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Effect of Bagging on Quality and Shelf Life of Mango (*Mangifera indica* L.) cv. BARI Mango- 4

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MTI designed the study, wrote the protocol and first draft of the manuscript. Author MMA managed the analyses of the study. Author MSU managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to manage mango pests with maintaining fruit quality through fruit bagging technology. This research was executed from April, 2019 to August, 2019 for ensuring safe mango production with minimum use of pesticides. The fruits were bagged at the age of 45 to 50 days with different types of bags. Four treatments viz: No bagging (control), Brown paper double-layered bag; White paper single-layered bag; Transparent polythene bag were included. Apparently, brown and white paper bag showed maximum fruit weight (557.90 g and 498.67g), fruit length (10.77 and 10.67 cm), fruit diameter (24.90 and 24.67 cm) and pulp weight (465 and 453 g) respectively, compared to control treatment while polythene bag gave the minimum result. Meanwhile in bagging fruit chemical parameters of ascorbic acid, reducing and non reducing

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sugars, total sugars, total soluble solids, percent of citric acid and β-carotene were improved over polythene bag and control. The fruit color was non-persistent in brown paper bag. The sensory attributes of color and flavor in fruits of brown bags were improved over control. Fruit retention was significantly enhanced with brown paper bag (88.67%), white paper bag (87.00%) and control (82.33%) compared to polythene bag (61.33%). Fruits with brown paper bag gave the highest shelf life up to 12.67 days with the lowest weight loss and good physical appearances as against 10.67 days of control fruits. The infestation of fruit fly also had reduced by pre-harvest fruit bagging. These results indicate that fruit bagging can enhance fruit quality and shelf life of mango cv. BARI mango-4 through reduction insect-pest attack.

Keywords: Mango; bagging treatments; quality; sensory attributes.

1. INTRODUCTION

Mango (*Mangifera indica* L), belonging to the family Anacardiaceae, is a popular tropical fruit. In Bangladesh, mango production is about 1165.80 thousand ton under 44366 ha of land [1]. The area under mango cultivation is increasing every year. It provides a lot of energy with as much as 74 Kcal per l00 g edible portion and both unripe and ripe mangoes are also a good source of vitamin C. It is also a good source of Vitamin A. BARI mango-4 is a hybrid, developed from the crosses between M-3896 line (male) and local Ashwina variety (female) and developed by Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. High fruit yielding, regular bearing, sweet and late variety, panicle initiate in February, flesh deep yellow, fibreless and fruit size around 600g. To reduce the losses caused by biotic and abiotic factors, several GAPs are becoming popular throughout the World. Furthermore, the development of alternative techniques to enhance the appearance and attributes of fruits and to reduce the diseases and insect infestations are becoming important as consumer anxiety over the misuse 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]. The fruits of spotless, attractive and pest free that ensured premium rate in the market. In recent years, the climatic changes such as sudden rise in the temperature and humidity, high frequency of rainfall during fruit development are often experienced. It had not only affected the external appearance of the fruit but also increases the pest infestation such as mealy bugs, fruit fly and physiological disorder like incidence of spongy tissue which further added in the losses. The infested fruits gain poor price in the market and not suitable for processing. As a result, mango growers face a serious economic loss every year. Among several such alternatives, the pre-harvest bagging technique of fruits has been used widely in several fruit crops for attracting skin color and to reduce the incidence of diseases, insect pests, mechanical damages, sunburn of the skin, agrochemical residues on the fruits and bird damages [3,4,5,6,7]. However, recently fruit bagging technology is commercially going to be promoted in mango orchards of different location in Bangladesh. This technology is the accommodating pre-harvest season to protect mango from pest attack besides facilitating the farmers to get quality yield. Therefore, this research has been undertaken to justify the effectiveness of different types of fruit bags on mango cv. BARI mango-4.

2. MATERIALS AND METHODS

The research work was conducted at the farmer's field of Pirganj under Thakurgoan district of Bangladesh during April to August, 2019. Chemical analyses were done at the laboratory of Atomic Energy Commission, Savar, Dhaka and other parameters were evaluated at the Department of Horticulture, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The experiment was designed in Randomized Complete Block Design (RCBD) with four treatments replicated three times with a unit of 10 fruits per treatment per replication. The treatments are: No bagging (Control), Brown paper double-layered bag, White paper single-layered bag and transparent Polythene bag. Uniformly grown fruits (45 to 50 days after fruit set) were selected for bagging and the sizes of bags were 25 × 20 cm. Before bagging two perforations (≤4 mm diameter) was made for proper ventilation at the bottom end of each polythene bag. Each bag were wrapped properly with the stalk of each fruit so that it would not be fall down as well as there would not be open space for entry of insects or rain water etc. The observations of fruit retention (%) and

day's required for harvesting after bagging were recorded accordingly. 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

The length from stalk end to the apex of fruit and diameter was measured with the help of a digital Vernier caliper and expressed in centimeters (cm). Weight of fruit, pulp and stone were recorded by using an electronic balance and expressed in grams (g).

2.2 Chemical Compositions

2.2.1 Moisture content (%)

Moisture was determined according to [8].

2.2.2 Ascorbic acid (mg/100 g of fruit pulp)

Ascobic acid was estimated as described by [9]. Mango pulp (1 g) was homogenized with 3% metaphosphoric acid and was filtered through filter paper (Whatman No. 1). Then an aliquot (5 ml) of filtrate was titrated with the 2, 6-dichloroindophenol dye to a pink end-point.

$$\text{Vitamin C (mg/100 g)} = \frac{\text{Titre} \times \text{dye factor} \times \text{volume made up}}{\text{Volume of filtrate taken} \times \text{Sample weight}} \times 100$$

2.2.3 Reducing sugars (%)

Total reducing sugar content of the samples was determined according to the classical and widely used method [10]. Mango pulps were homogenized with benzoic acid solution (0.2%). An aliquote of the filtrate was mixed with the copper reagents (a mixture of alkaline Rochelle salt and acidic $CuSO_4$). After heating in boiling water (15 min) and cooling, arsenomolybdate color reagent was added. Finally a blue color produced, the absorbance measured at 520 nm and compared with a set of standard (glucose). Result calculated based on standard curve.

2.2.4 Non-reducing sugars

Non reducing sugar content was determined by subtracting the reducing sugar content from total sugar content [11]. Non-reducing sugar content was determined by using the following formula:

Percentage of non-reducing sugar= (% Total sugar-% Reducing sugar) x 0.95

2.2.5 Total sugars (%)

Total sugar content of mango pulp was estimated by Anthrone reagent as per the method given by [12]. 0.1 ml extract of mango pulp mixed with 1.9 ml distilled water and kept in ice box for 10 min. Then 3 ml anthrone reagent was added and heated in boiling water for 15 min. After cooling at room temperature, the absorbance measured at 620 nm. D-Glucose at the concentration of 20 to 100 gml^{-1} was used to prepare the standard curve. Result calculated based on standard curve.

2.2.6 Total Soluble Solids (TSS, in ^{0}Brix)

5g pulp was crushed in mortar and pestle which was transferred to 100 ml beaker and diluted in 1:2 proportions with distilled water. Soluble solids content was measured by Erma Hand Refractometer (0 to 32°Brix) and expressed in Brix.

2.2.7 Citric acid (%)

The samples were titrated with 0.1N NaOH solution using titration kit, where phenolphthalein (3-5 drops) was used as an indicator. The volume of alkali used was noted and calculation was made using the following formula. The results were expressed in percent of citric acid [13].

$$\text{\% Citric acid} = \frac{\text{Titrate value} \times \text{Normality of alkali} \times 0.06406 \times 100}{\text{Volume of sample taken}}$$

2.2.8 β-Carotene (µg/100 g of pulp)

β-carotene in mango pulp was determined according to the method of [14]. 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.

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

2.3 Shelf Life of Fruits (Days)

The mature fruits were harvested at 80-85% maturity level. Twenty five 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 fruit fly (%) were recorded. When the fruits were spoiled then shelf life was recorded.

2.4 Sensory Evaluation

The ripe fruits of both bagged and control were also examined for their sensory qualities for assessing color, flavor, texture sweetness and overall expression 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 [15].

2.5 Fruit Fly Infestation and Spongy Tissue

After harvesting, fruits were cut to check fruit fly infestation, spongy tissue development and for physical fruit quality. The percent incidence of spongy tissue was determined based on visual scoring of 10 ripe fruits from each treatment after cutting them open.

2.6 Statistical Analysis

The data were analyzed by using SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA) with Duncan's multiple range test (DMRT) at $P \leq 0.05$.

3. RESULTS AND DISCUSSION

Pre-harvest fruit bagging has been widely used in various fruit crops, such as mango [3,4,16], apple [17], pear [18], peach [19], to enhance the commercial standard of the fruit, namely, promoting fruit coloration [20], reduces mechanical damage [21] and sunburn [22] of the skin. Pre-harvest bagging also reduces the use of pesticides in the fruit and controlling insect [23], disease [24] and bird damage. Therefore, fruit bagging had been a demanding technical ways to enhance the economic value and produced export quality fruits [17].

Fruit retention was significantly improved in both brown paper bag (88.67%) and white paper bag (87.00%) over control (82.33%). Meanwhile in polythene bag produced the minimum fruit retention (61.33 %) because of polythene bag warmed rapidly and inside temperature was higher compare to other bags. High temperature influences the formation of abscission layer. The harvesting time noted earlier in polythene bag (61.00 days) compared to white paper bag (65.67 days) which is statistically significant. This is due to microclimatic change inside bags that helpful for fruits growth and development. Ripening process delayed both for brown paper and white paper bag since in polythene bag, ripening process promoted because of inside temperature increases quickly (Table 1).

Pre-harvest fruit bagging with brown paper bag improved physical characters viz: fruit weight and pulp weight over control, and the variation were statistically significant (Table 2). The polythene bag produced the smallest fruit weight (346.87 g), length (7.13 cm), diameter (16.17 cm), pulp weight (204.00 g), stone weight (33.20 g) and pulp stone ratio (6.15) over control (479.00 g, 9.93 cm, 24.67 cm, 409.33 g, 37.33 g and 11.01, respectively). The brown paper bag showed the maximum fruit length (10.77 cm), fruit weight (557.90 g) and pulp stone ratio (11.34). Previous reports on effects of fruit bagging on fruit size and weight reveals that it may be due to differences in the type of bag used, fruit and cultivar responses [25]. Fruit weight also increased in mango fruit due to pre-harvest bagging with two-layer paper bags, newspaper or golden paper bags [26]. Bagging increased fruit growth and development, resulting in more

Table 1. Impacts of bagging on fruit retention and days required for harvesting after bagging in mango cv. BARI mango-4

Treatments	Fruit retention (%)	Days required for harvesting after bagging
No bagging	82.33±0.88b	63.67±0.33 b
Brown paper bag	88.67±0.33a	64.67±0.33 ab
White paper bag	87±0.58a	65.67±0.33a
Polythene bag	61.33±0.33c	61±0.58c
CV (%)	0.88	1.20
LSD	1.705	1.408

Means± standard error within a column followed by different letter(s) are significantly different (DMRT, p <0.05)

weight and larger-sized fruit over control [27]. Microenvironment might be helpful for the growth and development of mango [28].

From Table 3, it was observed that moisture content was not significantly affected by bagging at harvest and at ripe stages. However, the highest moisture content was observed in polythene bag (84.00% and 81.33%, respectively), whereas the lowest in white paper bag (81.78%, 79.00%). These results are confirmed with previous studies [29] in mango fruit.

At harvest and ripe stage, ascorbic acid was significantly varied. The highest was observed in the white paper bag fruits (13.00 and 9.33 mg/100gm, respectively) while the lowest in the brown paper bag (2.8 and 2.4 mg/100gm, respectively) (Table 3). This result suggested that the fruits with white paper bag are not directly exposed to the sunlight which ensures higher xanthophylls content therefore, stored more ascorbic acid compared to control. Simultaneously, Vit-C contains is lower in double layed brown paper bags compared to white bag because of inside carbon layer restrict penetration of sunlight into bags. The highest content of vitamin C, sucrose, glucose and fructose were found bagging treatments over control in Zill mango [30] (Table 3).

At harvest and ripe stage, reducing sugar was significantly variation between different treatments. The highest reducing sugar was in the control fruit at harvest and ripe stage (2.93% and 3.16%, respectively) while lowest was in the polythene bag (1.91% and 2.17%, respectively). Non reducing sugars at harvest and ripe stage were the highest in the treatment of white paper bag (1.85% and 2.62%, respectively) while the lowest in the brown paper bag (1.33%) and in the polythene bag (1.58%) (Table 3).

At harvesting stage, control fruits exhibited maximum total sugar (4.90%) over other treatments while in the other treatments were noted in the brown paper bag (4.20%), white paper bag (4.66%) and polythene bag fruits (1.49%). During ripening stage, white paper bag exhibited maximum total sugar (5.96%) whereas minimum (4.00%) was recorded in polythene bag (Table 3). These results are very close to the earlier findings [31,4]. They reported that bagged fruits of mango and palm exhibited the maximum total sugars at ripening stage (Table 3).

At harvest and ripe stage, TSS had significantly varied among different treatments. The highest TSS content recorded in the control fruits (16.20 ^{o}Brix and 19.86 °Brix, respectively) while lowest in polythene bag (4.77 °Brix and 10.80°Brix, respectively) (Table 3). These results are accordance with some previous studies [3,19].

Maximum citric acid content at harvest stage was recorded in the polythene bag (5.46%) while the minimum in the white paper bag (2.23%) which is statistically significant. At ripe stage, the higher percentage of citric acid showed in the polythene bag (1.13%) while the lowest in the control fruits (0.16%) (Table 3). The findings support by [3,4] they revealed that percent of citric acid decreased sharply from harvest to ripe fruits in mango.

At harvest stage, the highest β-carotene content was recorded in the brown paper bag (158.9 µg) which was statistically superior over in the white paper bag (114.6 µg), polythene bag (113.4 µg) and control fruits (125.3 µg). At ripe stage, the brown paper bag (1189. 0 µg) gave the highest β-carotene which was statistically similar in treatment white paper bag (1188.0 µg) while lowest in the polythene bag fruits (1070.0µg) (Table 3). These findings are accordance with previous reports that a flesh lycopene and β-carotene content was increased due to pre-harvest bagging treatments in mango [16,17,32].

Sensory evaluation with respect to color, flavor, sweetness and overall expression were significantly different among various treatments while texture was non-significant. Beside, bagging treatments showed less sweetness compared to control. It indicated that the organoleptic taste, quality of fruits were affected by pre-harvest bagging in mango (Table 4).

The control treatment had showed lower shelf life of 10.67 days compared to brown paper bag (12.67 days) and white paper bag (12.33 days) (Table 5). Brown paper bag showed the maximum shelf life because of, this bag are always dry, healthy and no chance for disease and insect infestation. Inside temperature in polythene bag becomes higher than outside due to this reason, humidity increases rapidly and water drops stored continuously inside the bag that's why polythene bagged fruit showed the lowest shelf life.

Table 2. Effects of types of bag on physical parameters of mango cv. BARI mango- 4

Treatment	Fruit wt. (g)	Fruit length (cm)	Fruit dia. (cm)	Pulp wt. (g)	Stone wt. (g)	Pulp : Stone
No bagging	479±2.89 c	9.93±0.07 a	24.67±0.33 a	409.33±0.88 c	37.33±1.76d	11.01±0.52a
Brown paper bag	557.90±9.41 a	10.77±0.33a	24.90±1.05 a	465±0.58 a	41±58a	11.34±0.17a
White paper bag	498.67±3.92 b	10.67±0.33 a	24.67±0.33 a	453±58 b	43.33±0.67a	10.46±0.17a
Polythene bag	346.87±2.67 d	7.13±0.07 b	16.17±0.17 b	204±1.57 d	33.20±0.42c	6.15±0.049b
CV (%)	1.67	4.55	5.56	0.45	4.54	5.09
LSD	14.29	0.9618	2.527	3.049	3.695	1.028

Means± standard error within a column followed by different letter(s) are significantly different (DMRT, p <0.05)

Table 3. Effects of pre-harvest bagging on chemical parameters of mango cv. BARI mango-4 at harvesting and ripe stage

Treatment	Moisture content (%)		Ascorbic acid (mg/100gm)		Reducing sugar (%)		Non reducing sugar (%)	
	At harvest	At ripe	At harvest	At ripe	At harvest	At ripe	At harvest	At ripe
No bagging	83.11±4.28a	80.61±1.48 a	11.87±0.74a	3.33±0.13b	2.93±0.0a	3.16±0.02a	1.78±0.04a	2.01± 0.04b
Brown paper bag	82.66±0.38a	79.11± 0.11a	2.80±0.0c	2.40±0.0c	2.80±0.01c	2.84±0.03b	1.33±0.0b	1.90± 0.02b
White paper bag	81.78±0.22a	79.00±0.51a	13.00±0.58a	9.33±0.33a	2.85±0.02b	2.90±0.01b	1.85±0.03a	2.62± 0.03a
Polythene bag	86.00±0.58a	81.33±0.88a	8.46±0.57a	2.93±0.13b	1.91±0.01d	2.17±0.07c	1.46±2.47b	1.58± 0.10c
CV (%)	4.63	2.00	8.86	7.14	0.74	2.79	8.20	4.58
LSD	8.674	3.684	1.514	0.4403	0.0209	0.1150	0.2816	0.1756

Treatment	Total sugar (%)		TSS (^{0}Brix)		Citric acid (%)		β-carotene (µg/100 g)	
	At harvest	At ripe	At harvest	At ripe	At harvest	At ripe	At harvest	At ripe
No bagging	4.90 ±0.03a	5.06± 0.02b	16.20±0.01a	19.87±0.12a	3.21±0.00b	0.16± 0.00c	125.3 ± 0.03b	1173.0b
Brown paper bag	4.20± 0.02c	4.87± 0.03c	13.20±0.00c	15.33±0.07c	2.23± 0.01c	0.24±0.00b	158.9 ±0.02a	1189.0a
White paper bag	4.66±0.01b	5.96±0.01a	14.90±0.01b	18.43±0.03b	2.28±0.01 c	0.26±0.02b	114.6 ± 0.02c	1188.0a
Polythene bag	1.49±0.01d	4.0 ± 0.12d	4.77 ±0.15d	10.80±0.61d	5.46±0.29 a	1.13±0.09a	113.4 ± 0.31d	1070.0c
CV (%)	0.62	2.08	1.03	3.45	7.72	18.30	0.21	0.40
LSD	0.0209	0.1626	0.2571	0.6047	0.1626	0.0663	0.5553	6.021

Means± standard error within a column followed by different letter(s) are significantly different (DMRT, p <0.05)

Table 4. Effect of bagging on sensory attributes of mango cv. BARI mango-4

Treatments	Color	Flavor	Texture	Sweetness	Overall expression
No bagging	7.17±0.17b	7.00±0.00 ab	7.00±0.00a	8.67±0.33a	7.33±0.33a
Brown paper bag	8.33±0.17a	7.67±0.17 a	7.00±0.33a	8.00±0.00ab	7.67±0.33a
White paper bag	7.8±.15ab	7.17±0.17 ab	7.17±.17a	8.00±0.00ab	7.66±0.33a
Polythene bag	6.50±0.29c	6.33±0.33 b	6.67±0.33a	7.33±0.33b	4.67±0.17b
CV (%)	3.19	5.29	5.88	6.68	21.43
LSD	0.5351	0.8474	0.8129	0.77	0.82

Means± standard error within a column followed by different letter(s) are significantly different (DMRT, p <0.05)

Table 5. Effect of bagging on shelf life of mango cv. BARI mango-4

Treatments	Shelf life (days)	Fruit fly infestation (%)	Spongy tissue (%)
No bagging	10.67±0.33b	9.98±00a	6.00±0.58a
Brown paper bag	12.67±0.33a	0.00±0.00c	0.00±0.00d
White paper bag	12.33±0.33a	0.00±0.00c	0.00±0.00d
Polythene bag	8.00±0.58c	5.67±0.33b	4.33±0.33b
CV (%)	6.29	7.37	9.47
LSD	1.571	0.6435	0.69

Means± standard error within a column followed by different letter(s) are significantly different (DMRT, p <0.05)

Polythene bag treatments showed less incidences of fruit fly as compared to control whereas the fruits bagged in brown and white paper bags were totally free from fruit fly infestation (Table 5).

This may be fruit fly could not enter inside the bags as it was tightly tied by GI wire. Similar results were found in [33,17,3]. The maximum incidence of fruit fly (9.98%) and spongy tissue content (6.00%) was recorded in control because control fruits faced highest rainfall during its growth and development. In the same time, internal abnormalities or unusual growth of the tissue may happen. The longer shelf life of bagged fruits indicated that the effect of bagging persisted after ripening. Bagging provided physical barrier between fruit and pests, which helped in reducing the occurrence of spongy tissue in fruits. So, fruit bagging was one of the necessary techniques for producing high quality fruits, which had been widely accepted in some fruit production [34].

4. CONCLUSION

Thus, it is concluded that the pre-harvest treatment with brown and white paper bagging were found effective to increase the fruits quality in respect of fruits weight, TSS, ascorbic acid, total sugars and β-carotene, with minimum weight loss in mango fruits cv. BARI mango-4. Among all treatment, brown paper bag was provided the best performance for all parameters while without bagging in produced inferior. Therefore, pre-harvest fruit bagging with brown and white paper bags are suggested to the mango traders and grower of Bangladesh and suggested for quality production with prolonged shelf life. These bagging mangoes are sold at fair price in domestic and export markets ensuring profitable mango business.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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