 2.5 g $10L^{-1}$ and Topsin-M @ 1 gL^{-1} along with HWQT @ 48^0C for 60 min gave greater total titratable acidity. However, color, total sugar, non-reducing sugar, total

soluble solids contents and organoleptic acceptability of the fruits were found to be non-significantly influenced by the treatments. The postharvest, pre-transport treatment of Topsin-M @ 1 gL^{-1} followed by HWQT (48^0C for 60 min) was effective in reducing incidence of postharvest diseases, and fulfilling market access criteria. The higher degree of soft nose development in hot water quarantine treatment fruits.

Ezz and Awad (2011) carried out an experiment to find out the effect of various treatments of potassium permanganate, hot water treatment under 50^0C for 30 minutes and shrink film addition to control shelf life of mango cultivars 'Hindi Be-Besennara' (early ripe) and 'Alphonse' (mid-season) under three levels of temperature including 8, 10 and 13^0C and relative humidity of (80-85%) for 30 days. The parameters such as decay, shelf life, weight loss, firmness, titratable acidity, TSS, ascorbic acid, reducing and total sugars were studied. Results showed that the treatment of shrink film at 8^0C was proved the most effective in keeping shelf life of the two cultivars and this also showed better performance of physical and chemical parameters for the two cultivars. It was found that keeping quality in low temperature and decreased with increasing temperature degree. Similarly, the hot water treatment showed the same trend with control in TSS, acidity, reducing and total sugars and also low content in ascorbic acid.

Venkatesan and Tamilmani (2010) conducted an experiment to find out the influence of ethereal on the ripening of off season fruits of *Mangifera indica* L. var. Neelum. In the experiment the experimental fruits were treated with different concentrations of ethereal (100, 200 and 300 ppm) while the untreated fruits were placed inside the laboratory naturally. They treated the fruits with different concentrations (100, 200 and 300 ppm) of ethereal ripened on 13^{th} day, 11^{th} day and 9^{th} day, respectively after treatment of different concentrations. The color of the treated fruits changed from green greenish to yellow and the fruits were fit to be eaten. Also the color changed from green to greenish yellow to yellow. On the other hand control fruits, partial ripening led to incomplete metabolic changes,

which did not change the presence of sourness in the fruits. Comparing the 100, 200 and 300 ppm ethrel treatments, it was found that 200 ppm had the better results of ripening of off season fruits of *Mangifera indica* L. var. Neelum.

Singh and Singh (2010) carried out an experiment to study the effect of post-harvest treatment on physiological and chemical properties of mango cultivar Amrapali. They used seven treatments of postharvest were specified as T_1 (control), T_2 (hot water treatment), T_3 (Frutox wax treatment), T_4 (hot water t treatment + FWE), T_5 (ALPF), T_6 (hot water treatment + ALPF), T_7 (FEW + ALPF), T_8 (hot water treatment + FWF + ALPF). The changes in physical, biochemical and organoleptic characteristics of the fruits were encouraged and their determination was noted in Amrapali mango fruit. Physical change viz physiological weight loss percent, specific gravity, size of fruits, percentage of spoilage and ratio of pulp-peel were appreciably different over control. On fifteenth day of exploration, fruit which was treated with water (hot) + wax and enfold in ALPF showed lowest physiological weight loss.

Islas-Osuna *et al*. (2010) conducted an experiment with treated the fruits with 1-Methylcyclopropene (750 ml L^{-1}) to identify the physical and chemical characteristics, compounds (bioactive) and activities of cell wall degrading throughout ripening period and storage. The mature green mangoes of Kent cultivar were compared for outer quality, Polygalacturonase phytochemicals and Pectin Methyl esterase activities of enzymes in storage by 20^0C for two weeks using 1-MCP and those without 1-MCP. The results showed that the concentration of ascorbic acid reduced during the ripening of fruit and losses were reduced in 1-MCP-treated mangoes. The enzymatic activities of pectin methylesterase and Polygalacturonase were decreased in the treated fruits than untreated ones. There was little change observed in the β-carotene in the treated and untreated fruits. It may be concluded that 1-MCP influenced the process of ripening in Kent cultivar of mango fruit by decreasing the ascorbic acid losses, 1-MCP treatment was justified as it maintain nutritional value during its storage.

Le *et al*. (2010) determined the quality changes and control the occurrence of disease; treated the Taiwan native strain mango fruit with hot water (52, 55 and 58^0C); vapor heat (46.5^0C for 40 min) and treatment of hot water + vapor heat pursed cold storage (1, 3, 6, 9, 12, 15 and 20^0C). At 55^0C for 3 (minutes) the hot water reduced the spots and controlled of anthracnose disease for 6 days compared to control. The treatment of vapor heat retained firmness, peel color index and content of total soluble solid at 3^0C of storage time. The disease occurrence of the *Colletotrichum gloeosporiodes and Alternaria alternate* were reduced by hot water and vapor heat treatment application at 3^0C for 3 weeks by storage. The area of *Dothiorella mangiferae* increased during the similar time but did not change the quality. The combined treatment of hot water plus vapor heat with continuous storage at 3^0C for ambient room temperature the highest quality and firmness of fruit produced.

Payasi and Sanwal (2010) reported that the final stage of development is fruit ripening, which physiologically and biochemically measures that make fruit tasty and attractive to eat. The ripening of fruit can be retarded by different methods of modified atmosphere and packaging, gamma irradiation treatment and sucrose ester coating etc. The phytohormones, 1 methylen ecyclopropene and reducing agents treatments delayed the ripening of fruit. Molecular biology tackle like plants (transgenic) with control of genes concerned in production of ethylene otherwise over appearance of genes for deprivation of ethylene, virus stimulated gene quiet as well as exploitation of transcription aspect have been efficiently used for regulating or controlling ripening of mango fruit.

Rathore *et al*. (2010) recorded significant effect of active packaging in Cardboard Carton (APCC) on overall quality characteristics such as loss in weight, titratable acidity, ascorbic acid, pH and total soluble solids contents of mango (Chaunsa white variety). It was investigated at the ambient temperature (28-33^0C and 56.7-69.7% RH) during storage. The results showed that the uncoated fruit packed in carton had comparatively greater percent weight loss (10.96%) than control

(9.39%); however, after use of APCC system same packaging had significantly decreased the percent weight loss up to 6.89%. It was also observed that mango fruit through APCC system showed TSS (16.44-20.76%), pH (3.98-4.83), had increase, while TA (0.51-0.92%) had slower decrease, and slower increased of AA (23.06- 40.83 mg/100 g) during ripening stage with an average mean of 8.10%, 17.73%, 4.28%, 0.75%, 25.47%, respectively. The control sample (T) had higher weight loss (9.39%), TSS (20.83%), highest pH value (4.91), lowest acidity (0.44%), highest AA (42.06 mg/100 g), respectively at much earlier during storage. It can be concluded from the study that innovative approach of APCC with other protective chemicals such as coating emulsions having fungicide, ethylene absorbent and anti-ripening agent showed an effective role in enhancing the storage life up to 25 days and also controlled the compositional changes due to delayed ripening of the fruits with a minimum quality loss, as compared to control sample which had a greater changes in its composition and qualitative losses during storage at ambient temperature. The unappealing skin, changed color and poor taste the control fruit was perished within two weeks of their storage.

Amin *et al*. (2008) studied the sap burn injury and regarded it as the most threatening to external fruit quality of mango. When the pedicel of a mango fruit is broken, the sap exudes and spread over the fruit peel and causes a serious injury to the skin of mango. They estimated the suitable time of harvesting as well as de-sapping for control of sap burn injury in mango fruits. Australian industry product "Mango Wash" and Lime [Ca $(OH)_2$] at different times of the day including: 7 a.m. (morning), 12 p.m. (noon) and 5 p.m. (evening) were assessed. Lime @ 0.5% and Mango Wash @ 0.4% was used. Results showed that no sap injury (0 score) was recorded in the fruits harvested and de-sapped during morning, while maximum sap injury was found at noon in both the treatments (0.5 score for lime, 0.75 score for Mango Wash). Both the treatments (lime and Mango Wash) showed significantly reduced sap injury as compared with control for all the three times of treatment application. All of the physicochemical characteristics were non-significantly affected except fruit peel color and non-reducing sugar contents. The

color of fruit peel was slightly suppressed by the use of Mango Wash. Lime was found to impart attractive appearance to the mango fruits; however the skin color was non significantly improved as compared to control. Also the qualitative characteristics were non-significantly influenced by the time of mango fruit harvest. However, significantly greater TSS was found in the fruit harvested at noon as compared to other times of the day. It can be concluded that lime may be successfully used as an alternate instead of highly expensive Mango Wash for de-sapping of mango fruits.

Anwar *et al*. (2008) carried a study on two major problems related to postharvest of local mango industry. The firstly issue was the use of wooden crates which are being eliminated from the markets. Secondly, for early ripening of mango calcium carbide (CaC_2) is mostly used; due to health hazards caused by CaC_2 its use is being discouraged internationally. To find out an alternative for resolving the above mentioned problems, two experiments were carried out on cv. Samar Bahisht Chaunsa commercial mango. Fruits were packed in traditional wooden packaging with newspaper liner (WP) and corrugated cardboard packaging (CBP) for comparison. In first experiment, two chemicals CaC_2 (2 g kg^{-1} of fruit) and ethylene (C_2H_4) application (100 ppm, 20^0C, 48 h) were compared for ripening of mangoes, followed by ripening at ambient conditions (33 ± 1^0C and 60-65 %RH). The results showed that CBP fruit had significantly lower fresh fruit weight loss (FWL) and better storage life compared with WP fruit treated with or without CaC_2. It was also found that WP fruits with CaC_2 had faster ripening rate and better color of peel color as compared with C_2H_4 treated CBP. In 2nd experiment, WP or CBP fruit were stored (13 ± 1^0C and 85-90% relative humidity) for fifteen days, and allowed for natural ripening at two different temperatures ($28, 33 \pm 1^0$C). Also the performance of mango with C_2H_4 (100 ppm, 48 h) treatment at 25^0C and 30^0C was investigated in CBP fruit. Despite of ripening temperatures and methods, CBP showed significantly decreased in FWL as compared with WP. Ethylene treatment at higher temperature (30^0C) significantly improved quality compared with application at low temperature (25^0C), however, the fruit color was

not developed to the desired level. It may be concluded, CBP can be a better substituted for WP due to its demonstrated benefits; however, more work is needed to develop a precise ripening protocol use of ethylene at different concentrations and temperature etc.

Maqbool and Malik (2008) sap burn injury is a serious problem of mango fruit as it reduces the attraction and downgrade fruit. Management of sap burn in commercial cultivars Sindhri and Chaunsa of Pakistan at physiological maturity were harvested along with 4-5 cm pedicel. After de-stemming, fruits were immediately treated with potential chemical solutions i.e. calcium hydroxide [$Ca(OH)_2$], Tween-80, sodium carboximethyl cellulose (CMC), lauryl sulfate sodium (LS), detergents and vegetable oil. The fruits after treatment with the chemicals were dried in air and packed in boxes (cardboard), and brought in laboratory and were stored at14°C & RH 85% for seven and fourteen days in case of cv. Sindhri and cv. Chaunsa, respectively. Fruits treated with calcium hydroxide showed better results against sap burn injury followed by Tween-80 in both the cultivars. In the follow-up study, the chemicals with better results in experiment 1 were testes along with alum on cv. Chaunsa to verify the results. The fruits after application of chemicals were subjected to different conditions for storage (25^0C and RH 56% and 14^0C & RH 85%). The data on sap burn injury recorded after 24, 48 and 72 hours, showed almost similar results at different temperatures. Treatment with $Ca(OH)_2$ gave 95% sap burn injury control at different temperatures. The same treatment gave higher TSS levels ($Ca(OH)_2$ at 25^0C). At the same temperature total sugars was recorded maximum in fruits treated with simple water (30.80%), while in stored fruits, maximum total sugars (26.70%) were noted with alum treatment. De-stemmed under $Ca(OH)_2$ gave a maximum of total carotenoids in fruits at different storage temperatures. It may be concluded that $Ca(OH)_2$ was the better treatment in reducing sap burn injury and improving the fruit quality at different temperatures.

Ravindra and Goswami (2008) mango fruit has short shelf life after harvesting therefore; studied the important postharvest pre-cooling technique on mango (tropical) fruits. For pre-cooling process the cooling medium of liquid nitrogen with sufficient potential was used due to their motionlessness of the vaporized gas of nitrogen and high capacity of cooling. In comparison to pre-cooling like air cooling and hydro-cooling techniques for Amrapali mango fruit, the liquid nitrogen was used with the system of mechanical refrigeration like the cooling (medium). The performance of pre-cooling was evaluated for fruit quality like color, firmness of fruit, index of chilling injury, and the cooling coefficient and rate of cooling. They studied the effect of various pre-cooling techniques on mango fruit acidity (titratable), pH and the contents of total soluble solids of the ripened mango The results showed of this study that the system of liquid nitrogen (20.5 kg/h the flow rate of liquid nitrogen; 85^0C of average gas temperature) enhanced the cooling coefficient of the air cooling method by the forty percent and had no unfavorable effect produced on the fruit quality. The control of exposure time and careful plane would facilitate in understand the liquid nitrogen potential in techniques of precooling for mango fruits. This would be useful (practically) in system of control atmosphere storage methods.

Anwar and Malik (2007) determined the effect of hot water treatment on mango (cultivar Sindhri) fruits ripening behavior, shelf life and quality. The fruit of mango was transferred to treatment of hot water at 45^0C-75 minutes and 48^0C in 60 minutes along with wash only (control). A fruit coating, two percent (Fresh Seal P) was also used in combination with treatment of hot water on 48^0C-60 minutes. After application of water (hot) treatment, fruits were ripened without storage at room temperature otherwise were stored on 13 ± 2^0C and relative humidity 85±5 percent. The stored mango fruits were removed after seven, fourteen and twenty days and were ripened at ambient temperature (24 ± 1^0C, relative humidity 68-70 percent). Hot water treatment effects on physical and biochemical properties were estimated. Fruit transferred to hot water treatment at 45^0C-75 minutes and naturally ripened (without storage), indicated non-

significant difference for different quality factors than wash only (control) whereas keeping the shelf life of fruits (6 days). Hot water application at 48^0C-60 minutes reduced the period of ripening i.e. 3 days. Whereas, during storage non-significant differences among treatments indicated that hot water treatment does not influence the post-storage fruit quality. Among various treatments, fruit transferred to hot water treatment at 45^0C-75 minutes created superior results than treatment of water (hot) on 48^0C-60 minutes total carotenoids contents were found maximum in washed only fruits (62.78 μg/g) followed by treatment of hot water on 45^0C-75 minutes (59.39 μg/g). Fruits transferred to higher temperature during hot water treatment developed uniform color and more yellow. The results were non-significant for rests of the treatment.

Maqbool *et al*. (2007) accessed the international market for supply of superior quality mango there are different problems to be surmounted. Sap burn is one of the major problems in Mangoes and different management practices and experiments have been conducted to deal with this problem in Pakistan for various cultivars of Mangoes. In the current study, first experiment was explored the various cultivars of mango fruit for harvest time of a day and for sap quantity. The collected sap from Chaunsa cultivar was 11.89 times more than Sindhri cultivar and early in the morning the exudation of sap quantity was higher as compared to later throughout the day. Secondly it was noted that the effect of late de-stemming (after harvest) on sap quantity was little. But the quantity of total sap was highest in Chaunsa cultivar and lowest in Sindhri cultivar. Spurt and ooze were also tested in the three commercial mango cultivars and the sap burn susceptibility after 24, 48 and 72 hrs at two various storage environment (ambient: 25 ± 1^0C; 14^0C and 85 percent relative humidity). The cultivar of Chaunsa was most vulnerable followed by cultivar Dusehri and Sindhri. The rate of sap burn was higher in Chaunsa cultivar at ambient (room) temperature (25 ± 1^0C) as compared to cold storage (14^0C, 85 percent relative humidity (RH)). The sap burn occurrence was about same in Dusehri and Sindhri cultivars at both the temperatures. With reference to harvest time of the day the severity of sap burn level was investigated. They noted

that with the proceeding of daytime the severity of sap burn increased. The severities score of sap burn was lowest in harvested fruits at 8:00 am (0.06) and was highest in fruits were harvested at 3:00 pm (1.08) after seven days of storage at ambient temperature and in cold storage (13 ± 1^0C and 80-85 percent relative humidity). They also determined the optimal de-sapping time and decreased the sap burn injury incidence; for this purpose they placed the fruits on desapping trays for various time phases. The sap burn incidence was lowest in fruits which were kept on de-sapping trays for twenty minutes (0.65) followed by ten minutes (0.73) than untreated (2.54)/fruit harvested by conventional technique after fifteen days of storage (13 ± 1^0C and 80-85 percent relative humidity).

Singh *et al*. (2007) reported the fleshy fruits go through textural changes with ripening that lead to tissue firmness loss and subsequent softening due to cell wall take to pieces carried out through various and in particular articulated enzymes in laboratory condition. They investigated the effect of different chemical treatments on mango fruit ripening at level of physiologically and biochemically. The changes in firmness, respiration, total soluble sugar, pH and a degrading enzyme of cell wall pectatelyase action, treatment with 1-methylcyclopropene, gibberlic acid, sodium metabisulphite, ascorbic acid and silver nitrate, retarding the process of ripening whereas those of ethereal increased the process. They observed pectatelyase activity of mango fruit was to be inhibited by certain metabolites present in enzyme of dialyzed ammonium sulphate take out and EDTA. The mango pectatelyase activity showed an entire requirement for calcium and an optimal 8.5 pH.

Zheng *et al*. (2007) investigated the oxalic acid effects on ripening and occurrence of decay mango fruit at room temperature (25^0C) during storage. The Zill cultivar of mango fruit was dipped in oxalic acid solution (5 mM) for ten minutes at 25^0C. The data demonstrated that the ripening of fruit was retarded and decay occurrence was also decreased by treatment of oxalic acid compared to the control. They concluded that reducing production of ethylene was a major provider to delaying

the process of ripening by the physiological effect of oxalic acid. The treatment of oxalic acid showed potential technique for mango postharvest storage.

Kaswija *et al*. (2006) studied the organoleptic quality and microbial infectivity on mature green Dodo mango fruit before and during a 3- and 6-day period of ripening by smoked pit ripening, ethylene (fruit generated) pit ripening, untreated pit ripening and room temperature as control technique. The changes of post-harvest ripening in the quality parameters of the ripened mango fruit were associated with treatments and compared by same changes in other verities of mango. They concluded that the organoleptic characteristics have significant differences with the employed method. The quality of microbial was significantly different among the treatments, while with aroma profiles there were significant differences of identified compounds of aromatic reflected the most important scores of sensory quality at ripening stage.

Malik *et al*. (2006) explored the advantage of postharvest polyamines application (Spermidine, Spermine and Putrescine) on the shelf life and quality of Kensington Pride mango fruit. Application of polyamine slow down the color development, fruit softness and physiological weight loss was decreased through storage without a significant reduction in ethylene production. Low concentrations of Spermine (0.01 mM), high concentrations of Spermidine (0.5 mM) and Putrescine (1 mM) were more useful in delay fruit softening. Through fruit ripening, Spermine (0.01 mM) showed the lowest amount of respiration compared with the fruit control. The ripe fruit analysis stored for three or four weeks, illustrated that polyamine application appreciably improved the firmness of fruit, ascorbic acid, acidity, while reducing the ratio of TSS/acid and content of total carotenoid compared with the control. The exogenous polyamines application enhanced the shelf life of mango fruit without having harmful result on quality of fruit.

Zeng *et al*. (2006) for disease control treated the Matisu variety of mango fruit with 1 mmol/L salicylic acid solution for two minutes in vacuum diffusion on a low down pressure and for an extra ten minutes at pressure of air. The mango fruit

was immunized by anthracnose spore suspension 1×104 CFU m/L when fruit was kept (incubated) at 13^0C and relative humidity 85-95%. At the fourth day of incubation, in treated (with salicylic acid) fruit the lesions diameter and disease incidence were 20.9 percent and 37.5 percent lesser as compared to control fruit. By treatment of salicylic acid, the action of protection enzymes was notably increased and the action of phenylalanine ammonia-lyase and β-1, 3-glucanase was six/0.9 double higher as compared to control fruit. In treated (salicylic acid) fruit the superoxide radicals and hydrogenperoxide production speed was 79.44 percent and 22.3 percent superior as compared to control fruit on the eight day. They concluded that phenylalanine ammonia-lyase, β-1, 3- glucanase and hydrogen peroxide/superoxide radicals possibly occupied in the disease resistance enhancement in fruit of mango.

Anjumand Ali (2004) studied the post-harvest treatment on green mature mango cultivar SS-1 fruits; were immersed for ten minutes in 2.5, 5.0 or 7.5 percent calcium sulphate ($CaSO_4.2H_2O$), calcium ammonium nitrate {$Ca(NH_4NO_3)_2$} and calcium chloride ($CaCl_2.2H_2O$) solutions. A control was also incorporated in which fruits were dipped in fresh water for ten minutes. At ambient temperature (25 ± 3^0C) the fruits were ripened in boxes lined and enclosed with newspaper. Calcium chloride delayed the ripening of fruit about three days as compared to control and resulted in superior aroma of the fruits, however, it stimulate shriveling of skin. Calcium sulphate treatments showed in better color of pulp. The increase in concentration of calcium salts resulted in reduced the ripening but had harmful effect on quality of fruit by rising skin shrinking and decreasing taste and flavor of the fruits. CaC_2 at 5.0 percent delayed the ripening for four days and resulted in better skin and pulp color but with enlarged skin shriveling and poor taste and flavor, showing reduced eating quality.

Santos *et al.* (2004) studied the effect various maturity stages of Rosa cultivar mango with calcium chloride. Fruits were harvested at the mature-green (green yellowish) and pre-climacteric (yellow-greenish) maturity stages. Calcium

chloride was applied by 15-cm deep fruit immersion during two hours in solutions contain 0.0 (control); 4.0 and 8.0 percent. The mango fruit was stored at 10 ± 1^0C and 85 percent relative humidity during twenty days, followed by five day storage at room temperature (24 ± 2^0C). Fruit skin color, weight loss, firmness (scores one to seven), internal and external appearances (scores one to six), total soluble solids and total titratable acidity were evaluated. Calcium chloride was particularly more useful when applied to pre-climacteric fruits. The fruits treated with 4.0 percent calcium chloride demonstrated fruits presented skin black spot, soaked areas, and decay particularly pre-climacteric mangoes. As compared to controls, 8.0 percent calcium chloride treatment provided a five-day enhance in shelf life of mature-green 'Rosa' mango stored at 10 ± 1^0C. The calcium chloride 8.0 percent showed lowest weight losses when transferred to room temperature, while maintaining total soluble solids, titratable acidity, fruit firmness, and best external and internal appearances, even though, no significant delay on skin color progress was noticed.

Nair and Singh (2003) tested the effects of pre-storage ethereal application on chilling injury development, ethylene production, respiration rate and quality of Kensington Pride mango fruit. This mango (mature green) fruit was dipped in aqueous solution including different ethereal application zero, fifty, 250 and 500 mg L^{-1} along with surfactant (Tween 80) 0.01percent for five minutes. These fruits were stored for 4 weeks at 5^0C. At 22^0C, the mango fruit was permitted toward ripening. Chilling injury index, respiration rate and ethylene production was noted throughout the period of ripening from one to nine days. The rots of fruit, acidity, taste, firmness, TSS/acid ratio, total sugars, non-reducing and reducing sugar and total soluble solids were noted from fruit entirely ripe. Chilling injury was decreased significantly among every ethereal treatment. The 500 mg/L ethereal treatment showed to be mainly useful into decreasing the chilling injury. In ethereal treated fruit the ethylene production and respiration rate was also enhanced with ripening period than fruit untreated. The quality of fruit enhanced by the treatment of ethereal with improved sugars, TSS/acid ratio, total soluble solids and decreased the firmness of fruit. They concluded that pre-storage

treatment of 500 mg/L ethereal dip for 5 min decreased chilling injury as well as enhanced quality of fruit and taste.

Prusky *et al*. (1999) studied the reduction of postharvest diseases occurrence source by *Alternariaalternata* and increasing the quality of mango fruit. For this purpose combined spray of hot water & brushing of fruit treatment for 15-20s was used. The treatment of hot water effectiveness was investigated at various temperatures (48 to 64^0C), in mixture with treatment of prochloraz plus waxing of fruit. Fruits brushing by hot water considerably decreased the rot progress through *Alternaria alternata*. After storage, the decrease of disease incidence by treatment (hot water brushing and prochloraz @ 900 μg ml^{-1}) for three weeks at 12^0C and another week at 20^0C was more effective than by hot water brushing alone. The treatment of hot water brushing for 15s enhanced the development of fruit color and more useful as compared to common treatment of commercial dip for five minutes on 55^0C. High quality for mango fruits with a lesser amount of decay progress by the combination of hot water brushing and waxing.

Menezes *et al*. (1995) studied the obvious flows of sap squirt out from the point of abscission of the mango fruit stalk after harvesting. The sap burn produced undesirable aesthetic on the fruit skin due to seepage of sap with considerable economic loss. They discussed the problem of economic significance, the biochemical description of the mango latex and injury of sap burn and some techniques to decrease the injury.

Holmes *et al*. (1993) evaluated the standard harvesting technique to pick the mango fruit with elongated stem and transport them in crates made of plastic to the packing shed. The mango fruit were then de-sapped by removing the pedicel or stem and the fruits were placed stem end down on a conveyor for 20- 30 minutes. This technique still resulted in between 50 and 60 percent of the mango fruit suffering from some extent of sap burn. The current work by officers of the Queensland Department of Primary Industries has verified that these levels could be reduced by various techniques: (1) packing with short stems; (2) de-stemming

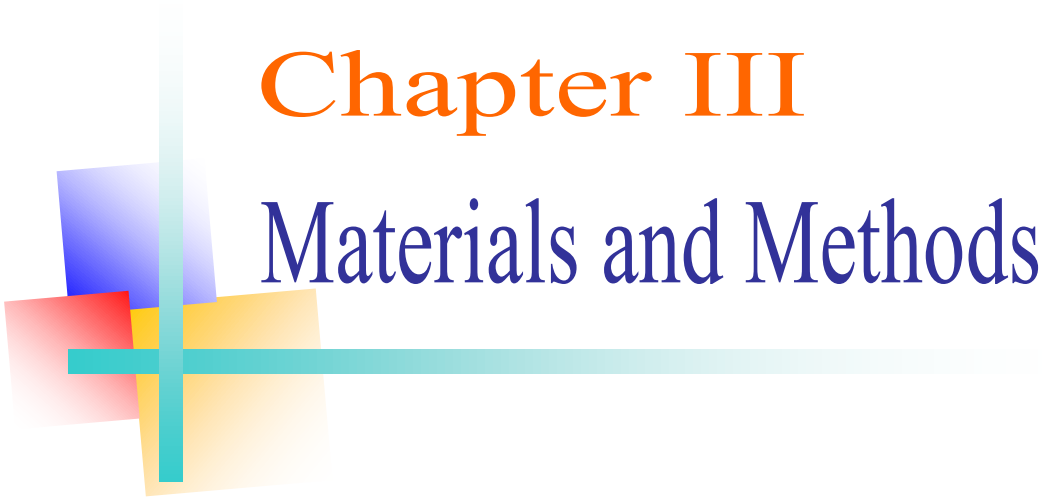
in a lime solution; (3) treatment with sprays and dips detergent earlier to destemming; (4) picking the fruit without stems on a harvesting support spraying and or dipping detergent on the mango fruit without delay. All techniques reduced the severity and the sap burn fruit percentage. The harvesting aid proved most useful reducing the total sap burn to 15.9 percent, and resulted in reduction of the pickers' number to almost half and hence a significant saving in the overall cost.

Loveys *et al*. (1992) studied that the skin of mango fruit damage through exuded of sap from the broken or cut pedicel decreased the acceptance of consumer and shelf life of the storage fruit. The Kensington mango fruit are mainly vulnerable to sap burn damage. The sap of fruit separated into two parts by centrifugation. Damage skin was caused mostly through the top non aqueous part. The main factor of this part was terpinolene which provided symptom identical from sap burn damage when applied to the fruit surface. The indistinguishable kind of injury could be stimulated by the terpinolene synthetic application when applied with no added water and diluted in hexane or as an aqueous mixture. The components of non-volatile sap separated by cleansing were not harmful to the skin of mango. The sap exuded from the leaf petioles of mango also enclosed terpinolene, but its application was a lesser amount of than one percent of the application in pedicel sap and this sap has no harmful effect on the fruit skin. Irwin cultivar of Florida is a lesser amount responsible to sap burn damage & in sap the major terpene was recognized as 3-carene. When applied to skin of Kensington mango, 3-carene caused notably less injured than terpinolene. They concluded that the main cause of sap burn in mango is entrance of the sap volatile components for instance terpinolene for the period of lenticels, resultant in injured of browning and tissue of following enzymes.

Yuniarti and Suhardi (1992) minimized the postharvest losses during transportation by applying different methods for retarding ripening process in mangoes (cv. Arumanis). For this purpose mango fruit was harvested at optimal maturity and treated with (1) 2, 4, 6 percent solution of $CaCl_2$; (2) 4, 5, 6 or 7

percent wax emulsion; (3) perforated polyethylene bags wrapping have KMnO4 as an absorbent of ethylene (2.5, 5.0, 7.5, 7.5 or 10.0 percent); (4) sealed polyethylene bags wrapping with $KMnO_4$ as in (3); or (4) control untreated. The mango fruits were placed perforated cartons and these cartons were transported for 36 hours. At room temperature analyzed these samples for soluble solids contents, texture, weight loss and days taken to reach the best possible ripeness or the condition of over-ripe. Emulsion of wax at six or seven percent had the maximum result in slow down the ripening process (by eleven days) and the stage of over-ripe (by nine days), and was compared by control fruits, and resulted weight loss was lowest. The soluble solids contents (14.8 percent after transportation subsequent 6% wax treatment) were also lowest by treatment of wax emulsion as compared to control.

The above cited review revealed that post-harvest management practices greatly influenced shelf life and quality of mango.



Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The study was conducted to assess the postharvest management of 'Harivanga' mango variety to increase shelf life and quality. The materials and methods were used for conducting the study has been presented in this chapter under the following headings and sub-headings-

3.1 Description of the study location

3.1.1 Period of the study

The study was conducted during the period from June to August 2018.

3.1.2 Description of the study site

The study was conducted at the laboratory of the Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in $24^0 09'$N latitude and $90^0 26'$E longitudes. The altitude of the location was 8 m above from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207.

3.1.3 Physical condition of the storage room

The experiment was done at room temperature at Plate 2.

3.2 Details of the study

3.2.1 Experimental materials

The popular Mango variety 'Harivanga' were used as experimental materials for the study. These mangos at matured stage were collected from mango orchard of Rangpur District. Fruit were treated with different management practices as per treatment. Treatments were applied on the mango after few hours of harvesting from orchard at Plate 1. All of these agents that were used as management practices were collected from local market.

Plate 1. Collection and Processing of mangoes

3.2.2 Treatments of the experiment

The experiment comprised of the following post-harvest practices as treatment:

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment (50^0C at 5 minutes)

T_3: Stored in net bag after hot water treatment (50^0C at 5 minutes)

T_4: Stored in polybag after sodium metabisulphite treatment (1.5% at 10 min)

T_5: Stored in net bag after sodium metabisulphite treatment (1.5% at 10 min)

T_6: Stored in polybag after $CaCl_2$ treatment (1.5% at 10 min)

T_7: Stored in net bag after $CaCl_2$ treatment (1.5% at 10 min)

T_8: Stored in polybag after Bavistin dips treatment (0.1% dips at 50°C water at 5min)

T_9: Stored in net bag after Bavistin dips treatment (0.1% dips at 50°C water at 5 min)

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after edible wax treatment

T_{17}: Stored in net bag after edible wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

3.2.3 Design and layout of the study

The study was laid out in a Completely Randomized Design (CRD) with three replications. A total of 285 ‘Harivanga’ mangos of more or less similar shape and size and free of visible disease symptoms were collected. Five uniform sized mango fruits were kept in each treatment. The skin adherences, dots and latex were cleaned by gently wiping the fruits with moist and clean towel.

3.2.4 Application of post-harvest management practices

Different management practices were applied as per the treatment of the experiment which were presented in treatments of the experiment 3.2.2. In case of polythene bags low density (LD) perforated polybag were used. For net bag it was collected from local market. Treatments were applied at the mango orchard in Rangpur after few hours of harvesting mangoes.

3.3 Parameters studied

In this experiment the following parameters were studied:

3.3.1 Shelf life

3.3.2 Physical parameters

- Firmness
- Color score
- Weight loss
- Moisture content
- Dry matter content

3.3.3 Chemical parameters

- TSS (Total soluble solids)
- TA (Titratable acidity)
- Vitamin C

3.3.4 Microbial parameters

- Disease incidence (%)

3.4 Observation

During the entire period of storage, the mangos were observed every day with keen observation. Data were recorded at an interval of 2 days starting from 3 Days after harvest (DAH) and continued upto shelf life that influenced by different post-harvest management practices.

3.5 Methods of studying parameters listed earlier

3.5.1 Estimation of shelf life

Shelf life of 'Harivanga' mango fruits as influenced by different management post-harvest practices was estimated by counting the days required to ripening of mango fully as to retaining, optimum marketing and eating qualities.

3.5.2 Physical parameters

3.5.2.1 Firmness

Days required to reach different stages of firmness during storage and ripening were determined at an interval of 2 days using numerical rating scale of,1-6, where 1 = mature hard, 2 = sprung, 3 = between sprung and eating ripe, 4 = eating ripe, 5 = over ripe, 6 = totally unfit for consumption. Similar rating scale was used by Hassan (2006).

3.5.2.2 Color score

Days required to reach suitable color during storage and ripening were determined at an interval of 2 days using numerical rating scale of, 1-7, where 1 = green, 2 = breaker, 3 = One-quarter yellow (< 25%), 4 = two-quarter yellow (< 50%), 5 = three-quarter yellow (< 75%), 6 = fully yellow (75-100%), 7 = blackened/rotten (fully yellow and black). Similar rating scale was used by Hassan (2006).

3.5.2.3 Estimation of total weight loss

The fruits of each treatment were individually weight by using electric balance and kept for storage. Percent total weight loss was calculated at an interval of 2 days during storage by using the following formula:

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

Where,

IW= Initial fruit weights (g) and

FW= Final fruit weight (g)

3.5.2.4 Estimation of moisture content

Ten (10) gram of fruit pulp of 'Harivanga' mango 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 80^0C 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:

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

Where,

IW= Initial weight of fruit pulp (g) and

FW= Final weight of oven dried fruit pulp (g)

3.5.2.5 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.

3.5.3 Chemical parameters

3.5.3.1 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).

3.5.3.2 Titratable acidity (TA)

Titratable acidity was estimated by chemical analysis process using mango pulp stored in refrigerator. The TA of mango pulp was determined by method of Ranganna (1979). The following reagents were used for the determination of TA.

i) Standard NaOH solution (0.1 N)

ii) 1% phenolphthalein solution

Extraction of mango juice

Ten (10) gram of fresh mango pulp was taken in a 500 ml beaker and then it was homogenized with distilled water in blender. The blender materials were then filtered and transferred to 500 ml volumetric flask and the volume was made up to the mark with distilled water.

Procedure

Five milliliters (5 ml) of pulp solution was taken in a conical flask. Two to three drops of phenolphthalein indicator solution was added and then the conical flask was shaken vigorously. It was then titrated immediately with 0.1 N NaOH solution from a burette till a permanent pink color was appeared. The volume of NaOH solution required for the titration was noted from burette reading. Percent titratable acidity was calculated by using the following formula:

$$\text{Titratable acidity (\%)} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 1000} \times 100$$

Where,

T= Titre

N= Normality of NaOH

V_1= Volume made up

E= Equivalent weight of acid

V_2= Volume of sample taken for estimation

W= Weight of sample taken

3.5.3.3 Vitamin C content

Ascorbic acid content was determined according to the method of Ranganna (1979) and the following reagents were used for this estimation:

i) Three percent (3%) metaphosphoric acid (HPO_3)

It was prepared by dissolving the sticks of HPO_3 in distilled water.

ii) Standard ascorbic solution

Ten milligram percent (10 mg%) of L-ascorbic acid solution was prepared by dissolving ascorbic acid in 3% metaphosphoric acid solution.

iii) Dye solution

It was prepared by dissolving 50 mg of the sodium salt of 2, 6-dichlorophenol indophenol in approximately 50 ml of hot distilled water containing 42 mg of sodium bicarbonate. It was then cooled and diluted to 100 ml with distilled water. The following steps were followed for the estimation of ascorbic acid:

Standardization of dye solution

Ten milliliters (10 ml) of standard ascorbic acid solution was taken in a conical flask and 5 ml of metaphosphoric acid HPO_3 was added to it. A micro burette was filed with the dye solution. The content of the conical flask was titrated with dye solution. The content of conical flask was titrated with dye till the pink-colored end point appeared. The milliliters of dye solution required to complete the titration was recorded. Dye factor was calculated using the following formula:

$$\text{Dye factor (\%)} = \frac{0.5}{\text{Titre}} \times 100$$

Preparation of sample

About five grams (5 g) of fresh fruit and 35 ml of 3% metaphosphoric acid solution was taken in a blender and homogenized for 2 minutes. After blending it was filtered and centrifuged at about 2000 ppm for 5 minutes. The supernatant homogenized liquid was transferred to a 50 ml volumetric flask and the volume was made up with 3% metaphosphoric acid.

Procedure

Ten milliliters (10 ml) of the aliquot was taken in a conical flask and titrated with dye solution. The ascorbic acid content was calculated by using the following formula:

$$\text{Ascorbic acid content (mg/100g)} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre; V_2 = Volume of extract used for titration

D = Dye factor; W = Weight of sample (g)

V_1 = Volume made up (ml)

3.5.4 Microbial characters

3.5.4.1 Assessment of disease incidence

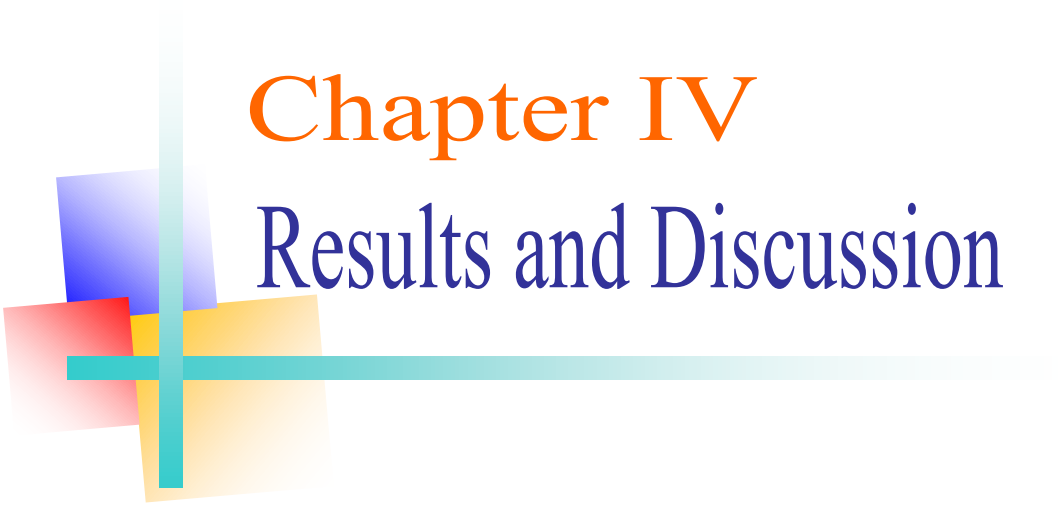
The fruits were critically examined one day later for the appearance of rot. The incidence of fruit rot was recorded after one day. The first count was made at the 3 days after harvest. Diseases incidence means percentage of fruits infected with disease. This is measured by calculating the percentage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

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

3.6 Statistical analyses

The data on quality and shelf life of mango were statistically analyzed to find out the significant differences for different post-harvest management practices. The mean values of all the characters were calculated and analyses of variance were performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the differences among the mean values of treatment in respect of different parameters was estimated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

Plate 2. Stored mango after application of different treatments



Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprised demonstration and discussion of the results obtained from the study on the management of 'Harivanga' mango variety to increase shelf life and quality. The analyses of variance (ANOVA) of the data on shelf life and quality of mango are presented in Appendix I-IX. The results which are influenced by different post-harvest management treatments have been presented and discussed under the following headings:

4.1 Shelf life

Shelf life of 'Harivanga' mango varied significantly due to different post-harvest treatments under the present trial (Appendix I). The highest shelf life (15.67 days) was observed from T_8 treatment (Plate 4) and the 2nd highest of shelf life (13.33 days) was found from T_{12} treatment, whereas the lowest shelf life (9.00 days) was recorded from T_1 treatment (Table 1 and Plate 3). Hoque *et al*. (2017) found the longest shelf life of 15.41 days was found in mango fruits wrapped with thin plastic film. Karemera and Habimana (2014) reported that 1.50% $CaCl_2$ significantly increased the shelf-life of fruits.

4.2 Physical parameters

4.2.1 Firmness score

Firmness score of 'Harivanga' mango at 3, 5, 7 and 9 days after harvest (DAH) varied significantly due to different post-harvest treatments (Appendix I). At 3, 5, 7 and 9 days after harvest (DAH), the highest firmness score (2.67, 3.58, 4.62 and 5.96, respectively) was found from T_1 treatment and the 2nd highest firmness score (2.55, 3.41, 4.49 and 5.81, respectively) was recorded from T_7 treatment, while the lowest firmness score (1.48, 2.13, 3.12 and 4.04, respectively) was observed from T_8 treatment under the present trial (Table 1). Le *et al*. (2010) reported that continuous storage at 3^0C for ambient room temperature the highest quality and firmness of fruit produced.

Table 1. Effect of different postharvest treatments on shelf life and firmness score at different days after harvest (DAH) of Harivanga mango

Treatments	Shelf life (days)	Firmness score at			
		3 DAH	5 DAH	7 DAH	9 DAH
T_1	9.00	2.67	3.58	4.62	5.96
T_2	13.00	1.68	2.39	3.42	4.44
T_3	12.33	1.75	2.45	3.62	4.52
T_4	11.33	2.22	2.84	4.05	4.95
T_5	11.33	2.25	2.96	4.12	5.02
T_6	9.67	2.51	3.35	4.45	5.76
T_7	9.33	2.55	3.41	4.49	5.81
T_8	15.67	1.48	2.13	3.12	4.04
T_9	13.33	1.56	2.19	3.21	4.13
T_{10}	12.33	1.86	2.51	3.68	4.69
T_{11}	12.33	2.01	2.58	3.75	4.72
T_{12}	13.33	1.59	2.24	3.29	4.24
T_{13}	13.00	1.64	2.36	3.33	4.38
T_{14}	12.00	2.07	2.63	3.86	4.78
T_{15}	11.67	2.18	2.78	3.95	4.82
T_{16}	10.67	2.45	3.18	4.32	5.48
T_{17}	10.00	2.48	3.29	4.38	5.64
T_{18}	11.00	2.32	3.03	4.19	5.12
T_{19}	10.67	2.39	3.11	4.27	5.31
$LSD_{(0.01)}$	1.057	0.185	0.305	0.490	0.420
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.12	4.03	4.93	5.70	3.86

Firmness scores: 1 = mature hard, 2 = sprung, 3 = between sprung and eating ripe, 4 = eating ripe, 5 = over ripe, 6 = totally unfit for consumption

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

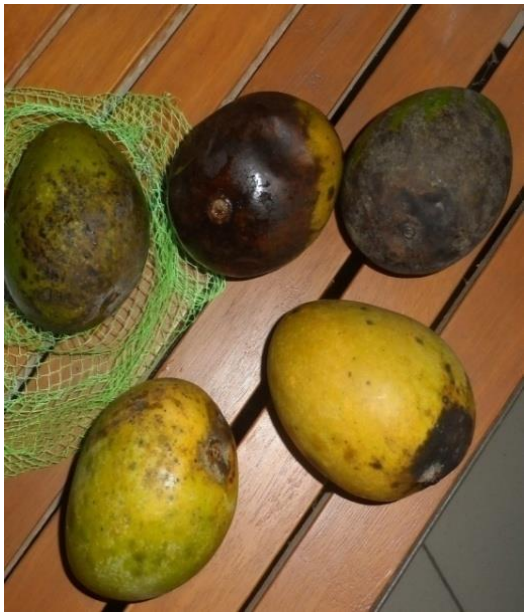
T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

3 days mangoes of T_1 treatment



9 days mangoes of T_1 treatment

T_1 treatment mango flesh

Plate 3. Stored mangos with T_1 treatment (control condition)

T_8 treatment mangoes at 5 days

T_8 treatment mangoes at 7 days

T_8 treatment mangoes at 15 days

T_8 treatment mango flesh

Plate 4. Stored mango with T_8 treatment (Low density perforated polybag at Bavistin dips treatment)

4.2.2 Color score

Statistically significant variation was recorded in terms of color score of 'Harivanga' mango at 3, 5, 7 and 9 DAH due to different post-harvest treatments (Appendix II). At 3, 5, 7 and 9 DAH, the highest color score (1.95, 4.70, 6.15 and 7.02, respectively) was recorded from T_9 treatment and the 2nd highest color score (1.87, 4.52, 5.61 and 6.89, respectively) was found from T_8 treatment, whereas the lowest color score (1.21, 2.56, 3.15 and 5.38, respectively) was observed from T_{13} treatment (Table 2). Netravati *et al*. (2018) recorded higher score for visual skin colour (8.83) throughout the storage period in azoxystrobin treated fruits as compared to untreated fruits.

4.2.3 Weight loss

Different post-harvest treatments showed statistically significant differences in terms of weight loss of 'Harivanga' mango at 3, 5, 7 and 9 DAH (Appendix III). At 3, 5, 7 and 9 DAH, the highest weight loss (4.68%, 7.56%, 9.92% and 12.25%, respectively) was observed from T_1 treatment and the 2nd highest weight loss (4,14%, 7.13%, 9.55% and 12.02%, respectively) was found from T_7 treatment, while the lowest weight loss (2.46%, 5.14%, 7.45% and 10.12%, respectively) from T_{16} treatment (Table 3). Singh and Singh (2010) reported that fruit treated with water (hot) + wax showed lowest physiological weight loss.

4.2.4 Moisture content

Moisture content of 'Harivanga' mango at 3, 5, 7 and 9 DAH showed statistically significant variation due to different post-harvest treatments (Appendix IV). At 3, 5, 7 and 9 DAH, the highest moisture content (85.44%, 83.36%, 82.18% and 80.14%, respectively) was found from T_8 treatment and the 2nd highest moisture content (84.57%, 82.88%, 81.71% and 79.87%, respectively) was recorded from T_9 treatment, whereas the lowest moisture content (81.76%, 80.22%, 78.66% and 75.85%, respectively) was observed from T_1 treatment (Table 4). Karemera and Habimana (2014) reported that 1.50% $CaCl_2$ significantly increased moisture content of mango compared to control.

Table 2. Effect of different postharvest treatments on color score at different days after harvest (DAH) of Harivanga mango

Treatments	Color score at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	1.25	3.45	5.34	6.12
T_2	1.75	4.46	5.32	5.95
T_3	1.68	4.35	5.15	5.81
T_4	1.34	3.96	4.82	5.43
T_5	1.29	3.81	4.75	6.78
T_6	1.32	3.28	5.45	6.78
T_7	1.38	3.33	5.35	6.04
T_8	1.87	4.52	5.61	6.89
T_9	1.95	4.70	6.15	7.02
T_{10}	1.23	4.04	3.22	6.84
T_{11}	1.34	2.68	3.34	6.87
T_{12}	1.34	3.98	5.98	6.58
T_{13}	1.21	2.56	3.15	5.38
T_{14}	1.43	2.92	5.42	6.83
T_{15}	1.53	3.02	3.43	6.75
T_{16}	1.48	3.67	4.84	5.74
T_{17}	1.55	4.28	5.02	5.65
T_{18}	1.48	4.05	4.95	5.52
T_{19}	1.53	3.56	4.78	5.63
$LSD_{(0.01)}$	0.157	0.542	0.533	0.485
Level of significance	0.01	0.01	0.01	0.01
CV(%)	4.96	6.58	4.99	3.49

Color scores: 1 = green, 2 = breaker, 3 = One-quarter yellow (< 25%), 4 = two-quarter yellow (< 50%), 5 = three-quarter yellow (< 75%), 6 = fully yellow (75-100%) 7 = blackened/rotten (fully yellow and black)

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

Table 3. Effect of different postharvest treatments on weight loss at different days after harvest (DAH) of Harivanga mango

Treatments	Weight loss (%) at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	4.68	7.56	9.92	12.25
T_2	3.06	5.95	8.24	10.72
T_3	3.16	6.06	8.32	10.83
T_4	3.68	6.48	8.84	11.31
T_5	3.74	6.54	8.92	11.45
T_6	4.08	6.98	9.39	11.78
T_7	4.14	7.13	9.55	12.02
T_8	2.62	5.52	7.84	10.34
T_9	2.71	5.68	7.97	10.45
T_{10}	3.23	6.14	8.45	10.94
T_{11}	3.31	6.22	8.51	11.06
T_{12}	2.85	5.73	8.02	10.58
T_{13}	2.94	5.84	8.14	10.67
T_{14}	3.42	6.34	8.68	11.12
T_{15}	3.54	6.42	8.75	11.23
T_{16}	2.46	5.14	7.45	10.12
T_{17}	2.55	5.42	7.84	10.24
T_{18}	3.84	6.69	9.02	11.52
T_{19}	3.96	6.75	9.22	11.64
$LSD_{(0.01)}$	0.305	0.767	0.649	1.076
Level of significance	0.01	0.01	0.01	0.01
CV(%)	4.12	5.55	3.42	4.39

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

Table 4. Effect of different postharvest treatments on moisture content at different days after harvest (DAH) of Harivanga mango

Treatments	Moisture content (%) at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	81.76	80.22	78.66	75.85
T_2	84.24	82.36	81.36	78.18
T_3	83.88	82.06	80.96	78.35
T_4	83.39	81.68	80.66	77.46
T_5	82.98	81.36	80.05	77.37
T_6	82.73	81.16	79.46	76.24
T_7	82.25	80.79	79.16	76.61
T_8	85.44	83.36	82.18	80.14
T_9	84.57	82.88	81.71	79.87
T_{10}	84.06	82.16	81.38	78.06
T_{11}	83.66	81.88	80.76	77.97
T_{12}	84.66	82.74	81.22	79.48
T_{13}	84.16	82.18	81.19	78.75
T_{14}	83.55	81.95	81.04	77.68
T_{15}	83.15	81.52	80.38	77.51
T_{16}	82.96	81.38	79.86	76.88
T_{17}	82.46	81.05	79.38	76.55
T_{18}	83.16	81.29	80.17	77.18
T_{19}	82.68	81.26	79.66	77.06
$LSD_{(0.01)}$	1.858	1.274	1.142	1.688
Level of significance	0.01	0.01	0.01	0.01
CV(%)	3.01	4.70	3.64	5.98

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

4.2.5 Dry matter content

Significant variation was found for dry matter content of 'Harivanga' mango at 3, 5, 7 and 9 DAH due to different post-harvest treatments (Appendix V). At 3, 5, 7 and 9 DAH, the highest dry matter content (18.24%, 19.78%, 21.34% and 24.15%, respectively) was observed from T_1 treatment and the 2nd highest dry matter content (17.75%, 19.21%, 20.84% and 23.76%, respectively) was found from T_7 treatment, while the lowest (14.56%, 16.64%, 17.82% and 19.86%, respectively) from T_8 treatment (Table 5). Singh *et al*. (2017) reported that potassium permanganate treated mango showed the highest dry matter content.

4.3 Chemical parameters

4.3.1 TSS (Total soluble solids)

Different post-harvest treatments varied significantly in terms of TSS content of 'Harivanga' mango at 3, 5, 7 and 9 DAH (Appendix VI). At 3, 5, 7 and 9 DAH, the highest TSS (16.34%, 20.83%, 23.55% and 26.12%, respectively) was recorded from T_8 treatment and the 2nd highest TSS content (16.14%, 20.62%, 23.28% and 25.83%, respectively) was found from T_9 treatment, whereas the lowest TSS content (13.02%, 16.82%, 19.46% and 21.55%, respectively) was observed from T_1 treatment (Table 6). Netravati *et al*. (2018) recorded minimum TSS (15.60%) in hot water treated fruits as compared to untreated fruits.

4.3.2 Titrable acidity

Titrable acidity of 'Harivanga' mango at 3, 5, 7 and 9 DAH showed statistically significant variation due to different post-harvest treatments (Appendix VII). At 3, 5, 7 and 9 DAH, the highest Titrable acidity (2.12%, 1.98%, 0.934% and 0.565%, respectively) was found from T_1 treatment and the 2nd highest titrable acidity (2.06%, 1.83%, 0.897% and 0.504%, respectively) was recorded from T_7 treatment, while the lowest titrable acidity (1.27%, 1.11%, 0.782% and 0.362%, respectively) was observed from T_8 treatment (Table 7). Karemera and Habimana (2014) reported that 1.50% $CaCl_2$ significantly increased the physico-chemical parameters of mango fruits compared to control.

Table 5. Effect of different postharvest treatments on dry matter content at different days after harvest (DAH) of Harivanga mango

Treatments	Dry matter content (%) at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	18.24	19.78	21.34	24.15
T_2	15.76	17.64	18.62	21.82
T_3	16.12	17.94	19.04	21.65
T_4	16.61	18.32	19.34	22.54
T_5	17.02	18.64	19.95	22.63
T_6	17.27	18.84	20.54	23.39
T_7	17.75	19.21	20.84	23.76
T_8	14.56	16.64	17.82	19.86
T_9	15.43	17.12	18.64	20.13
T_{10}	15.94	17.84	18.78	21.94
T_{11}	16.34	18.12	19.24	22.03
T_{12}	15.34	17.26	18.29	20.52
T_{13}	15.84	17.82	18.81	21.25
T_{14}	16.45	18.05	18.96	22.32
T_{15}	16.85	18.48	19.62	22.49
T_{16}	17.04	18.62	20.14	23.12
T_{17}	17.54	18.95	20.62	23.45
T_{18}	16.84	18.71	19.83	22.82
T_{19}	17.32	18.74	20.34	22.94
$LSD_{(0.01)}$	1.858	1.274	1.142	1.688
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.07	3.15	2.64	3.43

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

Table 6. Effect of different postharvest treatments on total soluble solids-TSS (%) at different days after harvest (DAH) of Harivanga mango

Treatments	Total soluble solids-TSS (%) at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	13.02	16.82	19.46	21.55
T_2	15.76	19.96	22.71	25.28
T_3	15.58	19.83	22.56	25.02
T_4	14.94	18.54	21.74	23.83
T_5	14.82	18.44	21.52	23.65
T_6	13.82	17.54	20.38	22.64
T_7	13.55	17.42	20.14	22.34
T_8	16.34	20.83	23.55	26.12
T_9	16.14	20.62	23.28	25.83
T_{10}	15.42	19.44	22.32	24.82
T_{11}	15.36	19.13	22.16	24.65
T_{12}	16.04	20.34	23.02	25.75
T_{13}	15.92	20.12	22.87	25.54
T_{14}	15.21	18.84	22.02	24.43
T_{15}	15.11	18.61	21.89	24.15
T_{16}	14.48	17.94	20.79	22.93
T_{17}	14.25	17.76	20.51	22.76
T_{18}	14.71	18.22	21.34	23.48
T_{19}	14.54	18.03	21.11	23.14
$LSD_{(0.01)}$	1.207	1.843	2.380	1.276
Level of significance	0.01	0.01	0.01	0.01
CV(%)	3.63	4.41	4.94	2.39

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

Table 7. Effect of different postharvest treatments on titrable acidity (%) at different days after harvest (DAH) of Harivanga mango

Treatments	Titrable acidity (%) at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	2.12	1.98	0.934	0.565
T_2	1.45	1.28	0.804	0.389
T_3	1.50	1.31	0.811	0.394
T_4	1.65	1.53	0.832	0.434
T_5	1.68	1.56	0.837	0.453
T_6	2.01	1.79	0.894	0.496
T_7	2.06	1.83	0.897	0.504
T_8	1.27	1.11	0.782	0.362
T_9	1.32	1.15	0.789	0.371
T_{10}	1.53	1.36	0.816	0.398
T_{11}	1.57	1.39	0.819	0.404
T_{12}	1.36	1.19	0.791	0.377
T_{13}	1.41	1.24	0.797	0.383
T_{14}	1.59	1.45	0.823	0.415
T_{15}	1.62	1.48	0.828	0.419
T_{16}	1.88	1.71	0.881	0.482
T_{17}	1.92	1.76	0.889	0.489
T_{18}	1.71	1.61	0.842	0.462
T_{19}	1.79	1.65	0.876	0.469
$LSD_{(0.01)}$	0.271	0.221	0.221	0.221
Level of significance	0.01	0.01	0.01	0.01
CV(%)	7.46	6.55	2.16	3.03

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

4.3.3 Vitamin C content

Statistically significant variation was observed in terms of Vitamin C content of 'Harivanga' mango at 3, 5, 7 and 9 DAH due to different post-harvest treatments (Appendix VIII). At 3, 5, 7 and 9 DAH, the highest Vitamin C (21.66%, 20.14%, 17.05% and 15.15%, respectively) was observed from T_1 treatment and the 2nd highest Vitamin C content (20.65%, 19.55%, 16.23% and 14.29%, respectively) was found from T_7 treatment, whereas the lowest Vitamin C content (18.38%, 16.66%, 13.16% and 11.76%, respectively) was recorded from T_8 treatment (Table 8). Ninama and Patel (2018) observed that fruits packed in CFB box with newspaper covering proved to be effectively reduced the physiological loss in weight as well as spoilage loss and thereby maintain good balance between vitamin C and sugar content of fruits during storage.

4.4 Microbial parameters

4.4.1 Disease incidence

Disease incidence of 'Harivanga' mango at 5, 7 and 9 DAH showed statistically significant variation due to different post-harvest treatments (Appendix IX). At 5, 7 and 9 DAH, the highest disease incidence (33.33%, 58.33% and 100.00%, respectively) was recorded from T_1 treatment and the 2nd highest disease incidence (33.33%, 50.00% and 100.00%, respectively) was found from T_7 treatment, while the lowest disease incidence (0.00%, 0.00% and 8.33%, respectively) was observed from T_8 and T_9 treatments (Table 9). Hoque *et al*. (2017) reported that fruit treated with neem extract and wrapped with thin plastic film reduced diseases incidence.

Table 8. Effect of different postharvest treatments on Vitamin C content at different days after harvest (DAH) of Harivanga mango

Treatments	Vitamin C (mg/100 g) at			
	3 DAH	5 DAH	7 DAH	9 DAH
T_1	21.66	20.14	17.05	15.15
T_2	18.94	17.38	14.34	12.43
T_3	19.12	17.56	14.49	12.65
T_4	19.69	18.47	15.15	13.38
T_5	19.74	18.55	15.27	13.46
T_6	20.33	19.34	15.97	14.14
T_7	20.65	19.55	16.23	14.29
T_8	18.38	16.66	13.16	11.76
T_9	18.63	16.73	13.67	11.88
T_{10}	19.25	17.69	14.56	12.78
T_{11}	19.37	17.92	14.73	12.89
T_{12}	18.74	16.95	13.95	11.97
T_{13}	18.82	17.14	14.12	12.14
T_{14}	19.48	18.16	14.84	13.02
T_{15}	19.56	18.31	14.95	13.24
T_{16}	20.13	18.97	15.62	13.89
T_{17}	20.34	19.13	15.78	13.95
T_{18}	19.86	18.63	15.38	13.61
T_{19}	20.04	18.85	15.46	13.78
$LSD_{(0.01)}$	1.443	1.256	0.840	0.653
Level of significance	0.01	0.01	0.01	0.01
CV(%)	3.32	3.11	2.53	2.24

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment

Table 9. Effect of different postharvest treatments on disease incidence at different days after harvest (DAH) of Harivanga mango

Treatments	Disease incidence (%) at		
	5 DAH	7 DAH	9 DAH
T_1	33.33	58.33	100.00
T_2	0.00	16.67	25.00
T_3	8.33	16.67	33.33
T_4	16.67	25.00	66.67
T_5	16.67	25.00	66.67
T_6	25.00	50.00	100.00
T_7	33.33	50.00	100.00
T_8	0.00	0.00	8.33
T_9	0.00	0.00	8.33
T_{10}	8.33	16.67	41.67
T_{11}	8.33	25.00	50.00
T_{12}	0.00	8.33	16.67
T_{13}	0.00	8.33	16.67
T_{14}	8.33	16.67	58.33
T_{15}	16.67	16.67	58.33
T_{16}	25.00	33.33	91.67
T_{17}	25.00	41.67	91.67
T_{18}	16.67	25.00	75.00
T_{19}	25.00	25.00	83.33
$LSD_{(0.01)}$	23.18	23.18	26.43
Level of significance	0.01	0.01	0.01
CV(%)	24.61	13.41	20.78

T_1: Control condition (no postharvest treatments and stored in open condition)

T_2: Stored in polybag after hot water treatment

T_3: Stored in net bag after hot water treatment

T_4: Stored in polybag after sodium metabisulphite treatment

T_5: Stored in net bag after sodium metabisulphite treatment

T_6: Stored in polybag after $CaCl_2$ treatment

T_7: Stored in net bag after $CaCl_2$ treatment

T_8: Stored in polybag after Bavistin dips treatment

T_9: Stored in net bag after Bavistin dips treatment

T_{10}: Stored in polybag after olive oil treatment

T_{11}: Stored in net bag after olive oil treatment

T_{12}: Stored in polybag after garlic extract treatment

T_{13}: Stored in net bag after garlic extract treatment

T_{14}: Stored in polybag after ginger extract treatment

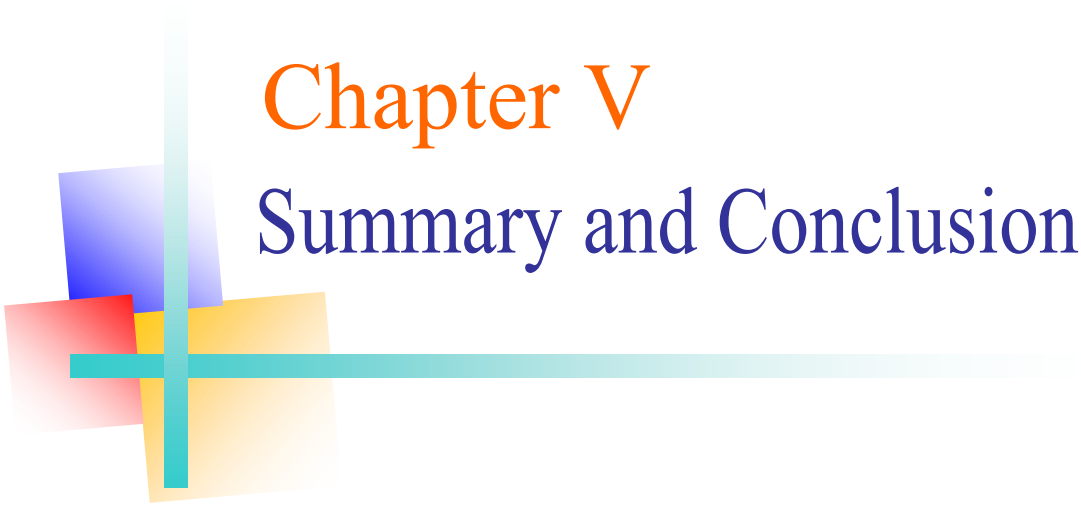
T_{15}: Stored in net bag after ginger extract treatment

T_{16}: Stored in polybag after wax treatment

T_{17}: Stored in net bag after wax treatment

T_{18}: Stored in polybag after detergent treatment

T_{19}: Stored in net bag after detergent treatment



Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the laboratory of the Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from June to August 2018 to assess the management of 'Harivanga' mango variety to increase shelf life and quality. The popular Mango variety 'Harivanga' were used as experimental materials for the study. The experiment comprised of different post-harvest practices as treatment and they were- T_1: Control condition (no postharvest treatments and stored in open condition), T_2: Stored in polybag after hot water treatment, T_3: Stored in net bag after hot water treatment, T_4: Stored in polybag after sodium metabisulphite treatment, T_5: Stored in net bag after sodium metabisulphite treatment, T_6: Stored in polybag after $CaCl_2$ treatment, T_7: Stored in net bag after $CaCl_2$ treatment, T_8: Stored in polybag after Bavistin dips treatment, T_9: Stored in net bag after Bavistin dips treatment, T_{10}: Stored in polybag after olive oil treatment, T_{11}: Stored in net bag after olive oil treatment, T_{12}: Stored in polybag after garlic extract treatment, T_{13}: Stored in net bag after garlic extract treatment, T_{14}: Stored in polybag after ginger extract treatment, T_{15}: Stored in net bag after ginger extract treatment, T_{16}: Stored in polybag after wax treatment, T_{17}: Stored in net bag after wax treatment, T_{18}: Stored in polybag after detergent treatment and T_{19}: Stored in net bag after detergent treatment. Data were recorded on shelf life and different quality parameters and statistically significant differences was observed for different treatments.

The highest shelf life (15.67 days) was observed from T_8 treatment, whereas the lowest shelf life (9.00 days) was recorded from T_1 treatment. At 3, 5, 7 and 9 days after harvest (DAH), the highest firmness score (2.67, 3.58, 4.62 and 5.96, respectively) was found from T_1 treatment and the lowest firmness score (1.48, 2.13, 3.12 and 4.04, respectively) was observed from T_8 treatment. At 3, 5, 7 and 9 DAH, the highest color score (1.95, 4.70, 6.15 and 7.02, respectively) was recorded from T_9 treatment, whereas the lowest color score (1.21, 2.56, 3.15 and

5.38, respectively) was observed from T_{13} treatment. At 3, 5, 7 and 9 DAH, the highest weight loss (4.68%, 7.56%, 9.92% and 12.25%, respectively) was observed from T_1 treatment and the lowest weight loss (2.46%, 5.14%, 7.45% and 10.12%, respectively) was recorded from T_{16}treatment. At 3, 5, 7 and 9 DAH, the highest moisture content (85.44%, 83.36%, 82.18% and 80.14%, respectively) was found from T_8 treatment, whereas the lowest moisture content (81.76%, 80.22%, 78.66% and 75.85%, respectively) was observed from T_1 treatment. At 3, 5, 7 and 9 DAH, the highest dry matter content (18.24%, 19.78%, 21.34% and 24.15%, respectively) was observed from T_1 treatment and the lowest dry matter content (14.56%, 16.64%, 17.82% and 19.86%, respectively) was recorded from T_8 treatment.

At 3, 5, 7 and 9 DAH, the highest TSS (16.34%, 20.83%, 23.55% and 26.12%, respectively) was recorded from T_8 treatment, whereas the lowest TSS content (13.02%, 16.82%, 19.46% and 21.55%, respectively) was observed from T_1treatment. At 3, 5, 7 and 9 DAH, the highest titrable acidity (2.12%, 1.98%, 0.934% and 0.565%, respectively) was found from T_1 treatment and the lowest titrable acidity (1.27%, 1.11%, 0.782% and 0.362%, respectively) was observed from T_8 treatment. At 3, 5, 7 and 9 DAH, the highest Vitamin C (21.66%, 20.14%, 17.05% and 15.15%, respectively) was observed from T_1 treatment, whereas the lowest Vitamin C content (18.38%, 16.66%, 13.16% and 11.76%, respectively) was recorded from T_8 treatment. At 5, 7 and 9 DAH, the highest disease incidence (33.33%, 58.33% and 100.00%, respectively) was recorded from T_1 treatment and the lowest disease incidence (0.00%, 0.00% and 8.33%, respectively) was observed from T_8 and T_9 treatments.

Conclusion:

In consideration of shelf life and quality treatment T_8 as stored in polybag after Bavistin dips treatment were superior which was followed by T_9 treatment as stored in net bag after Bavistin dips treatment for ‘Harivanga’ mango.

Recommendation:

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. Other post-harvest management practices may be included and repeated study need to be done for a final suggestion in regards to shelf life and quality of ‘Harivanga’ mango;

2. Other popular variety also included for further study to specify the specific post-harvest management practices for mango in regards to shelf life and quality.

References

REFERENCES

Abd El-Monem, E.A.A., Zahran, A.A. and Shaban, A.E. (2013). Role of some postharvest treatments in maintaining mango fruit quality during cold storage. *J. Appl. Sci. Res*., **9**(3): 2355-2366.

Amin, M., Malik, A.U., Mazhar, M.S., Din, I., Khalid, M.S. and Ahmad, S. (2008). Mango fruit de-sapping in relation to time of harvesting. *Pakistan J. Bot*., **40**(4): 587-1593.

Anjum, M.A. and Ali. H. (2004). Effect of various calcium salts on ripening of mango Fruits. *J. Res. Sci*., **15**(1): 45- 52.

Anonymous. (2013). Species and cultivation of mango. Press, Inc. Boca. Raton, Florida, p. 33.

Anwar, R. and Malik, A.U. (2007). Hot water treatment affects ripening quality and storage life of mango (*Mangifera indica* L.). *Pakistan J. Agric. Sci*., **44**: 304-311.

Anwar, R., Malik, M. Amin, K., Jabbar, A. and Saleem, B.A. (2008). Packaging material and ripening methods affect mango fruit quality. *Intl. J. Agric. Biol*., **10**: 35-41.

Asif, M. (2012). Physico-chemical properties and toxic effect of fruit-ripening agent calcium carbide. *Annals Trop. Med. Public Health*. **5**(3): 150-156.

BBS. (2013). Monthly Statistical Bulletin, Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning. Government of People's of Bangladesh, p. 55.

Bhuyan, M.A.J. (1995). Mango (*Mangifera indica* L.) in fruit production manual. *Hort. Res. Dev. Proj*. (FAO/UNDP/ASDB Project: BDG/87/025. pp. 1-286.

Candole, A.D. (1984). Origin of cultivated plants. *Vegal Paul Trench and Company, London.* pp. 1-67.

Chien, P.J., Sheu, F. and Yang, F.H. (2007). Effects of edible chitosan coating on quality and shelf life of sliced mango fruit. *J. Food Eng*., **78**(1): 225-229.

Cua, A.U. and Lizada, M.C.C. (1990). Ethylene production in the 'Carabao' mango (*Mangifera indica* L.) fruit during maturation and ripening. *Acta Hort.,* **269**: 169-79.

Dissa, A.O., Desmorieux, H., Degrave, P., Bathiebo, J. and Koulidiati, J. (2011). Impact of fruit ripeness on physiochemical properties and convective drying characteristics of Kent mango (*Mangifera indica* L. cv. Kent). *Intl. J. Food Eng*., **7**(3): 12-19.

Ezz, T.M. and Awad, R.M. (2011). Effect of some post harvest treatments under different low temperature on two cultivars. *Australian J. Basic & Appl. Sci*., **5**(10): 1164-1174.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York. p. 453.

Hassan, M.K. (2006). Constitutive alkenyl resorcinol's and resistance to postharvest diseases in mango. PhD. thesis, School of Agronomy & Horticulture, The University of Queensland, Australia. p. 286.

Hassan, M.K., Dann, E.K., Coates, L.M., Hofman, P.J. and Irving, D.E. (2010). Retention of the fruit peduncle at harvest retains sap and contributes to resistance against postharvest anthracnose disease in 'Kensington Pride', but not in 'R_2E_2', mango. *J. Orti. Sci. & Biotech.,* **86**(3): 261-266.

Holmes, R.J., Ledger, S.N. and Macleod, W.N.B. (1993). Handling systems to reduce mango sapburn. *Acta Hort*., **341**: 528-532.

Hoque1, M.I., Chowhan1, S. and Kamruzzaman, M. (2017). Physiological changes and shelf life of mango (*Mangifera indica* L.) influenced by post-harvest treatments. *SAARC J. Agric*., **15**(2): 219-226.

Islas-Osuna, M.A., Stephens-Camacho, N.A., Contreras-Vergara, C.A., Rivera-Dominguez, M. and Sanchez-Sanchez. E. (2010). Novel postharvest treatment reduces ascorbic acid losses in mango (*Mangifera indica* L.) var. *Kent. Am. J. Agric. Biol. Sci*., **5**(3): 342-349.

Jabbar, A., Malik, A.U., Din, I., Anwar, R., Ayub, M., Rajwana, I.A. Amin, M., Khan, A.S. and Saeed, M. (2011). Effect of combined application of fungicides and hot water quarantine treatment on postharvest diseases and quality of mango fruit. *Pakistan J. Bot*., **43**(1): 65-73.

Karemera, N.J.U. and Habimana, S. (2014). Effect of pre-harvest Calcium Chloride on Post-harvest Behavior of Mango Fruits (*Mangifera indica* L.) cv. Alphonso. *Universal J. Agril. Res*., **2**(3): 119-125

Kaswija, M., Peter, M. and Leonard, F. (2006). Sensory attributes, microbial quality and aroma profiles of off vine ripened mango (*Mangifera indica* L.) fruit. *African J. Biotech*., **5**(2): 201-205.

Khader, S.E. (1985). Effect of postharvest application of GA_3 on postharvest behaviour of mango fruits. *Hort. Sci.,* **47**(3-4): 317-321.

Lashley, D. (1984). Advances in postharvest technology and new technologies in food production. Ptoc. Seminar. St. Augustine (Trinidad Tobago), pp. 173-183. .

Le, T.N., Shiesh, C.C. and Lin, H.L. (2010). Effect of vapor heat and hot water treatments on disease incidence and quality of Taiwan native strain mango fruits. *Intl. J. Agric. Biol*., **12**: 673-678.

Loveys, B.R., Robinson, S.P., Brophy, J.J. and Chacko, E.K. (1992). Mango Sapburn: Components of fruit sap and their role in causing skin damage. *Australian. J. Plant. Physiol*., **19**: 449-457.

Malik, A.U., Singh, Z. and Tan, S.C. (2006). Exogenous application of polyamines improves shelf life and fruit quality of mango. *Acta Hort*., **699**: 291-296.

Maqbool, M. and Malik, A.U. (2008). Anti-Sap chemicals reduce sap burn injury and improve fruit quality in commercial mango cultivars. *Intl. J. Agric. Biol*., **10**: 1-8.

Maqbool, M., Malik, A.U. and Jabbar, A. (2007). Sap dynamics and its management in commercial mango cultivars of Pakistan. *Pakistan J. Bot*., **39**(5): 1565-1574.

Mariappan, P. (2004). How do raw mangoes and bananas become ripe when treated with chemicals. *In: The Hindu–Online edition of India's National Newspaper*. Dated: 29th July, 2004.

Mata, M., Sarker, K. P. and Ramesh, M. N. (2007). Ripening reactions for the application of ethylene. *Plant Growth Regul*., **53**: 102-112.

McCollum, T.G., Aquino, S.D., Miller, W.R. and Mcdonald, R.E. (1992). Individual shrink film wrapping of mangoes. *Proc. Fla. State Hort. Soc*., **105**: 103-105.

Medlicott, A.P. and Sigrist, J.M.M. (1990). Ripening of mangoes following low temperature storage. *J. Amer. Soc.,* **115**(3): 430-434.

Medlicott, A.P., Bhogal, M. and Reynolds, S. (1986). Changes in Peel Pigmentatiqn during ripening of mango fruit *(Mangifera indica* L. cv. TomyAtkins). *Annual App. Biol.,* **109**: 651-656.

Menezes, J.B., Alves, R.E. and Freire, F.C.O. (1995). Mango sapburna postharvest injury. *Veg*., **7**(2): 181-184.

Miller, W.R., Spalding, D.H. and Hale, P.W. (1986). Film wrapping mangoes at advancing storage of postharvest ripening. *Trop. Sci.,* **26**(1): 9-17.

Mondal, M.F., Rahim, M.A. and Paramanik, M.A.J. (1995). Effects of different postharvest treatments on physico-chemical changes and shelf-life of mango. *Bangladesh Hort.,* **23**(1&2): 1-5.

Nair, S. and Singh, Z. (2003). Prestorageethrel dip reduces chilling injury, enhances respiration rate, ethylene production and improves fruit quality of 'Kensington Pride' mango. *Food Agric. Envron.*, **1**: 93-97.

Netravati, S., Jagadeesh, L., Nataraja, A. and Suresha, G.J. (2018). Effect of Eco-Friendly Post Harvest Treatments on Decay Index of Mango Fruits Cv. Alphonso. *Intl. J. Curr. Microbiol. App. Sci*., **7**(5): 1-7.

Ninama, A.S. and Patel, K.M. (2018). Effect of post-harvest treatments on physical, physiological and shelf life of mango (*Mangifera indica* L.) CV. Amrapali. *Intl. J. Che. Studies***, 6**(3): 2592-2594.

Padmini, S. and Prabha, T.N. (1997). Biochemical changes during acetylene-induced ripening in mangoes (var. Alphonso). *Trop. Agric.,* **74**: 265-71.

Payasi, A. and Sanwal, G.G. (2010). Ripening of climacteric fruits and their control. *J. Food Biochem*., **34**: 679-710.

Prusky, D., Fuchs, Y., Kobiler, I., Roth, I. and Weksler, A. (1999). Effect of hot water brushing, prochloraz treatment and waxing on the incidence of black spot decay caused by *Alternaria Alternata* in mango fruits. *Postharvest Biol. Technol*., **15**(10): 165-174.

Purohit, M.A. (1985). Vitamin and mineral content in mango and their influence on the prevention of diseases. *Intl. Tropical Agric.,* **6**(1): 45-56.

Quroshi, S.U. and Meah, M.S. (1991). Postharvest loss in mango owing to stem-end rot. *Intl. Trop. Agric.,* **9**(2): 98-105.

Ranganna, P. (1979). Estimation procedure of chemical parameters in Mnago. *Vegal Paul Trench and Company, London,* p. 76.

Rathore, H.A., Masud, T., Sammi S. and Majeed, S. (2010). Innovative approach of active packaging in cardboard carton and its effect on overall quality attributes such as weight loss, total soluble solids, pH, acidity and ascorbic acid contents of Chaunsa White variety of mango at ambient temperature during storage. *Pakistan. J. Nutrition*., **9**(5): 452-458.

Ravindra, M.R. and Goswami, T.K. (2008). Modelling the respiration rate of green mature mango under aerobic conditions. *Biosystems Eng*., **99**: 239-248.

Rodov, V., Fishman, S., Asuncion, R.D., Peretz, J., and Yehoshua, S.B. (1997). Modified atmosphere packaging (MAP) of Tommy Atkins mango in perforated film. *Acta Hort*., **455**: 654-661.

Salunkhe, D.K. and Desai, B.B. (1984). Postharvest Biotechnology of Fruits 1 CRC Press, Inc. Boca. Raton, Florida, p. 168.

Santos, A.F., Silva, S.M., Mendonça, R.M.N., Alves, R.E. and Martins, L.P. (2004). Storage of mango fruits cv. Rosa treated with calcium chloride after harvest at different maturity stages. *Acta Hort*., **645**: 663-670.

Sergent, S., Majuder, S.K., and Roy, P.K. (1993). Post harvest treatment on the production of soluble solids content and improvement of the quality of mango. *ASEAN Food J.*, **7**: 207-208.

Sethi, S., Srivastav, M., Samuel, D.V.K., Singh, A.K., Dubey, A.K. and Singh, G. (2011). Evaluation of newly developed mango (*Mangifera indica*) hybrids for their storage behaviour and peel colour. *Indian J. Agric. Sci*., **81**(3): 252-255.

Siddiqui, A.B. and Scanlan, F. (1995). Nutritive values of fruits. International Fruit Production Manual. Horticultural Research Development Project. (FAO/UNDP/ASDB Project. BGD/87/025). pp. 12-88.

Singh, R.K. and Singh, R.N. (2010). Effect of postharvest treatments on shelf life of mango (*Mangifera indica* L.) fruits cv. *Amrapali. Res. J. Agric. Sci*., **1**(4): 415- 418.

Singh, R., Ahirwar, D.K. and Baghel, S.S. (2017), Post-Harvest Factors Affecting on Shelf-Life and Quality of Mango cv. Langra, *Intl. J. Pure App. Biosci*. **5**(4): 2090-2096.

Singh, R., Singh, P., Pathak, N., Singh, V.K. and Dwivedi, U.N. (2007). Modulation of mango ripening by chemicals: physiological and biochemical aspects. *Plant Growth Regul*., **53**: 137-145.

Singh, Z. and Janes, J. (2001). Effect of postharvest application of ethephon on fruit ripening, quality and shelf life of mango under modified atmosphere packaging. *Acta Hort.,* **553**: 599-601.

Srinivasa, P.C., Baskaran, R., Ramesh, M.N., Prashanth, K.V.H. and Tharanthan, R.N. (2002). Storage studies of mango packed using biodegradable chitosan film. *European Food Res. Technol.,* **215**(6): 504-508:

Subramanian, S. (2004). How do raw mangoes and bananas become ripe when treated with chemicals. *In*: *The Hindu-Online Edition of India's National Newspaper*. Dated: 29th July, 2004.

Tharanathan, R.N., Yashoda, H.M., and Prabha, T.N. (2006). Mango (*Mangifera indica* L.) The King of Fruits-An Overview. *Food Reviews Intl.*, **22**: 95-123.

USDA. (2013). Nutritional value in different fruits/or http://usdastat.usda.org.

Venkatesan, T. and Tamilmani, C. (2010). Effect of ethreal on phenolic changes during ripening of off season fruits of mango (*Mangifera indica* L. var. Neelum). *Curr. Bot*., **1**(1): 22-28.

Yuniarti, P, and Suhardi, K. (1992). Ripening retardation of Arumanis mango. *ASEAN Food J*., **7**: 207-208.

Zeng, K.F., Cao, J.K. and Jiang, W.B. (2006). Enhancing disease resistance in harvested mango (*Mangifera indica* L. cv. "Matisu") fruit by salicylic acid. *J. Sci. Food Agric*., **86**: 694-698.

Zheng, X., Shiping, T., Michael, J.G., Hong, Y. and Boqiang, L. (2007). Effects of exogenous oxalic acid on ripening and decay incidence in mango fruit during storage at room temperature. *Postharvest Biol. Technol*., **45**: 281-284.

Zhong, Q.P., Xia, W.S. and Jiang, Y. (2006). Effects of 1-methylcyclopropene treatments on ripening and Quality of harvested sapodilla fruit. *Food Technol. and biotechnol*., **44**(4): 535-539.

Appendices

APPENDICES

Appendix I. Analysis of variance of the data on shelf life and firmness score at different days after harvest (DAH) of Harivanga mangoas influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square				
		Shelf life (days)	Firmness score at			
			3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	6.068**	0.441**	0.605**	0.671**	1.046**
Error	38	0.228	0.007	0.019	0.049	0.036

** Significant at 0.01 level of probability

Appendix II. Analysis of variance of the data on color score at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Color score at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	0.134**	1.200**	2.490**	1.049**
Error	38	0.005	0.060	0.058	0.048

** Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on weight loss at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Weight loss (%) at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	1.125**	1.165**	1.277**	1.109**
Error	38	0.019	0.120	0.086	0.236

** Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on moisture content at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Moisture content (%) at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	2.573**	1.770**	2.725**	4.229**
Error	38	0.704	0.331	0.266	0.581

** Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on dry matter content at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Dry matter content (%) at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	2.573**	1.770**	2.725**	4.229**
Error	38	0.704	0.331	0.266	0.581

** Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on total soluble solids-TSS at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Total soluble solids-TSS (%) at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	2.479**	4.130**	3.900**	5.259**
Error	38	0.297	0.693	1.156	0.332

** Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data on titrable acidity at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Titrable acidity (%) at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	0.192**	0.187**	0.006**	0.009**
Error	38	0.015	0.010	0.0001	0.000

** Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data on Vitamin C content at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square			
		Vitamin C (mg/100 g) at			
		3 DAH	5 DAH	7 DAH	9 DAH
Treatments	18	1.932**	2.971**	2.684**	2.531**
Error	38	0.425	0.322	0.144	0.087

** Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data on disease incidence at different days after harvest (DAH) of Harivanga mango as influenced by different postharvest treatments

Source of variation	Degrees of freedom	Mean square		
		Disease incidence (%) at		
		5 DAH	7 DAH	9 DAH
Treatments	18	394.737**	807.749**	3168.860**
Error	38	109.649	109.649	142.544

** Significant at 0.01 level of probability