Research Article
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Postharvest loss assessment of mango at different stages of supply chain through traditional and improved handling practices

Abstract

A study was carried out to estimate the postharvest losses of mango cv. 'Khirsapat' occurred at different stages of value chain from harvesting to retailoutlets as influenced by traditional and improved handling practices.The experiment was started from a mango orchard of Chapainawabganj and ended at retail outlets of Gazipur wet fruit market. Improved handling practices comprising of the use of BARI mango harvester, use of plastic crates as packaging container, stalk trimming and desapping, hot water treatment and modified atmosphere packaging (MAP). In traditional handling practices, mangoes were harvested by a person sitting on the branch of a tree using a local mango harvester and then threw the fruits that received by another person from the ground using a gunny bag, bamboo basket was used as field container and sorted mangoes were finally packed in plastic crate for transporting to the wholesale market. Trimming, desapping and hot water treatment were not practiced in the traditional handling system. Three treatments, viz.T_0 = traditional practice (Control); T_1= Improved technology +plastic crates without MAP; and T_2 = Improved technology +plastic crates with MAP were used in this study. Significant differences were observed among the treatments. At harvesting stage the postharvest losses were amounted by 1.5 and 5.0%, respectively, in improved and conventional methods, while at wholesale market, losses were 0.4 to 2.4% among the treatments.Transpiration loss of fruit reduced significantly in IP+MAP during transportation from Chapainawabganj to Gazipur wholesale market. Unmarketable mangoes due to decay caused by anthracnose and stem end rot on day 4 at retail outlets were 20.00, 13.00, and 11.5% in T_0, T_1, and T_2 treatments, respectively. Total postharvest losses of mango amounted to 35 and 18.6% in traditional and improved practice, respectively. Thus, the reduction of postharvest loss over traditional practices was 46.80%. The firmness of fresh ripe mangoes were 52.80, 49.40 and 49.70 N in T_0, T_1, and T_2 treatments at 3days after mango harvest, which decreased significantly to 13.20, 11.50, and 11.20 N in T_0, T_1, and T_2 treatments on day 4 in retail shop. The TSScontents in ripe mangoes were found 13.90, 14.73, and 14.33% inT_0, T_1, and T_2treatments on3 days after harvest, which increased to 18.30, 18.50, and 18.00%, respectively, on day 4 at retail shop. The Vit-C content decreased in all the treatmentssignificantlyon day 4in retail shop, while theβ-carotene (µg/g) increased in all the treatments on day 4 in retail shop. The results revealed that the intervention ofimproved postharvest technologies and the best practices were verymuch effective in reducing the postharvest losses and managing qualityof mango.

Keywords: mango, postharvest loss, desapping, trimming, hot water treatment, MAP and conventional methods

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Introduction

Mango *(Mangiferaindica*L.) is one of the most important and popular fruits in Bangladesh. The fruit grows in almost all parts of Bangladesh. It is a very demandable fruit in the country and its demand is increasing very rapidly. From nutritional point of view, it contains adequate quantity of appreciable β-carotene, vitamin C, and dietary fiber.[1] It also contains soluble sugars and different minerals. It is one of the most relished fruit crops in Bangladesh.The commercial and good quality grafted mangoes with known varietal names are mostly grown in the North-Western districts. The mangoes of unknown varieties (seedling mangoes) are grown in the south-eastern and other parts of the country. Bangladesh ranks the 7th position as a mango producing country in the world.[2] The mango tops the list in terms of area and occupies the second position in production among the fruits grown in Bangladesh.[3] The major mango producing districts in Bangladesh are Rajshahi, Chapainawabganj, Nawgaon, Jessore, Kustia, Satkhira and Chittagong Hill Tracts. Its production in the country was estimated at 11,61,685 metric tons from 37,846.15 hectares of land.[3]

Mango is a highly perishable fruit. The perishability of the fruit is attributed to rapid deterioration after harvest. It is also susceptible to insect-pest infestation and decay causing postharvest losses due to lack of proper pre-harvest practices. Mango has a short shelf life and vulnerable to environmental stress especially high temperature. Considerable quantities of mangoes are lost every year during harvesting, transport and marketing.[4] However, very little information is available on the postharvest practices and losses of mango at the grower, collector, transport, and wholesaler and retailer levels. The technologies used in production and postharvest processing, handling, transportation and storage of mango in Bangladesh are mostly traditional. As a result, considerable quantity of production

and postharvest losses are occurred. The losses occur all along the value chain, beginning for the time of harvesting right up to packaging, storage, transportation, retailing and consumption. In most developing countries this is mainly due to the combination of poor infrastructures and logistics, poor farm practices, lack of postharvest handling knowledge and a convoluted marketing system. As a result of postharvest losses of fruits, the nutritional status of the population and the economy of the developing countries are deeply affected. It is reported that 25-45% postharvest loss occurs at different postharvest stages of mango.[4] The major causes of postharvest losses are enormous like improper harvesting, traditional handling practices at different stages of supply chain and postharvest diseases. It is essential to apply improved postharvest handling practices to reduce the postharvest losses of mango in a minimum acceptable level in the industry. Postharvest measures of mango include improved handling, packaging, transportation and storage facilities. In the areas of management for desired improvement, thrusts should be put on every level of stakeholders including governmental and organizational levels. In Bangladesh, earlier research, training, and extension activities were carried out putting thrust mainly on production, while it was quite scanty on improvement of harvest and postharvest measures. At present, Bangladesh Government has taken up various policies and program in order to reduce postharvest loss and retain quality and nutritive value of this important fruit. On the other hand, efforts have been made to establish industries so as to use this product as raw materials. As a whole, these activities and initiatives will give economic benefits to mango growers, boost country's economy and also contribute to human health and environment.

In this present investigation, we tried to assess the postharvest losses of mango at different supply chain starting from harvesting to retailers through traditional and improved handling postharvest practices. The results of this study will provide valuable information on the postharvest practices and losses of mango that will serve as the basis in the formulation of recommendation or intervention in the supply chain towards loss reduction.

Materials and methods

The experiment was carried out during June 2016 at the Regional Horticulture Center, Bangladesh Agricultural Research Institute, Chapainawabganj and at the Horticulture Research Center, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh. A popular commercial mango variety cv. "Khirsapat" was used in this study. In the traditional method, mango was harvested manually using a localmango harvester at commercially mature stage. At first, mangoes were detached from the tree using harvester and were subsequently removed from the harvesting net and thrown from the tree branch toward another person on the ground to receive the fruits on the soft jute sac. After receiving, the fruits were placed on the ground without using cushion material like cloth or polyethylene. So, the fruits were in direct contact with soil in the orchard. Mangoes were then sorted, graded, and packed in plastic crates having 25 kg holdingcapacity for transport and subsequent marketing. On the other hand, in the improved method, the mangoes were harvested by an improved 'BARI Mango harvester'with 3-4 inches stalks. Then harvested mangoes were placedon the ground with cushion material like jute sac under the tree in a shady place so that the fruits did not come in direct contact with soil of the orchard. The stalks of mangoes were then cut keeping only 8 to 10 mm and on a delatexing rack with stem end down for about 10-15minutes to flow out the sap. The mangoes were then sorted, graded, and packed in plastic crates as mentioned earlier. These packed mangoes were then treated with hot water at 55°C for 5 minutes using BARI Hot Water Treatment Plant. After treatment the surface water of mangoes was air dried using heavy duty stand fan. Afterthat the mangoes were repacked in plastic crates.During final packaging, clean newspaper was used as cushion material at each layer of mango both in traditional and improved practices. Thus, there were three treatments including a control viz. T_0 = traditional practice (TP, control); T_1 =improved practice (IP) including plastic crates without MAP, and T_2 = improved practice (IP) including plastic crates with MAP. MAP was used in plastic crates only during transportation from Chapainawabganj to retail shops at Gazipur. The containers were manually loaded on to a truck with other mangoes from different traders at the same day of harvest. The truck left at 2:00 am from Chapainawabganj and arrived at wholesale market at Joydebpur, Gazipur at 12:00 pm taking 10 hours travel time. The distance from Chapainawabganj to Joydebpur, Gazipur is around 450 km.After collecting data at wholesale level, mangoes were brought to Postharvest Laboratory of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) and subsequently distributed to three retail shops in wet fruit market at Gazipur city. Mangoes under the study were not sold during the four days of data collection. Data were collected every day on weight loss, ripening rate and decay caused by anthracnose, stem end rot, and mechanical injuries.

Experimental design and statistical analysis: The experiment was laid out in a randomized complete block design (RCBD) with three replications. The data were subjected to analysis of variance (ANOVA) using 'R' Statistical Software version 3.1.2. The results showing significant differences were then subjected to mean separation using LSD test at $P < 0.05$.

Results and discussion

Total weight of marketable and unmarketable mangoes harvested at orchard is summarized in Table 1. The total mango harvested with improved harvester and traditional methods were 198 and 303 kg, respectively. Total marketable fruits were 98.5 and 95% in improved and traditional methods, while the quantities of unmarketable fruits at harvest were 1.5 and 5%, respectively in improved and traditional methods. Thus, it is found that improved method of harvesting can save at least 3.5% harvesting loss over traditional method.

At wholesale market the lowest weight loss of 0.4% was found in mangoes packed in plastic crates with modified atmosphere packaging (MAP). However, 2.4% weight loss occurred at wholesale market both in T_1 and T_0 (control) treatments. Similar result was also found in tomato packaging with MAP which found effective in reducing weight loss due to maintenance of humid atmosphere that is inhibitory to transpiration loss and higher concentration of CO_2 which reduced respiration rate.[5,6] At retail shop on day 2 only 1.10% weight loss occurred in T_2, while 1.05% and 1.50% weight loss occurred in T_1 and T_0 treatments, respectively, at the same time. On day 3 on retail shop, 3.20% weight loss occurred in T_2 treatment, while on the same day, 3.12% and 3.74% weight loss occurred in $T_1$and T_0 treatment, respectively. The weight loss of mango was 5.22% on day 4 in T_2 treatment. At the same time, the weight losses of mango were 5.16 and 5.68% at retail shops in T_1 and T_0 treatment, respectively. There was no significant differencebetween T_1 and T_2 treatments (improved practices). However, the treatment T_1 and T_2 differed significantly with control (T_1) treatment (Table 2).

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The fruit ripening pattern showed that there was no ripe fruit at wholesale market and on day 2 at retailer shop. However, on day 3, 1.20, 4.00, and 3.60% fruits were ripened at retail shop, respectively, in T_0, T_1 and T_2. On day 4 the trend of fruits ripening was increased and the highest percentage of mango (65.20%) ripened in improved practice with MAP comprising of hot water treatment (HWT), which was significantly similar with improved practice without MAP (62.50%) (Table 3). In traditional practice on the other hand, only 21.50% mangoes were ripened on day 4 at retail shop. This result is in agreement with,[7] who reported that heat treatment may be enhanced the ripening process of mango through increasing the respiration rate of the fruit.

At wholesale market, there was no marketable mango with slight mechanical damage. However, on day 2 at retail shop, 2.00 and 1.20% mango was found to be damaged by slight mechanical injury in T_0 and T_1 treatment, respectively. The marketable mango with slight mechanical damage increased with passes of time at retail period. On day 3, 2.80% damage was found in T_0(control), which was significantly different from T_1 (1.60%) and T_2 (2.40%) treatment. However, on day 4, there was no significant different between T_0 (2.80%) and T_2(2.70%) treatments, although it differs significantly from T_1(2.40%) (Table 4).

There was no marketable mango with slight decay (%) at wholesale market. However, at retail shop the percentage increased with passes of time. On day 2, there was no significant difference among the three treatments on marketable mango with slight decay (%). However, on day 3, at retail shop, there were significant differences among the treatments (Table 5). On day 4, there was no significant difference between T_1 and T_2(4.80 and 5.60%) although it significantly varied from control treatment (7.80%).

There was no unmarketable mango due to decay caused by anthracnose and stem end rot (%) at wholesale market. Although it was found to be increased day by day in retail shops (Table 6). Significant variation was found on unmarketable mango due to decay caused by anthracnose and stem end rot at retail shop. On day 2, 1.00% unmarketable mango was found in control (T_0). On day 3, 2.00% mango was decayed due to anthracnose and stem end rot, which was significantly different from T_0 (13.80%). Although, there was no decay on mango in T_2 treatment on day 2 at retail shop. On day 3, significant difference among the treatments was found. Only 2.00% decay on mango was found in T_1 treatment on day 3 at retail shop. The maximum 13.80% decay on mango was found in T_0 (control) treatment, although there was no decay on mango in T_2 on day 3 at retail shop. On day 4, maximum quantity (20.00%) of decayed mango was found in control (T_0). However, only 13.00 and 11.50% decayed mangoes were found in T_1 and T_2, respectively. Findings of this experiment clearly showed the efficacy of hot water treatment (HWT) in reducing decay caused by anthracnose and stem end rot. Similar results were also found by Couey[8] and McGuire[9] who reported that the hot water treatment is effective postharvest treatment in reducing stem end rot and anthracnose of mango.

The total postharvest loss of mango in the whole supply chain is shown in Table 7. It is found that significantly the lowest amount of mangoes (1.50%) damaged due to dropping and cracking at harvest when used the improved mango harvester. On the other hand, with the traditional practice of harvesting 5.00%fruits were found damage due to faulty method. The lowest loss (5.60%) was found in mangoes packed in plastic crates with modified atmosphere package (MAP). The weight loss of mangoes with traditional practice was 8.00% that significantly differwith mangoes packed withMAP during the entire value chain. The cumulative decay loss on day 4 at retail shop was also significantly differed among the treatments. The maximum loss of 22.00% occurred in mangoes with traditional practice (TP) on day 4 at retail shop, while it was minimum (11.50%) in mangoes with improved practice on the same day. The total postharvest loss of mango at different stages of supply chain was 35.00% in traditional method, while it was only 18.60% in improved handling practices comprising of desapping, HWT and use of MAP packaging (Table 7). The total reduction of postharvest losses of mango over control was 46.8% and 37% in mangoes with improved management practiced with and without MAP, respectively. These results are in agreement with Mazhar,[10] who reported that significantly better quality of mango with less physical damage can be found by introducing improve harvesting and desapping practices along the supply chain.

The firmness (N) of unripe fruits was 52.80, which was significantly difference from 49.40 and 49.70N on day 0 at retail shop in T_0, T_1, and T_2 treatments, respectively. The firmness of mango decreased to 13.20, 11.50, and 11.20 Non day 4 at retail shop, respectively, in T_0, T_1, and T_2. Treatment T_0 significantly differed from T_1 and T_2. The TSSs (total soluble solid) of unripe mango were 13.90, 14.73, and 15.33% on day 0 at retail shop, respectively. The corresponding figures increased to 18.30, 18.50, and 18.00% in T_0, T_1, and T_2, respectively, on day 4 at retail shop.It was reported that TSS accumulation increased with the increase of storage duration,[11] which is reflected in this study. The pH of unripe fruits was 4.53, 4.57, and 4.55 on day 0 at retail shop in T_0, T_1, and T_2 treatments, which was increased to 5.86, 5.88, and 5.83 on day 4 at retail shop (Table 8). There was no significant different among the treatments.

The Vit-C content of unripe mango was 25.98, 24.50, and 24.43 (mg/g) on day 0 at retail in the T_0, T_1, and T_2 treatment, which was found to decrease to 8.02, 6.01, and 6.01(mg/g), respectively on day 4 at retail shop. There was significant difference between control and improved treatments. The β-Carotene content of unripe mango was 22.62, 23.61, and 21.93 (µg/g) on day 0 at retail shop in T_0, T_1, and T_2 treatment, which was found to increase to 37.34, 35.33, and 37.88 (µg/g), respectively on day 4 at retail shop (Table 9). There was significant different among the treatments.

Table 1 Weight of marketable and unmarketable mangoes harvested at Orchard

Harvesting method	Total Wt (kg)	Marketable fruit		Unmarketable fruit	
		wt (kg)	% of total wt (kg)	wt (kg)	% of total wt
Improved harvester & method	198	195	98.5	3.0	1.5
Traditional harvester & method	303	288	95.0	15.0	5.0

Table 2 Weight loss of mango at wholesale and retail shop (%)

Treatment	At wholesale market	At retail shop (%)		
		Day 2	Day 3	Day 4
T_0= (Control)	2.40b	1.50a	3.74a	5.68a
T_1= (IT+PC)	2.40b	1.05b	3.12b	5.16b
T_2= (IT+PC+MAP)	0.40a	1.10b	3.20b	5.22b
LSD	0.56	0.67	0.42	0.35

Table 3 Fruit ripening pattern at wholesale and retail shop (%)

Treatment	At wholesale market	At retail shop (%)		
		Day 2	Day 3	Day 4
T_0= (Control)	0.00	0.00	1.20b	21.50b
T_1= (IT+PC)	0.00	0.00	4.00a	62.50a
T_2= (IT+PC+MAP)	0.00	0.00	3.60a	65.20a
LSD	NS	NS	0.56	4.62

Table 4 Marketable mango with slight mechanical damage (%)

Treatment	At wholesale market	At retail shop (%)		
		Day 2	Day 3	Day 4
T_0= (Control)	0.00	2.00a	2.80a	2.80a
T_1= (IT+PC)	0.00	1.20b	1.60c	2.40b
T_2= (IT+PC+MAP)	0.00	0.00c	2.40b	2.70a
LSD	NS	*0.53	**0.34	*0.23

Table 5 Marketable mango with slight decay (%)

Treatment	At wholesale market	At retail shop (%)		
		Day 2	Day 3	Day 4
T_0= (Control)	0.00	0.80	3.90a	7.80a
T_1= (IT+PC)	0.00	0.50	3.00b	4.80b
T_2= (IT+PC+MAP)	0.00	0.70	2.00c	5.60b
LSD	NS	NS	*0.63	*1.16

Table 6 Unmarketable mango due to decay caused by anthracnose and stem end rot in retail shop (%)

Treatment	At wholesale market (%)	At retail shop (%)		
		Day 2	Day 3	Day 4
T_0= (Control)	0.00	1.00a	13.80a	22.00a
T_1= (IT+PC)	0.00	0.00b	2.00b	13.00b
T_2= (IT+PC+MAP)	0.00	0.00b	0.00c	11.50c
LSD	NS	*0.65	**2.20	**1.50

Table 7 Total postharvest loss (%) of mango in the whole supply chain

Treatment	At harvest (%) (dropping, cracking)	Weight loss (%)	Cumulative decay loss on day 4 at retail (%)	Total loss (%)	Loss reduction over control (%)
T_0= (Control)	5.00a	8.00a	22.00a	35.00a	-
T_1= (IT+PC)	1.50b	7.50a	13.00b	22.00b	37.00
T_2= (IT+PC+MAP)	1.50b	5.60b	11.50c	18.60c	46.80
LSD	1.45	*0.60	**1.50	**2.20	

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Table 8 Changes in TSS, pH and firmness of mango during ripening at 4-day retail period

Treatment	Firmness (N)		TSS (%)		pH	
	Unripe fruit on day 0 at retail shop	Ripe fruit on day 4 at retail shop	Unripe fruit on day 0 at retail shop	Ripe fruit on day 4 at retail shop	Unripe fruit on day 0 at retail shop	Ripe fruit on day 4 at retail shop
T_0= (Control)	52.80a	13.20a	13.90	18.30	4.53	5.86
T_1= (IT+PC)	49.40b	11.50b	14.73	18.50	4.57	5.88
T_2= (IT+PC+MAP)	49.70b	11.20b	14.33	18.00	4.55	5.83
LSD	2.5*	1.06*	0.71*	NS	NS	NS

Table 9 Changes in Vit-C and β-carotene content of mango during ripening at 4-day retail period

Treatment	Vit_C (mg/100g)		β-carotene (µg/g)	
	Unripe fruit on day 0 at retail shop	Ripe fruit on day 4 at retail shop	Unripe fruit on day 0 at retail shop	Ripe fruit on day 4 at retail shop
T_0= (Control)	25.98a	8.02a	22.62	37.34
T_1= (IT+PC)	24.50b	6.01b	23.61	35.33
T_2= (IT+PC+MAP)	24.43b	6.01b	21.93	37.88
LSD	1.2*	0.52*	NS	NS

Conclusion

The findings of this study revealed that the postharvest loss of mango at different stages of supply chain was reduced to a minimum level with improved handling practices. The traditional handling practices of postharvest management in Bangladesh are unscientific, labour consuming and less profitable. The postharvest loss can be reduced to an acceptable level qualitatively and quantitatively through improved handling practices. The best improved practice was found in this study through improved practices with plastic crates and modified atmosphere packaging, which reduced 46.80% postharvest loss of mango over traditional practices. Therefore, attempt to be taken to disseminate the improved postharvest handling practices among different stakeholders at different stages of supply chain of mango fruits.

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