Original Research Article

Influence of Pre-harvest Bagging on Fruit Quality of Mango (*Mangifera indica* L.) cv. Langra

ABSTRACT

Fruits are susceptible to insect pest infestations, bird attack, various pathogens, and mechanical damages, all of which can reduce their commercial value and thereby cause significant yield and economic losses. The objective of this study was to control mango pests and diseases as well as to improve the fruit quality of mango through bagging technology. An investigation was performed during the year 2016 from March to July for safe mango production by applying minimum use of pesticide entitled studies on influence of bagging on physico-chemical properties and shelf life of mango cv. Langra. The mango fruits were bagged at marble stage (40 days from fruit set) with different types of bags which constituted the various treatments *viz*: T_1: Brown paper bag; T_2: White paper bag; T_3: Polythene bag T_4: Muslin cloth bag; T_5: No bagging (control). Bagging with brown paper bag and white paper bag improved fruit retention, weight of fruit, diameter of fruit, pulp weight, total soluble solids, ascorbic acid, percent of citric acid, reducing sugars and β-carotene at harvest and ripe stage over control. Brown paper bag changed fruit color. In all cases good quality, cleaner, disease and insect free fruits were harvested. The sensory qualities in fruits of brown, white and muslin cloth bags were improved over control. Pre-harvest bagging also reduced occurrence of spongy tissue and the incidence of mealy bugs. These results indicate that fruit bagging can improve fruit quality through reduction in disease and insect-pest attack and shelf life of mango cv. Langra.

Key words: Mango; Fruit bagging; physico-chemical composition; sensory evaluation

1. INTRODUCTION

Mango (*Mangifera indica* L.) commonly known as the 'King of fruits' is a popular tropical fruit, especially in Asia. In Bangladesh, in terms of total area and production of fruit crops, mango ranks first and third respectively. During their growth and development, fruits undergo several physical and chemical changes and are susceptible to insect pest infestations, bird attack, various pathogens and mechanical damages all of which can reduce their commercial value and thereby cause significant yield and economic losses. To prevent the losses caused by biotic and abiotic factors, several good agricultural practices are becoming popular throughout the World [1]. Furthermore, the development of alternative techniques to improve the appearance and quality of fruits and to reduce diseases and insect infestations is becoming increasingly important as consumer anxiety over the use of manmade agro-chemicals and environmental awareness increases. Thus, more emphasis is being placed on reducing the use of pesticides to ensure worker safety, consumer health, and environmental protection [2]. An attractive, spotless and pest free fruits of this variety fetch premium rate in the market. In recent years, the climatic aberrations such as sudden rise in the temperature and humidity, abnormal rains especially during fruit development are often experienced. It had not only affected the external appearance of the fruit but also aggravated the pest such as mealy bugs and physiological disorder like spongy tissue which further added in the losses. The affected fruits gain poor price in the market and such fruits are also rejected for processing. It causes serious economic loss to mango growers.

Among several such alternatives, Pre-harvest paper bagging is a physical protection method which not only improves the visual quality of fruit by promoting skin coloration and reducing blemishes, but can also change the micro-environment for fruit development, which can have several beneficial effects on internal fruit quality. Pre-harvest bagging of fruit can also reduce the incidence of disease, insect pest and/or mechanical damage, sunburn of the skin, fruit cracking, agrochemical residues on the fruit, and bird damage [3,4,5,6,7,8,9,10]. The aim of this study was undertaken to control mango pests and diseases as well as to improve the fruit quality of mango through bagging technology.

2. MATERIALS AND METHODS

This research was conducted at the Department of Horticulture, HSTU, Dinajpur, Bangladesh during March to July, 2016. Uniformly grown 10 years old Langra mango grafted trees was selected. The experiment was constructed in Randomized Block Design with five treatments replicated three times with a unit of 50 fruits per treatment per replication. Different types of bags were constituted the treatments *viz*.: T_1: Brown paper double layered bag (BPB) T_2: White paper single layered bag (WPB); T_3: Perforated polythene bag (PB); T_4: Muslin cloth bag (MCB) and T_0: Non-bagged (control). Uniformly grown fruits (40 to 50 days after fruit set) were selected for bagging. The sizes of bags were 25 × 20 cm. Before bagging two perforations (≤ 4 mm diameter) was made for proper ventilation at the bottom of polythene bag and muslin cloth bag. White and brown paper bags were not perforated. The particular bags were wrapped properly at the stalk of each fruit of respective treatments so that it would not be fall down as well as there would not be open space. The observations *viz.* fruit retention (%) and day's require for harvesting after bagging were recorded. Four fruits were randomly selected per treatment per replication to record various physical and chemical compositions which were estimated by the following procedures:

2.1 Physical parameters:

Length and Diameter of Fruit were measured with the help of digital vernier caliper and expressed in centimeters (cm).Weight of fruit, pulp and stone was recorded by using electronic balance and expressed in grams (g).

2.2 Chemical composition:

Total Soluble Solid (TSS): Total soluble solids were found out by using Erma Hand Refractometer (0 to 32°Brix) and expressed in °Brix [11].

Citric Acid (%): 10g mango pulp was crushed in a mortar and pestle and transferred in a 100 mL volumetric flask. Volume was made up to 100 mL by distilled water. Then the sample was filtered and 10 mL filtrate was taken in a conical flask. The filtrated was titrated against 0.1 N NaOH using phenolphthalein as an indicator. The results were expressed in percent of citric acid [12].

$$\% \text{ Citric acid} = \frac{0.5 \times \text{Titrate value unknown soln} \times \text{Made volume of unknown sample}}{\text{Titrate value of known soln} \times \text{Aliquot taken} \times \text{Wt.of sample}}$$

Reducing Sugars (%): It was determined according to the method described by Haq (2012) and Santini *et al*. (2014) [13, 14] with slight modification. Crushing 20g of the mango pulp was transferred in a 200 mL volumetric flask. The volume was adjusted to 150 mL by purified water. After a few minutes, 10 mL of lead acetate solution and the minimum amount of potassium oxalate solution were added to allow the sugar dissolution. The volume of the resulting solution was adjusted to 200 mL, and was shaked, filtered and transferred in a burette for the titration. This extraction is titrated against Fehling solutions with the help of methylene blue indicator.

$$\% \text{ Reducing sugar} = \frac{\text{Fehling factor} \times \text{Dilution} \times 100}{\text{Titre} \times \text{weight or volume of sample}}$$

Total Sugars: An aliquot of 50 mL of the clarified, de-leaded filtrate was pipette to a 100 mL volumetric flask, 5 mL conc. HCl was added and allowed to stand at room temperature for 24 hours. It was neutralized with conc. NaOH solution followed by 0.1 N NaOH solutions. The volume was made up to the mark and transferred to 50 mL burette having an offset tip and performed the titration on Fehling's solution [15].

$$\% \text{ Total sugar} = \frac{\text{Fehling factor} \times \text{Dilution} \times 100}{\text{weight of sample x Titre}}$$

Ascorbic Acid (mg/100g of Fruit Pulp): Ascorbic acid was estimated as described by McHenry and Graham (1935) [16]. Mango pulp (5g) was mixed with 5 mL of 20% metaphosphoric acid solution and filtered. The filtrate (5 mL) was put in a small beaker and shaken with 2 drops of phenolphthalein solution and titrated against 2, 6-indophenol until pink colour developed.

$$\text{Vit C (mg/100 g)} = \frac{0.5 \times \text{Titrate value unknown soln} \times \text{Made volume of unknown sample}}{\text{Titrate value of known soln} \times \text{Aliquot taken} \times \text{Sample weight}}$$

β-Carotene (µg/100 g of pulp): β-carotene in mango pulp was determined according to the method of Nagata and Yamashita (1992) [17]. One gram of pulp was mixed with 10 mL of acetone: hexane mixture (4:6) and vortex for 5 minutes. The mixture was filtered and absorbance was measured at 453 nm, 505 nm and 663 nm.

$$\beta\text{-carotene (mg /100mL)} = 0.216\ A_{663} - 0.304\ A_{505} + 0.452\ A_{453}$$

Shelf Life of Fruits (Days): The mature fruits were harvested at 80-85 percent maturity. Twenty harvested mature fruits of each treatment were ripened at ambient temperature by using plastic crates with perforation and traditional paddy straw as ripening material. At the bottom, 2.5 cm layer of paddy straw was made on which fruits were arranged. Simultaneously, two more layers were kept on the first layer. After ripening the various observations *viz*. shelf life (days) and incidence of mealy bug (%) were recorded. The end of shelf life was noted when the fruits were spoiled.

The ripe fruits were also examined for their sensory qualities for assessing color, flavor and texture by panel of five judges with nine point Hedonic Scale *viz*.1-Dislike extremely, 2-Dislike very much, 3-Dislike moderately, 4-Dislike slightly, 6-Like slightly, 7-Like moderately, 8-Like very much and 9-Like extremely [18].

2.3 Statistical analysis

The data were analyzed by Duncan's multiple range test (DMRT) at $P < 0.05$. All statistical procedures were conducted using SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA).

3. RESULTS AND DISCUSSION

The practice of pre-harvest bagging has been extensively used in several fruit crops, such as mango [19,20,4,21,3,7,8], apple [22], pear [23,24], peach [25], longan [26], to improve the commercial value of the fruit, namely, improving fruit coloration [27], reducing mechanical damage [28] and sunburn [29] of the skin. Pre-harvest bagging also reduces pesticide in the fruit [28] and improves insect [30], disease [31] and bird damage control [28]. Therefore, pre-harvest bagging had been an important technical measure in improving the commercial value and promoting the export of the fruit [32].

This research showed that fruit retention was significantly improved by pre-harvest bagging materials with brown paper bag (92.92 %), white paper bag (90.97 %) and muslin cloth bag (89.00 %) over control (80.00 %). The fruit retention found in polythene bag (53.67 %) lowers than control (80.00%) condition because of polythene paper bag warmed quickly and inside temperature was higher compare to other bags. High temperature also enhances the development of abscission layer. The harvesting time was significantly preponed in white paper bag, polythene bag and muslin cloth bag whereas in brown paper bag, it was significantly delayed (78.67 days). The polythene bag took minimum days (70.00 days) for harvest after bagging where as by brown paper bag, microclimate helps for fruits growth and development. Ripening process is occurs delay by brown paper bag but in polythene bag, inside temperature increases quickly and high temperature enhances ripening process. The treatments brown paper bag, white paper bag, polythene bag and muslin cloth bag were as par with control (76.00 days) for days required for harvest after bagging (Table 1).

Table 1. Effects of pre-harvest bagging on fruit retention and days required for harvesting after bagging in mango cv. Langra

Treatments	Fruit retention (%)	Days required for harvesting after bagging
Brown paper bag	92.92±0.50 a	78.67±0.33 a
White paper bag	90.97±0.58 ab	77.00±0.58 ab
Polythene bag	53.67±1.86 d	70.00±0.58 c
Muslin cloth bag	89.00±0.58 b	76.00±0.58 b
No bagging (control)	80.00± 00 c	76.00±0.58 b
C.V. (%)	18.551	1.7392
F value	0.362	2.42

Mean followed by different letter(s) are significantly different at DMRT, $p < 0.05$

Pre-harvest bagging with brown paper bag improved physical parameters *viz*: weight of fruit, length of fruit, diameter of fruit, pulp weight and stone weight over control fruits, and the variation was statistically significant (Table 2). The fruits bagged in polythene produced the smallest fruit having fruit weight (166.55 g), diameter (5.49 cm) over control (205.84 g, and 5.49 cm, respectively). The brown paper bag exhibited the highest fruit length (8.35 cm), pulp weight (152.63 g) and pulp to stone ratio (5.73) because of favorable microclimate exist inside the brown paper bag and the days required for harvesting were greater in brown paper bag than controlled fruits which might have helped to record more fruit weight, fruit size, length, weight, pulp weight were increased compare to other bags. Previous studies on effects of fruit bagging on fruit size and weight opined that it may be due to differences in the type of bag used, fruit and cultivar responses [5]. Bagging in 'Nam Dok Mai 4' mango fruit with two-layer paper bags, newspaper or golden paper bags increased fruit weight [33]. Bagging increased fruit growth and development, resulting in more weight and larger-sized fruit over control [34]. Microenvironment created by brown paper bag, white paper bag, muslin cloth bag and polythene bag might have congenial effect on fruit growth of mango [26].

Table 2.Effects of pre-harvest bagging on physical parameters of mango cv. Langra

Treatments	weight of fruit (g)	Length of fruit (cm)	Diameter of fruit (cm)	Pulp weight (g)	Stone weight (g)	Pulp:Stone ratio
Brown paper bag	205.04±0.29 a	8.35±0.02 a	6.87±0.02 a	152.63±2.90 a	26.30±1.18 a	5.73±0.22 a
White paper bag	204.15 ±0.00 a	8.24±0.40 ab	6.90±0.00 a	119.69±1.76 b	24.39±1.70 a	5.56±0.20 a
Polythene bag	166.55±0.00 b	7.91±0.13 ab	5.49±0.00 d	107.28±0.00 d	25.87±0.47 a	4.23±0.00 c
Muslin cloth bag	191.58±2.7 ab	7.61±0.05 b	6.13±0.00 c	112.57±0.29 c	26.28±0.64 a	4.28±0.09c
No bagging	205.84±20.35 a	6.90±0.05 c	6.63±0.02 b	109.40±0.00 cd	23.03±0.51 a	4.75±0.00 b
C.V. (%)	10.546	7.7973	8.6421	14.483	7.9126	14.481
F value	1.14	0.831	0.193	0.556	1.297	0.880

Mean followed by different letter(s) are significantly different at DMRT, $p < 0.05$

The pre-harvest bagging at harvest stage had significant effect on ascorbic acid, reducing sugars, total sugars and β-carotene content of fruits (Table 3). The controlled fruits recorded the highest acidity (15.83 %) and TSS (6.28 ^{o}Brix) which were significantly superior over all bagging treatments because of controlled fruits exposed direct sunlight and sugar conversion process was faster compare to bagged fruits therefore TSS is high. The fruits covered with white paper bag had significantly highest total sugars (2.06 %) over control while brown paper bag showed the highest ascorbic acid (1387.44 mg/100g), β-carotene (131.36 µg/100g) content and reducing (0.90 %) sugars (Table 3) due to the fruits are not directly exposed to the sunlight and xanthophylls become higher therefore ascorbic acid stored more and β-carotene was higher compare to control.

The bagged fruits recorded highest content of vitamin C, sucrose, glucose and fructose over control in Zill mango [35]. The bagging of date palm fruits improved the total sugars [36]. Bagging enhanced carotenoid content in mango [37]. The bagging led to lower contents of chemical components such as sugar, phenols and organic acids in most of peach varieties [38]. Fruit firmness was slightly increased by bagging treatments, whereas soluble solids content was decreased in apple [39].

Table 3.Effects of pre-harvest bagging on chemical composition of mango cv. Langra during the harvest

Treatments	Ascorbic acid (mg/100 g)	TSS (^{0}Brix)	Citric acid (%)	Reducing sugars (%)	Total sugars (%)	β-carotene (µg/100 g)
Brown paper bag	138.44±0.01 a	5.66±0.01 b	15.39±0.05 a	0.90±0.00 a	1.53±0.03 c	131.36±0.68 a
White paper bag	123.12±0.03 b	5.78±0.14 ab	14.71±0.14 a	0.94±0.03 a	2.06±0.03 a	120.58±0.53 b
Polythene bag	120.52±0.02 c	2.72±0.23 c	15.35±0.9 a	0.74±0.02 bc	1.01±0.02 e	115.86±0.03 d
Muslin cloth bag	108.81±0.68 d	5.30±0.20 b	15.09±0.05 a	0.73±0.01 c	1.14±0.01 d	120.83±0.14 b
No bagging	107.09±0.34 e	6.28±0.05 a	15.83±0.10 a	0.81±0.03 b	1.75±0.03 b	118.26±0.01 c
C.V. (%)	9.8081	11.085	4.5504	25.585	6.4485	27.143
F value	0.669	0.933	0.378	0.460	0.094	0.543

Mean followed by different letter(s) are significantly different at DMRT, $p < 0.05$

In Table 4, fruits of brown paper bag exhibited the maximum TSS (14.14 ^{o}Brix), acidity (4.32%), reducing sugars (0.90 %), total sugars (4.42 %) and β-carotene (1218.83 µg/100g) at ripe stage and oxidative degradation was highest. The favorable condition for fruit growth and development was comparatively better inside the brown paper bag specially the β-carotene content was significantly increased with the advancement of storage period, likely due to the breakdown of chlorophyll and increase in carotenoids content by chlorophyllase enzyme during the storage. While the control fruit was showed higher content of ascorbic acid (108.67 mg/100g) due to control fruits has lower shelf life, we know with increasing storage time ascorbic acid gradually reduces. All chemical parameters were non-significant difference in between the polythene and muslin cloth bag fruits (Table 4).

Table 4. Effects of pre-harvest bagging on chemical composition of mango cv. Langra during ripe stage

Treatments	Ascorbic acid (mg/100 g)	TSS (^{0}Brix)	Citric acid (%)	Reducing sugars (%)	Total sugars (%)	β-carotene (µg/100 g)
Brown paper bag	85.43±0.11c	14.14±0.03 a	4.32±0.03 a	0.90±0.01a	4.42±0.01 a	1218.83±0.10 a
White paper bag	100.35±0.33 b	12.60±0.03 c	3.19±0.01 c	0.73±0.01 b	3.56±0.01 b	1207.69±0.37 b
Polythene bag	99.33±0.56 b	11.26±0.14 d	4.12±0.16 d	0.70±0.01 b	3.13±0.08 c	1152.80±0.16 d
Muslin cloth bag	99.33±1.45 b	11.33±0.35 d	4.13±0.15 d	0.72±0.03 b	3.20±0.11 c	1132.29±0.20 e
No bagging	108.67±0.07 a	13.39±0.08 b	4.26±0.02 b	0.85±0.02 a	3.21±0.01 c	1153.92±0.50 c
C.V. (%)	7.9113	11.223	2.9881	9.5395	11.618	14.485
F value	0.294	1.297	0.780	1.407	0.734	0.521

Mean followed by different letter(s) are significantly different at DMRT, *p* <0.05

Sensory evaluation with respect to color, texture, appearance and overall expression were significant variation among various treatments while flavor was non-significant. Beside, brown paper bag showed less sweetness compared to control. It indicated that the organoleptic qualities of fruits were affected by pre-harvest bagging in mango (Table 5)

Table 5. Effect of bagging on sensory evaluation in fruits of mango cv. Langra

Treatments	color	flavor	texture	sweetness	appearance	Overall expression
Brown paper bag	7.33±0.88a	7.66±0.33a	7.33±0.67a	8.06±0.35a	8.00±0.29a	7.67±0.33a
White paper bag	6.33±0.33a	7.33±0.33a	7.00±0.00a	7.83±0.44a	6.83±1.01a	6.67±0.88a
Polythene bag	7.33±0.67a	8.00±0.00a	7.33±0.33a	7.33±0.33a	7.00±0.58a	7.17±0.17a
Muslin cloth bag	6.67±1.45 a	8.33±0.33 a	7.00±0.58 a	7.83±0.17 a	7.33±0.95	7.06±0.64a
No bagging	7±0.58 a	7.33±0.33 a	7.67±0.33a	7.60±0.31	6.60±0.45	6.93±0.07a
C.V. (%)	19.248	7.6761	9.6844	7.0939	16.233	11.651
F value	0.250	2.125	0.389	0.705	0.578	0.511

The control fruits of Langra had shelf life of 15 days (Table6). The fruits of brown paper bag (17.00 days), white paper bag (17.33 days) and muslin cloth bag (15.67 days) had greater shelf life than control (15days). Brown paper bag showed the maximum shelf life because of, the fruits of this bag are always dry, healthy and no chance for disease and insect infestation. Inside temperature becomes higher in polythene paper bag than outside due to this reason humidity increases quickly and water drops continuously stored inside the bag that’s why the lowest shelf life (14.33 days) observed in polythene paper bag.

Polythene and muslin cloth bag treatments showed fewer incidences of mealy bugs as compared to control whereas the fruits bagged in brown paper and white paper bags were totally free from mealy bugs as well as spongy tissue (Table 6). This may be mealy bug could not enter inside the bags as it was tightly tied by GI wine and the spongy tissue was not found due to the bagged fruits were not directly associated with convective heat and exposure to sunlight. Similar results were found in Katrodia (1989) and Om & Prakash (2004) [40,41]. The maximum incidence of mealy bugs (9.33 %) and spongy tissue content (6.17 %) was recorded in control because control fruits faced highest rainfall during its growth and development due to that internal abnormalities may happened or unusual growth of the tissue was happened. The longer shelf life of bagged fruits indicated that the effect of bagging persisted after ripening. Bagging provided physical barrier between fruit and pests and protection against both which helped in reducing occurrence of spongy tissue in fruits. So, bagging fruits was one of necessary techniques for producing high quality fruits, which had been universally adopted in some fruit production [42].

Table6. Effect of pre-harvest bagging on shelf life, mealy bug incidence and spongy tissue content of mango cv. Langra

Treatments	Shelf life (days)	Mealy bugs (%)	Spongy tissue (%)
Brown paper bag	17.00±0.00 a	0.00±0.00 c	0.00±0.00 c
White paper bag	17.33±0.33 a	0.00±0.00 c	0.00±0.00 c
Polythene bag	14.33±0.33 c	5.33±0.33 b	2.39±0.96 b
Muslin cloth bag	15.67±0.33 b	6.67±0.33 b	1.72±0.48 b
No bagging	15.00±0.58 bc	9.33±0.88 a	6.17±1 a
C.V. (%)	8.2060	22.502	51.59
F value	0.371	1.243	62.357

Mean followed by different letter(s) are significantly different at DMRT, $p < 0.05$

4. CONCLUSION

The results of this study clearly demonstrate that pre-harvest fruit bagging has emerged as a novel technology in practice, which is simple, grower friendly, safe and beneficial for production of quality fruits. It is advisable to use brown paper bag for getting colored fruits i.e., yellow color since white paper bag for retains original color of the variety. Both bags showed their potentiality against major insect-pests and diseases attack. Bagging fruits have a good shelf life which is important criteria for exportable mango. On the other hand, bagging fruits having attractive color, farmer will get more market prices for their mangoes. Therefore, farmers might be used this technology for commercial mango cultivation.

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