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Increasing Shelf Life and Maintaining Quality of Mango by Postharvest Treatments and Packaging Technique

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Abstract

This experiment was carried out to increase the shelf life and maintaining the quality of mango (*Mangifera indica*) fruits. There were two factors. Factor A: postharvest treatments with six levels (1. untreated (control), 2. washing with chlorine, 3. dipping (5 minutes) in calcium chloride ($CaCl_2$), 4. dipping (5 minutes) in bavistin and rinse in clean water, 5. hot water treatment and 6. tap water wash) and factor B: packaging technique with five levels (1. without packaging (control), 2. perforated poly bag (0.5%), 3. non- perforated poly bag, 4. plastic crate and 5. corrugated fibre board carton). The fruits treated with chlorine wash, tap water wash, hot water treatment, dipping in calcium chloride and bavistin were significant difference on chemical parameter (total sugar content, vitamin-C, total titrable acidity and total soluble solid) of mango. Treated fruits performed less disease incidence compared to without treated fruits. Non-treated fruits were attacked by the sunken black spots on the surface of the fruits as well as anthracnose (*Colletotrichum gloeosporioides*). In case of packaging technique, fruits packed in different packaging materials (like corrugated fibre board carton, plastic crate, perforate and non-perforated polyethylene bag) had the maximum shelf life, lower physiological loss in weight and less disease incidence than without package. Among the different packaging materials, fruits packed in corrugated fibre board carton had the maximum shelf life (13.02 days), lower physiological loss in weight (4.11%) and less disease incidence (1.12%) without excessive deterioration compared to others. The shelf life of mango could be extended up to 5 days by hot water treatment and packed in. corrugated fibre board carton compared to others. The color and quality of mango was very better in treated fruits compared to non-treated fruits.

Keywords: Chemical factor and Packaging, Hot water, Mango, Postharvest.

INTRODUCTION

Mango (*Mangifera indica*) is one of the popular and delicious fruits in Bangladesh. It is grown almost all over the country but its production is mostly concentrated in the northern and eastern region (BBS, 2006). The leading mangoes producing districts are Chapai Nawabgonj, Rajshahi and Satkhira areas. At present, the area of this fruit under cultivation is 1681 hectares of land with production of 40195 metric tons (BBS, 2006). A considerable amount of mango fruits losses every year due to lack of proper harvesting technique, sorting, storing, transportation, selling and consumption due to its perishability nature. The perishability of this fruit is attributed to immense physiological changes after harvest (Momen *et al.,* 1993). Molla *et al.,* (2010) reported that the post harvest losses of mango in Bangladesh are 51.88% (including agro-food sector) while it is only 5-25% in developed countries (Kader, 1992). Postharvest diseases as well as anthracnose are appeared due to the effect of fruit maturity, handling and storage condition. Washing produce before preparation or consumption is recommended but does not guarantee that fresh produce is pathogen free. Washing produce in cold chlorinated water will reduce microbial populations by 2 or 3 logs (100 to 1000-fold), but sterility is not achieved because microorganisms adhere to surfaces of produce and may present in microscopic nooks and crannies on the surface of produce (Zhuang *et al.,* 1995). Wash with water is an important part of assuring produce quality during postharvest handling. The wash water can easily spread disease from one unit of produce to another if there is not use clean and sanitized with chlorine bleach (hypochlorite) 100 to 200ppm is the recommended level of chlorine in wash water that will provide adequate protection when the pH is 6.5 (Kitinoja, 2001). Many chemical treatments have been banned or restricted as postharvest fungicide treatments of fruits in some countries, and the demand of pesticide free produce has increased (Adaskaveg *et al.,* 2002). So, it has been necessary to develop alternative treatments in order to avoid toxic and dangerous chemicals compounds in foods for human consumption. Heat treatments may be effective as a non-chemical mean of improving postharvest quality of a range of horticultural products. They are usually applied as a hot water dips, vapor heat or hot air treatments (Lurie, 1998). Hot water treatments affect ripening and protect against physiological disorders (Klein and Lurie, 1992).In many countries of the world, fruits and vegetables are washed in chlorine or potassium permanganate or hot benomil as well as bavistin before storage (Giraldo *et al.,* 1977). Chlorine water is achieved by adding 200 ppm sodium hypochlorite in clean water (Amiruzzaman, 2000). Good package design contributes a great deal to the quality image of the product both in domestic and export markets. It is reported that different postharvest treatments have significant effect on the quality and storage life of mango. Use of packaging technique, washing with chlorine, dipping in fungicides, calcium chloride and hot water treatment are usually employed for increasing the shelf life and reducing the post-harvest losses of fruits. Information regarding packaging and postharvest treatments of mango is meager in Bangladesh. Hence, the study was undertaken to extend the shelf life, maintain the quality and minimize postharvest diseases of mango as well as reducing postharvest losses of mango.

MATERIALS AND METHODS

Nutrient Management of Orchard

Since, the farm yard manure directly responsible to increase the fruit yields either by accelerating the respiratory process by increasing cell permeability by hormone growth action or by combination of all these processes. Therefore, 900g nitrogen, 250g phosphorus and 250g potassium were applied per tree per year with irrigation at 55-60 per cent of field capacity.

Soil Texture of Orchard: Sandy-loam soil: Climatic condition

Maximum and minimum temperature were recorded as 31.6-32.5oC and 25.7-26.1oC with relative humidity 80-85%. The rainfall was recorded as 311.2- 345.1mm and the number of rainy day was found 14 and 16 days during conducting the experiment in Tangail.

Preparation Before Storage

After harvest from orchard, the mango was carried out in the laboratory of Postharvest Technology Section of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur. After carrying in laboratory, the fruits were cooled immediately in ice water to remove field heat. Then the fruits were sorted out to eliminate bruised, punctured and damaged ones.

Design of Experiment

The experiment was laid out in Complete Randomized Design (CRD) with factorial. There are two factors; factor A: postharvest treatment with six levels (1. untreated, 2 washing with chlorine, 3.dipping in bavistin for five minutes, 4. dipping in calcium chloride for five minutes, 5. treated with hot water at 55^{o}C for five minutes and 6. washing with tap water), factor B: packaging technique with five levels (1. without packaging, 2..perforated poly bag, 3. non-perforated poly bag, 4. plastic crate, 5. corrugated fibre board carton). These factorial treatments were replicated four times (three replications were used for physical parameter and one replication was used for chemical parameter)

Data Recorded

Data on physical parameter like physiological loss in weight (%), disease incidence (%) , shelf life (days) and chemical parameter like vitamin-C (mg/100g), total titrable acidity (%), total soluble solid (^{o}B), reducing sugar (%) and total sugar (%) content were recorded.

Physical Parameter

Physiological Loss in Weight (%)

It was determined by periodical weighing of fruits at storage and expressed as percentage of original weight. Damaged fruits were not included with it (Amayogi and Alloli, 2007).

$$\% \ PLW = \frac{IW - FW}{IW} X100$$

Where, PLW= Physiological loss in weight of mango
IW= Initial weight of mango
FW= Final weight of mango

Percent Disease Incidence (Anthracnose)

Disease incidence was calculated as the percentage of diseased fruit (1/10th) per total number of fruits (25 fruits in separate treatments). The fruits were observed visually for rotting and microbial infection. Percent disease incidence was identified and calculated using the formula of Mamatha and Rai (2000).

$$\%DI = \frac{Do}{D} X100$$

Where, DI= Disease incidence
Do= Number of diseased fruit
D= Total number of fruits

Disease severity was calculated as defined as the percentage of fruit area diseased ($1/10^{th}$). Estimates of disease severity per fruit were expressed as the mean disease severity of per fruit. Disease severity was calculated using the following formula of Johnston (2000).

$$\%DS = \frac{Ao}{A} X100$$

Where, DS= Percent disease severity
Ao= Area of fruit infected by disease
A= Total area of fruit

Shelf Life (Day)

The shelf life of fruits was determined from the days of harvesting to marketable stage by evaluating the non marketability parameter such as damaging, shriveling, bruising, disease infected etc. (Nazrul *et al.,* 2010). During storage, the room temperature and relative humidity was 28-32^{o}C and 85-905% respectively. Each package contains 25 fruits per replication.

Chemical Analysis

Among four replications three replications were used for physical parameter like physiological loss in weight (%), disease incidence (%), shelf life (days) and one replication were used for chemical analysis like vitamin-C (mg/100g), total titrable acidity (%), total soluble solid (^{o}B), reducing sugar (%) and total sugar (%).

Vitamin-C (mg/ 100g)

Vitamin-C (mg/100g) by 2, 6- Diclorophenol-Indophenol Visual Titration Method described by Rangana (1991).

Total Titratable Acidity

The acidity was determined by diluting the known volume of clear juice, filtered through whatmen paper, with distilled water and titrating the same against standard 0.1N sodium hydroxide solution, using phenolphthalein indicator. The appearance of light pink colour was marked as the end point. The result was expressed in terms of citric acid as per cent total titratable acidity of the fruit juice according to the method of Ranganna (1991).

Total Soluble Solids

The total soluble solids of the pulp for each treatment was recorded with the help of hand Refractometer of 0-80^{o} Brix range and expressed as per cent total soluble solids of the fruit (Ranganna, 1991).

Total and Reducing Sugar Content (%)

Total sugar (%) and reducing sugar (%) content was determined by Lane and Eynon Method. These methods were conducted described by Rangana (1991).

Statistical Analysis

The experiment was laid out in Complete Randomized Design (factorial) with three replications. A two-way analysis of variances (ANOVA) was done by using statistical method (MSTAT-C). The difference was quantified by Duncan's Multiple Range Test (DMRT)

RESULTS AND DISCUSSION

Postharvest Quality Of Mango

Most of the mango fruits lost their quality due to postharvest diseases when the fresh fruits were stored at ambient condition and without treated (control). The symptoms of postharvest diseases were appeared sunken black spots on the surface of the fruits and it was identified anthracnose (*Colletotrichum gloeosporioides*) (Hadi and Meity, 2007). This fungal disease might be occurred from flowering to fruit set and after harvest. After harvest, disease is mostly severed during ripening process of the fruits. The combined effect (Table 1) shows that fruits treated with different treatments (like chlorine wash, tap water wash, hot water, dipping in calcium chloride and bavistin) and packed in different packaging materials (like corrugated fibre board carton, plastic crate, perforated polyethylene and non- perforated polyethylene bag) minimized maximum postharvest diseases through maintaining the quality compared to without treated (control) and non-packed at different storage periods (Table 1). These might be due to its thermal treatment and packaging technique which has a lethal effect of surface pathogens for minimizing damages of fruits. These results are partially supported by the Wenzhong *et al.,* (2004).

Combined Effect of Postharvest Treatments and Packaging Technique for Maintaining Quality of Mango

The fruits were treated with chlorine water (NaoCl), tap water, bavistin, calcium chloride and packed in plastic crate, corrugated fibre board carton, perforated and non-perforated polyethylene bag within 24 hours of harvest. The lowest physiological loss in weight was recorded in mango fruits treated with hot water treatment, bavistin, chlorine and calcium chloride followed by untreated fruits (control) (Table 1). Considering storage periods (after 12 days) and treatments combination, the lowest physiological loss in weight and less disease incidence was recorded in hot water treatment and packed in corrugated fibre board carton compared to others. Therefore, the corrugated fibre board carton could contribute to minimize the postharvest losses of mango during storage. The lowest physiological loss might be due to inactivate the protein and tissue of surface flesh of mango to retard the evaporation of water through the skin and also formed the protection tissue from pathogens. These results are supported by the Wenzhong *et al.,* (2004).The less disease incidence might be due to wash out of spores of the pathogens and less contamination as well as prevents the transfer of spores and debris from fruit to fruit in the same container during storage. These results are fully supported by the (Barmore *et al.,* (1983). In case of shelf life, fruits treated with hot water treatment and packed in corrugated fibre board carton had the maximum shelf life (13.02 days) compared to untreated and without packed (Table 1). Therefore, the fruits treated with hot water and packed in corrugated fibre board carton increased the shelf life 5 days compared to others (Table 1). These results are partially supported by Amin *et al.,* (2007).On the other hand, fruits packed in plastic crate resists the produce from internal and external stresses during handling of mango due to its adequate strength to hold. These results are an agreement with Kitinoja (2001).

Effect of Postharvest Treatments on Chemical Parameter of Mango

There was significant difference between the treated and non-treated mango (Table 3). The highest total sugar content was observed in the treated mango compared to untreated mango (Table 3). This might be due to hydrolysis of starch and accumulation of sugars (Patil and Magar, 1976 and Ngalana *et al.,* 1999) and conversion of starch through the process of glucogenesis (Islam, 1998).There was an appreciable increase in the content of total sugar with the increase of storage periods. The vitamin-C of treated mango was more than non-treated fruits comparatively. But after 12 days of storage, the decreasing tendency of vitamin-C was observed with the increasing of storage periods (Table 2&3). These might be due to its oxidation during the long concentration steps in room temperature. The results were similar to El.Ashwash *et al.,* (1980). It was interesting to note that the highest total titrable acidity was recorded in non-treated mango compared to treated mango (Table 3). Waskar and Roy (1992) stated that the acid content in fruits during ripening depends upon the proton transfer process as the fruits ripen. Therefore, the lower acidity in treated fruits might be resulting from an excess transfer of proton during ripening. On the other hand, after 12 days of storage, the acidity was decreased with the increase of storage periods (Table 2&3). The decreased acidity might be due to inverse relation with the increased of storage periods. The results are an agreement with Singh and Roy (1984). The total soluble solid increased during ripening process of mango during storage (Table 2&3). These might be due to hydrolysis of polysaccharides and concentration of the pulp as a result of dehydration.

Effect of Packaging Technique on Chemical Parameter of Mango

The effect of different packaging materials on pattern of changes in total sugar content of mango fruits during storage is shown in Table 4. The total sugar content of the mango fruits increased with the advancement of storage periods. Vitamin-C of storage fruits were 0.333 in open condition (without packed) but it was increased in perforated and non-perforated polyethylene bag and then it was decreased in other packaging materials. However, the difference of vitamin-C for various packaging materials was non- significant. Total titrable acidity and total soluble solid slightly increased in different packaging materials compared to without package. But, the differences were statistically negligible. Therefore, the effect of packaging materials on chemical parameters like total soluble solid, total titrable acidity, vitamin-C, total sugar and reducing sugar content was non-significant (Table 4). These results are supported by Mohla *et al.,* (2000).

Combined Effect of Postharvest Treatments and Packaging Technique on Chemical Parameter of Mango

The fruits were treated with different postharvest treatments like hot water treatment, wash with chlorine (NaoCl), dipping in bavistin and calcium chloride and packed in plastic crate, corrugated fibre board carton, perforated and non-perforated polyethylene bag. But after 12 days of storage, vitamin-C, total titrable acidity, total soluble solid, total sugar and reducing sugar content slightly increased compared to non-treated and non-packed fruits. But, statistically, no significant difference was observed among the different postharvest treatments and packaging techniques on chemical parameter of mango (Table 5). These results are partially supported by Dilawar *et al.,* (2007).

CONCLUSION

The fruits treated with chlorine wash, tap water wash, hot water treatment, dipping in calcium chloride and bavistin were significant difference on chemical parameter (total sugar content, vitamin-C, total titrable acidity and total soluble solid) of mango. In case of packaging, no significant difference was observed on chemical parameter of mango. Treated fruits performed less disease incidence compared to without treated fruits. Non-treated fruits were attacked by the sunken black spots on the surface of the fruits as well as anthracnose (*Colletotrichum gloeosporioides*). In case of packaging technique, fruits packed in different packaging materials (like corrugated fibre board carton, plastice crate, perforated and non-perforated polyethylene bag) had the maximum shelf life, lower physiological loss in weight and disease incidence than without package. Among the different packaging technique, fruits packed in corrugated fibre board carton had the maximum shelf life (13.02 days) without excessive deterioration compared to others. The shelf life of mango could be extended up to 5 days by hot water treatment and packed in. corrugated fibre board carton compared to others. The colour and quality of mango was very attractive in treated fruits compared to untreated fruits. But further study, it is necessary to know the toxicity of bavistin of the treated mango.

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Literature Cited

Adaskaveg J.E, Forster H, Sommer NF. 2002. Principles of postharvest pathology and management of decays of edible horticultural crops. Ch. 17. In: Kader AA (ed) Postharvest technology of horticultural crops. University of California. Agriculture and Natural Resources. Publication 3311, P. 163–195

Amin M. N, Roy, K.C, Matin, M.A, Wohab,M.A and Molla, M. M. 2007. Design and development of hot–water treatment plant for mango. Bangladesh Journal of Agricultural Research. 32(4): 637-648.

Amiruzzaman M. 2000.Postharvest Technology/Management (vegetables). A consultancy report. AVRDC-USAID Bangladesh Project. P.193.

Amayogi R. K. and Alloli, T.B. 2007. Studies on integrated nutrient and postharvest management of fig (Ficus carica L.). Ph.D. Thesis. Department of Horticulture. College of Agriculture, Dharwad University of Agricultural Sciences Dharwad – 580 005.143p

BBS. 2006. Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh. P. 98.

Barmore C.R, Purvis AC and Fellers PJ. 1983. Polyethylene film packing of citrus fruit: Containment of decaying fruit. Journal of Food Science, 48:1558-1559.

Dilawar K., Arbab R., Khan, Saiqa. B., Sajid. A. and Iqtidar A. K. 2007. Storage stability of persimmon fruits (diospyros kaki) stored in different packaging materials. Journal of Agricultural and Biological Science. 2(2). 20-23.

EI. Ashwah F.A.; N.M.Abd-EI-Baki, EI. S.K. Samahy and EI. M.G. Fedul. 1980. Effect of storage on the characteristics of the concentrated orange and lime beverages.Agricultural Research review 58(3). 275-288.

Giraldo L.F.,Forero, R.A., Salazar, C.R. and torres, R. 1977.The effect of packaging and Potassium permanganate on the storage of tomatoes under room conditions. Ravista Inst. collanbiano Agropecuario, 12(4):393-405.

Hadi K. Purwadaria and Meity S. Sinaga. 2007. Pest and diseases in postharvest handling of fruits and vegetables. ASEAN training course on postharvest technology on fruits and vegetables. Lembang, Indonesia. P.4

Islam M. N.,. Molla M. M, Nasrin T.A.A, Uddin A.F.M.M and Bhuyan M. A. J.2009. Determination of maturity indices of ber (zizyphus mauritiana lam.) var. bari kul-2. Annual report, HRC, BARI, Gazipur.P.143

Kader A.A. 1992. Postharvest Biology and Technology. An Overview. In, Postharvest Technology of Horticultural Crops. 2nd ed. Publication No. 3311. University of California, California. 192P.

Kitinoja L. 2001. Postharvest book IARW, Part-1: Postharvest handling of fruits and vegetables. P.28

Klein, J.D. and S. Lurie. 1992. Prestorage heating of apple fruit for enhanced postharvest quality: interaction of time and temperature. Hort. Science 27:326-328.

Lurie S. 1998. Postharvest heat treatments. Postharv. Biol. Technol. 14:257-269.

Mohla R., Singh S. and Singh S. 2000. Shelf life of sub-tropical sand pear as influenced by picking dates and packing materials under ambient conditions. VII International Symposium on Temperate Zone Fruits in the Tropics and Subtropics - Part Two.

Mamatha T., S. Lokesh and Rai V.R. 2000. Impact of seed mycoflora of forest treesseeds on seed quality and their management. Seed Res. 28(1):59-67

Molla M..M.,.Islam M.N, Nasrin T.A.A. and Karim M.R. 2010. Survey on postharvest practices and losses of mango in selected areas of Bangladesh. Postharvest Management of Horticultural Crops, Annual report, HRC, BARI, Gazipur-1701. P.64

Momen M.N., Rahim M.A., Farooque, A.M. and Choudhury M. S. H. 1993. Effect of some coating materials and physical measures on the prolongation of shelf life of banana. Agric., 4(1-2): 41-51.

Ngalani, J.A; J.T. Tchango and M. Reynes. 1999. Starch and Sugar transformation during ripening of banana and plantain cultivars grown in cameroon.Trop.Sci. 39:115-119

Patil D.L. and Magar N.G. 1976. Physiochemical changes in banana fruit during ripening. J. Maharastra Agric. Univ.1:95-99.

Ranganna S. 1986. Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill Publishing Co. Ltd., New Delhi, India. 1112p.

Singh R.N. and Roy S.K. 1984. The Bael cultivation and processing Indian-Agril. Res.Inst. New Delhi, India. P: 25-27

Waskar, D.P. and Roy S.R. 1992. Post harvest ripening changes in banana-a review. Agric. Rev. 13(1): 36-42.

Wenzhong HU, Shun-ichiro TANAKA and Yoshiaki HORI, 2004. Effect of Heat Treatment on Quality of Sweet Potato inWrapper Type Cold Store during Long-term Storage. J. Fac. Agr.,

Kyilshu Univ., 49 (1), 129-138.
Zhuang R.Y., Beuchat L.R. and Angulo F.J. 1995. Fate of Salmonella montevideo on and in raw tomatoes as affected by temperature and treatment with chlorine. Appl. Environ. Microbiol. 61: 2127-2131.

Tables

Table 1. Shelf life (days), physiological loss in weight (%) and disease incidence (%) of mango after 4,8 and 12 days storage

Treatments combination	After 4 days			After 8 days			After 12 days		
	Shelf life (days)	Physio-logical loss in weight (%)	Disease inci-dence (%)	Shelf life (days)	Physio-logical loss in weight (%)	Disease inci-dence (%)	Shelf Life (days)	Physio-logical loss in weight (%)	Disease inci-dence (%)
A_oB_o	4.00	11.05a	4.5	8.00	14.14a	8.50	8.11j	16.21a	16.70a
A_oB_1	4.00	9.58b	3.50	8.00	10.14b	6.50	8.28j	13.21b	12.62b
A_oB_2	4.00	9.02b	3.35	8.00	10.13b	6.35	8.38j	11.14c	11.63d
A_oB_3	4.00	8.10c	2.50	8.00	8.41d	6.56	8.80j	9.58e	12.03c
A_oB_4	4.00	9.09b	3.50	8.00	9.55c	6.51	8.28j	10.14d	12.13c
A_1B_o	4.00	6.79d	-	8.00	7.11e	-	10.50fgh	7.59f	2.16e
A_1B_1	4.00	4.05h	-	8.00	4.13h	-	10.50fgh	4.35j	1.54f
A_1B_2	4.00	4.31h	-	8.00	4.43h	-	9.83h	6.32h	2.14e
A_1B_3	4.00	4.15h	-	8.00	4.27h	-	12.09bc	4.31j	1.12f
A_1B_4	4.00	4.17h	-	8.00	4.37h	-	11.28de	4.53j	1.55f
A_2B_o	4.00	6.07e	-	8.00	6.15f	-	10.50fgh	6.54h	2.16e
A_2B_1	4.00	4.50gh	-	8.00	4.47h	-	11.32de	5.22i	1.54f
A_2B_2	4.00	4.42gh	-	8.00	5.48g	-	10.08gh	5.09i	2.14e
A_2B_3	4.00	4.11h	-	8.00	4.14h	-	12.20bc	4.24j	1.12f
A_2B_4	4.00	4.14h	-	8.00	4.14h	-	10.51fgh	4.61j	1.55f
A_3B_0	4.00	5.14fg	-	8.00	5.15g	-	10.67efg	5.52i	2.16e
A_3B_1	4.00	4.14h	-	8.00	4.18h	-	12.00bc	4.41j	1.54f
A_3B_2	4.00	4.17h	-	8.00	4.36h	-	10.17fgh	4.45j	2.14e
A_3B_3	4.00	4.10h	-	8.00	4.22h	-	12.64ab	4.26j	1.12f
A_3B_4	4.00	4.16h	-	8.00	4.35h	-	10.51fgh	4.45j	1.55f
A_4B_0	4.00	5.37ef	-	8.00	6.42f	-	11.29de	6.36h	2.16e
A_4B_1	4.00	4.11h	-	8.00	4.26h	-	11.59cd	4.39j	1.54f
A_4B_2	4.00	4.14h	-	8.00	4.37h	-	10.87ef	4.33j	2.14e
A_4B_3	4.00	4.82fgh	-	8.00	4.19h	-	12.30b	4.53j	1.55f
A_4B_4	4.00	4.14h	-	8.00	4.28h	-	13.02a	4.11j	1.12f
A_5B_0	4.00	5.48ef	-	8.00	7.12e	-	8.15j	7.13g	2.16e
A_5B_1	4.00	4.20h	-	8.00	4.29h	-	8.25j	4.50j	1.54f
A_5B_2	4.00	4.15h	-	8.00	4.35h	-	8.31j	4.52j	2.14e
A_5B_3	4.00	4.13h	-	8.00	4.23h	-	9.86h	4.54j	1.12f
A_5B_4	4.00	4.21h	-	8.00	4.36h	-	9.07i	4.47j	1.55f
LSD	ns	**	-	ns	**	-	**	**	**
CV (%)	-	6.19	-	-	3.18	-	2.78	3.49	4.75

A_oB_o= without wash and kept in ambient condition, A_oB_1= without wash and kept in perforated polyethylene bag, A_oB_2= with out wash and kept in non-perforated polyethylene bag, A_oB_3= without wash and kept in plastic crate, A_oB_4 =without wash and kept in corrugated fibre board carton, A_1B_o = wash with chlorine water and kept in ambient condition, A_1B_1 = wash with chlorine and packed in perforated polyethylene bag, A_1B_2 = wash with chlorine and packed in non- perforated polyethylene bag , A_1B_3 = wash with chlorine and packed in plastic crate, A_1B_4 = wash with chlorine and packed in corrugated fibre board carton, A_2B_o = dipping in calcium chloride and kept in ambient condition, A_2B_1 = dipping in calcium chloride and packed in perforated polyethylene bag, A_2B_2 = dipping in calcium chloride and packed in non-perforated polyethylene bag,, A_2B_3 = dipping in calcium chloride and packed in plastic crate, A_2B_4 = dipping in calcium chloride and packed in corrugated fibre board carton, A_3B_o = dipping in bavistin and kept in ambient condition, A_3B_1 = dipping in bavistin and packed in per-forated polyethylene bag, A_3B_2 = dipping in bavistin and packed in non-perforated polyethylene bag,, A_3B_3 = dipping in bavistin and packed in plastic crate, A_3B_4 = dipping in bavistin and packed in corrugated fibre board carton, A_4B_o = treated with hot water and kept in ambient condition, A_4B_1= treated with hot water and packed in perforated polyethylene bag, A_4B_2 = treated with hot water and packed in non-perforated polyethylene bag, A_4B_3 = treated with hot water and packed in plastic crate, A_4B_4 = treated with hot water and packed in corrugated fibre board carton, A_5B_o = tap water wash and kept in ambient condition, A_5B= tap water wash and packed in perforated polyethylene bag, A_5B_2 = tap water wash and packed in non-perforated polyethylene bag, A_5B_3= tap water wash and packed in plastic crate, A_5B_4= tap water wash and packed in corrugated fibre board carton, (-) indicates no disease found

Table 2. Chemical parameter of mango on the day of storage (0 day)

Treatment	Total sugar (%)	Reducing sugar (%)	Vitamin-C (mg/100g)	Total titrable acidity	TSS (°B)
Fresh mango (before treated)	11.47	`2.98	0.44	0.95	11.50

Table 3. Effect of postharvest treatments on chemical parameter of mango after 12 days of storage

Treatment	Total sugar (%)	Reducing sugar (%)	Vitamin-C (mg/100g)	Total titrable acidity	TSS (°B)
A_o	15.335d	2.525	0.311d	0.605a	14.773d
A_1	19.510bc	2.523	0.345a	0.449b	17.093b
A_2	20.028b	2.519	0.343a	0.442c	17.213a
A_3	20.982b	2.520	0.339b	0.439d	15.687c
A_4	22.015a	2.517	0.336b	0.451b	15.667c
A_5	18.608c	2.520	0.327c	0.441c	15.067c
LSD	**	ns	**	**	**
CV (%)	12.66	0.81	7.05	23.35	10.70

A_o = non-treated, A_1 = washing with chlorine, A_2 = dipping (5 minutes) in calcium chloride, A_3 = dipping (5 minutes) in bavistin and rinse in clean water, A_4 = hot water treatment and A_5 = wash with tap water

Table 4. Effect of packaging technique on chemical parameter of mango after 12 days of storage

Treatment	Total sugar (%)	Reducing sugar (%)	Vitamin-C (mg/100g)	Total titrable acidity	TSS (°B)
B_o	19.321	2.521	0.333	0.470	16.028
B_1	19.351	2.518	0.334	0.473	16.028
B_2	19.525	2.518	0.335	0.474	16.078
B_3	19.432	2.525	0.331	0.473	16.156
B_4	19.436	2.521	0.332	0.474	16.128
B_5					
LSD	ns	ns	ns	ns	ns
CV (%)	12.66	0.81	7.05	23.35	23.35

B_o= without packaging, B_1= perforated poly bag, B_2= non-perforated poly bag, B_3=plastic crate and B4= corrugated fibre board carton

Table 5. Combined effect of postharvest treatments and packaging technique on chemical parameter of mango after 12 days of storage

Treatment	Total sugar (%)	Reducing sugar (%)	Vitamin-C (mg/100g)	Total titrable acidity	TSS (°B)
A_oB_o	15.293	2.527	0.307	0.607	14.533
A_oB_1	15.303	2.523	0.307	0.603	15.000
A_oB_2	15.300	2.517	0.317	0.610	14.667
A_oB_3	15. 353	2.517	0.320	0.603	14.833
A_oB_4	15.423	2.540	0.350	0.600	14.833
A_1B_o	19.580	2.527	0.353	0.440	17.333
A_1B_1	19.203	2.527	0.347	0.447	17.033
A_1B_2	19.803	2.523	0.347	0.443	17.033
A_1B_3	19.283	2.520	0.330	0.453	17.033
A_1B_4	20.200	2.517	0.333	0.463	17.033
A_2B_o	20.233	2.483	0.343	0.437	17.033
A_2B_1	20.100	2.527	0.333	0.447	17.033
A_2B_2	19.803	2.520	0.350	0.443	17.333
A_2B_3	19.803	2.547	0.357	0.440	17.333
A_2B_4	20.867	2.520	0.353	0.443	17.333
A_3B_0	20.967	2.517	0.347	0.437	15.667
A_3B_1	20.767	2.510	0.337	0.430	15.667
A_3B_2	21.203	2.527	0.337	0.437	15.667
A_3B_3	21.107	2.523	0.323	0.447	15.867
A_3B_4	21.397	2.523	0.323	0.450	15.867
A_4B_0	21.690	2.517	0.333	0.453	15.833
A_4B_1	22.560	2.527	0.333	0.453	15.667
A_4B_2	22.380	2.507	0.327	0.453	15.667
A_4B_3	22.047	2.520	0.320	0.447	15.667
A_4B_4	18.770	2.517	0.340	0.450	15.500
A_5B_0	18.527	2.540	0.327	0.457	15.867
A_5B_1	18.620	2.513	0.343	0.457	15.867
A_5B_2	18.570	2.513	0.330	0.443	16.200
A_5B_3	18.553	2.523	0.340	0.447	16.200
A_5B_4	ns	2.510	ns	ns	16.200
LSD	12.66	ns	7.05	23.35	ns
CV (%)		0.81			23.35

A_oB_o= without wash and kept in ambient condition, A_oB_1= without wash and kept in perforated polyethylene bag, A_oB_2= with out wash and kept in non-perforated polyethylene bag, A_oB_3= without wash and kept in plastic crate, A_oB_4 =without wash and kept in corrugated fibre board carton, A_1B_o = wash with chlorine water and kept in ambient condition, A_1B_1 = wash with chlorine and packed in perforated polyethylene bag, A_1B_2= wash with chlorine and packed in non- perforated polyethylene bag, A_1B_3 = wash with chlorine and packed in plastic crate, A_1B_4= wash with chlorine and packed in corrugated fibre board carton, A_2B_o= dipping in calcium chloride and kept in ambient condition, A_2B_1= dipping in calcium chloride and packed in perforated polyethylene bag, A_2B_2 = dipping in calcium chloride and packed in non-perforated polyethylene bag,, A_2B_3 = dipping in calcium chloride and packed in plastic crate, A_2B_4 = dipping in calcium chloride and packed in corrugated fibre board carton, A_3B_o = dipping in bavistin and kept in ambient condition, A_3B_1= dipping in bavistin and packed in perforated polyethylene bag, A_3B_2= dipping in bavistin and packed in non-perforated polyethylene bag,, A_3B_3 = dipping in bavistin and packed in plastic crate, A_3B_4 = dipping in bavistin and packed in corrugated fibre board carton, A_4B_o= treated with hot water and kept in ambient condition, A_4B_1= treated with hot water and packed in perforated polyethylene bag, A_4B_2 = treated with hot water and packed in non-perforated polyethylene bag, A_4B_3 = treated with hot water and packed in plastic crate, A_4B_4 = treated with hot water and packed in corrugated fibre board carton, A_5B_o = tap water wash and kept in ambient condition, A_5B_1 = tap water wash and packed in perforated polyethylene bag, A_5B_2= tap water wash and packed in non-perforated polyethylene bag, A_5B_3= tap water wash and packed in plastic crate, A_5B_4= tap water wash and packed in corrugated fibre board carton, (-) indicates no disease found