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EFFECT OF PRE-HARVEST FRUIT BAGGING ON THE QUALITY OF GOPALBHOG MANGO

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ABSTRACT
An experiment was conducted from March to June, 2022 for safe mango production under Dinajpur condition. The mango fruits were bagged at marble stage (45 days after fruit set) with different types of bags such as, Brown paper bag (BPB); White paper bag (WPB) and no bagging (control).The experiment was conducted in Randomized Complete Block Design with three replications. The pre-harvest bagging modified fruit retention, time required from bagging to harvest, physico-chemical composition of mature and ripening fruit, shelf life, chance of spongy tissue production and pest incidence. Fruit retention was significantly enhanced by pre-harvest fruit bagging with a brown paper bag (76.66%), white paper bag (78.97%), and control (66.00%). In physical parameters, the maximum fruit weight (145.67g) was recorded from a brown paper bag while the minimum result was found in the control (141.34g). Again, in bagging fruits, chemical parameters of total soluble solids, ascorbic acid, citric acid, reducing sugars and β- carotene were higher than the control. Brown paper bag changed fruit color. Fruits with brown paper bags showed shelf life up to 17 days with the lowest weight loss and good physical quality as against 12 days of controlled fruits. Pre-harvest bagging also reduced the chance of spongy tissue and the incidence of mealy bugs. These results indicate that fruit bagging can improve the quality of fruit through reduction in disease and insect-pest attack and quality of mango cv. Gopalbhog.

Key Words: Bagging materials, chemical composition, mango, quality, shelf life

INTRODUCTION
Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae. It is the choicest fruit of the world. In Bangladesh, it is one of the important commercial fruits. Currently, it is grown about 299054 acres with an annual production about 1207446 MT (BBS 2023). There are so many mango varieties in Bangladesh. Among them Gopalbhog is a popular variety especially grown in the northern region. Attractive, spotless and pest free fruits of this variety fetch a 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 to 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. Bagging is one of the most important good agricultural practices that are used leads to the production of more attractive fruits due to fewer blemishes and visible marks (Sharma *et al.* 2014), particularly in apple (Rajametov and Nurbekov 2019), pears fruits (Kim *et al*. 2008), pomegranate (Hamedi Sarkomi

et al. 2019), mango (Islam *et al.* 2020), guava (Sharma *et al.* 2020), litchi (Pal *et al*. 2016). In addition, post-harvest losses are significantly reduced for mango (Rahman *et al.* 2019). It also prevents damage occurring due to bruises, wounds, scars also diseases, pest attack and to produce cleaner fruit skin with attractive color. In mango, bagging also helps to prevent fruit fly attack and fungal disease incidence. Bagging increased fruit weight and peel color development from green to yellow, due to less chlorophyll a and chlorophyll b. regarding the fruit weight 2-layer bagged fruit had the highest weight (Watanawan *et al.* 2008). Several types of locally available materials can be used for bagging. However, the technique is seldom attempted in mango in Bangladesh and specifically in northern agroclimatic conditions. Hence, an experiment was undertaken to study the influence of pre harvest bagging of fruits on the quality of mango cv. Gopalbhog.

MATERIALS AND METHODS

The mango orchard near the Hajee Mohammad Danesh Science and Technology University (HSTU) in Dinajpur was used for an experiment from March to June 2022. The experiment used a Randomized Complete Block Design (RCBD) with three replications. No bagging (control), brown paper bag (BPB), and white paper bag (WPB) were used in this experiment. Fruits were bagged 45 days after fruit set and uniformly cultivated. Bags were 25×20cm. For polythene bag ventilation, two apertures (≤4 mm diameter) were made before bagging. Air exposure was easier for white and brown paper bags. The bags were properly wrapped around each fruit's stalk to prevent it from falling and leaving open space. The fruits were picked in June 2022. Local farmers harvest fruit when it is firm and turns yellow from bottom to top (Goutam *et al*. 2010). Quality characteristics were analyzed.

Analysis of Physico-chemical Properties: The length and diameter of fruit were measured by slide calipers in centimeter (cm). Fresh weight, pulp and stone ratio were measured using digital balance and expressed in gram (g).

Total soluble solids (TSS): Total soluble solids content was measured by Erma Hand Refract meter (0 to 32°Brix) and expressed in Brix (AOAC 2004).

Ascorbic acid (mg/100g of fruit pulp): Ascorbic acid was estimated according to McHenry and Graham (1935). 5g mango pulp and 5 ml 20% metaphosphoric acid solution were filtered through Whatman No. 1. In a small beaker, 5 ml of filtrate was agitated with 2 drops of phenolphthalein solution and titrated against 2,6-indophenol till pink. The following equation estimated vitamin C content:

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

Citric acid (%): A 100-ml volumetric flask contained 10 gram of mango pulp mashed in a mortar and pestle. By adding distilled water, the capacity reached 100 ml. After filtering, 10 ml of filtrate was collected in a conical flask. The filtrate was titrated against 0.1 N NaOH using phenolphthalein. The outcome was citric acid percent. (Moffett and Pater 2007).

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

Reducing sugars: It was determined according to the method described by Haq (2012) and Santini *et al*. (2014) with slight modification. Twenty grams of the mango pulp was crushed in a mortar and pestle then transferred in a 200 ml volumetric flask. By adding purified water, the volume was 150 ml. After sugar dissolution, 10 ml of lead acetate solution and the minimum amount of potassium oxalate solution were added. The solution was shacked, filtered, and titrated in a burette after adjusting its volume to 200 ml. 5 ml of Fehling solution A, 5 ml of Fehling solution B, and 40 ml of filtered water were put to a flask. Drop by drop, the solution was heated to boiling and added until the Fehling reagent was nearly decolorized. Two drops of methylene blue were added, and boiling proceeded for three minutes. Until the indicator's blue colour disappeared and the solution turned red, the burette solution was added. Reducing sugar was calculated using the following equation:

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

Total sugars: In a 100-ml volumetric flask, 50 ml of the cleared, de-leaded filtrate were pipette. 5 ml of HCL and left overnight at room temperature. It was neutralized using concentrated NaOH and 0.1-N NaOH solutions. The volume was filled to the mark and transferred to a 50-ml burette with an offset tip to titrate Fehling's solution. (AOAC 2004).

$$\%\,Total\ sugar = \frac{Fehling\ factor\ \times\ Dilution\ \times 100}{Weight\ of\ sample\ \times\ Titre}$$

β-carotene (µg/100 g of Pulp): β-carotene in mango pulp was determined according to the method of Nagata and Yamashita (1992). One gram of pulp was mixed with 10 ml of acetone: hexane mixture (4:6) and vortexes for 5 minutes. Then the mixture was filtered through WhatmanNo.1 and absorbance was measured at 453 nm, 505 nm and 663 nm. β-carotene content was calculated according to the following equation

β-carotene (mg /100ml) = 0.216 A_{663}-0.304 A_{505}+ 0.452 A_{453}

Shelf life of fruits (Days): Fruit was picked at 80–85% maturity. Twenty fruits from each treatment were transferred to the lab and matured at ambient temperature in plastic crates with perforations and paddy straw. On a 2.5-cm layer of rice straw, fruits were placed. Two further layers were kept on the initial layer simultaneously. When 50% of fruits rotted, shelf life was determined.

Statistical analysis: All the recorded data were statistically analyzed following the ANOVA technique and significant the mean differences were adjusted by Duncan's multiple range test (DMRT) with the help of computer package SPSS 22.0.

RESULTS AND DISCUSSION

Effects of pre-harvest fruit bagging on fruit retention and days required for harvesting

Fruit retention was non-significantly influenced by pre-harvest bagging with brown paper bag (76.66%) and white paper bag (78.97%) over control (66.00 %) (Figure 1). The harvesting time was significantly delayed (68 days) in brown paper bags over white paper bags (67 days). The control took minimum days (66 days) for harvest after bagging (Figure 2).

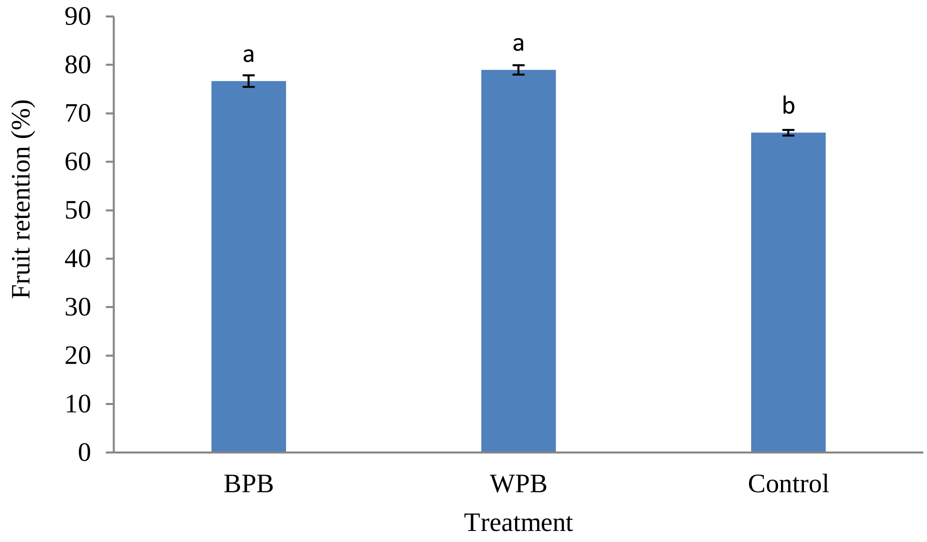

Figure 1. Effect of different bagging materials on fruit retention in mango cv. Gopalbhog. The vertical bar indicates the standard error and different lowercase letters (a-b) indicate significant differences among treatments (LSD at p≤0.05). BPB- Brown Paper Bag; WPB- White Paper Bag.

Fruit ripening is frequently accompanied with softening and changes to the cell wall, which enhance pectin solubility. As a result, the bagging may preserve fruit firmness by lowering cell wall activity and degrading enzymes such as polygalacturonase (PG), pectin methylesterase (PME), and galactosidase. Our findings demonstrated that the brown paper bag successfully delayed mango fruit hardness, which coincided with the findings of Rastegar and Atrash (2021).

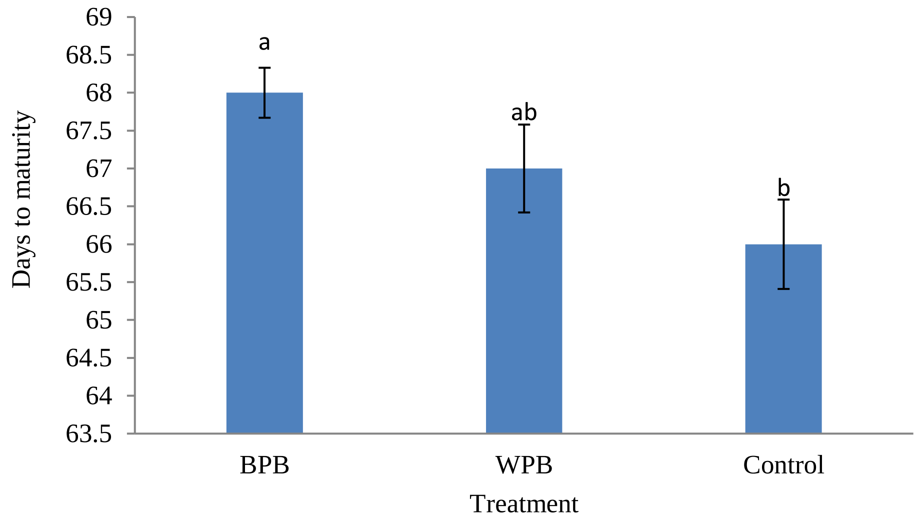

Figure 2. Effect of different bagging materials on days required for harvesting after bagging in mango cv. Gobaalbhog. The vertical bar indicates the standard error and different lowercase letters (a-b) indicate significant differences among treatments (LSD at p≤0.05).

Effects of pre-harvest fruit bagging on physical parameters of mango

Pre-harvest fruit bagging with brown paper bag and white paper bag were enhanced the physical parameters including fruit weight, length, diameter, pulp weight, stone weight and pulp to stone ratio over control (no bagging) and the variation was statistically significant (Table 1). The brown paper bag produced the biggest fruit (145.67 g) while in white paper bag produced moderate (143.97 g) and the minimum fruit size was recorded in the treatment of control (141.34g) (Table 1). The treatment of brown paper bag and white paper bag gave the maximum fruit length (8.16cm and 8.00cm,) respectively. The fruit length found in white paper bag (8.16cm) also higher than control (7.67cm) but the differences were non-significant (Table 1). Pre-harvest fruit bagging with brown paper bag gave the maximum fruit diameter (6.87 cm) over white paper bag (6.24 cm) while control gave the minimum fruit diameter (6.06cm) (Table 1). The treatment with brown paper bag had significantly highest pulp weight (125.27g) while control gave the minimum pulp weight (115.9) (Table 1). The maximum stone weight (24.37g) was recorded in the treatment of white paper bag while minimum stone weight (19.08 g) was recorded from control (Table 1). The maximum pulp stone ratio was obtained from control (6.08) which was statistically similar with brown paper bag (5.54) while white paper bag gave the minimum pulp stone ratio (4.91) (Table 1).

Previous studies on the effects of fruit bagging on fruit size and weight opined that it might be due to differences in the type of bag used, fruit and cultivar responses (Islam *et. al.* 2020; Sharma *et al.* 2014). Bagging in ‘Nam Dok Mai 4’ mango fruit with two-layer paper bags, newspaper or golden paper bags increased fruit weight (Watanawan *et al.* 2008). Bagging increased fruit growth and development, resulting in more weight and larger-sized fruit over control (Chonhenchob *et al.* 2011). Microenvironment created by the brown paper bag, white paper bag, muslin cloth bag and polythene bag might have a natural effect on the fruit growth of mango (Yang *et al.* 2009).

Effects of pre-harvest fruit bagging on chemical composition of mango

The pre-harvest bagging had significant effect on total soluble solids, ascorbic acid, citric acid, reducing sugars, total sugars and β-carotene content of fruits at harvesting and ripening stage (Table 2). The maximum ascorbic acid content (31.57 mg/100 g) was recorded in the treatment of white paper bag while the lowest (23.95 mg/100 g) was recorded in the brown paper bag at harvesting stage. But at ripening stage maximum ascorbic acid was obtained in brown paper bag (15.45 mg/100gm) while the lowest (12.83 mg/100g) was recorded in control (Table 2). At harvest stage, the significantly highest soluble solids content was recorded in white paper bag and no bagging fruits (5.58 % Brix and 5.96 % Brix, respectively) over the rest of treatments. At the ripening stage, the fruits of brown paper bag showed the highest soluble solids content (16.92% Brix) while lowest total soluble solids were recorded in no bagging (14.61% Brix) (Table 2).

Table 1. Effects of pre-harvest bagging on physical parameters of mango cv. Gopalbhog

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	145.67±0.88a	8.16±0.29 a	6.87±0.45 a	125.27±0.82 a	22.59±0.30 a	5.54±0.06 a
White paper bag	143.97±1.49 a	8.00±0.11 a	6.24±0.12 a	119.25±0.81 b	24.37±1.22 a	4.91±0.24 b
No bagging	141.34±0.88 b	7.67±0.12 a	6.07±0.11b	115.92±0.58 c	19.08±0.58 b	6.08±0.15 a
CV%	0.83	9.79	16.45	0.75	6.09	26.84
LSD	2.34	1.51	2.36	1.74	2.62	2.90

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

During ripening stage, maximum citric acid content was recorded in the treatment of no bagging (1.71%) while the minimum content of citric acid was recorded in white paper bag fruit (1.11%) (Table 2). The highest reducing sugars at harvest stage were recorded in no bagging (1.42%) while the lowest was recorded in brown paper bag fruits (0.54%). During ripening stage, the reducing sugars content statistically non-significant (Table 2). At harvest stage, the maximum total sugar was recorded in the fruits of no bagging (1.86%) while the minimum total sugar was recorded in the brown paper bag fruits (0.72 %). During ripening stage, the fruits of white paper bag exhibited maximum total sugar (3.50%) while the minimum total sugar was recorded in no bagging fruits (2.58%) (Table 2). The significantly highest β-carotene content at harvest stage was white paper bag (350.39 µg) and the lowest β-carotene content was obtained in control (240.08 µg). During ripening stage, the maximum β-carotene content was recorded in the treatment of brown paper bag (1251.00 µg) over control (1076.15) (Table 2). The bagged fruits recorded the highest content of vitamin C, sucrose, glucose and fructose over control in Zillmango (Hongxia *et al.* 2009). The bagging of date palm fruits improved the total sugars (Harhash and Al-Obeed 2010). Bagging enhanced carotenoid content in mango (Zhao *et al.* 2013). The bagging led to lower contents of chemical components such as sugar, phenols and organic acids in most of the peach varieties (Lima *et al.* 2013). Fruit firmness was slightly increased by bagging treatments, whereas soluble solids content was decreased in apple (Feng *et al.* 2014).

Table 2. Effects of pre-harvest bagging on chemical composition of mango cv. Gopalbhog at harvest and ripening stage

Treatments	Ascorbic acid (mg/100 g)		TSS (^{0}Brix)		Citric acid (%)	
	At harvest	At ripe	At harvest	At ripe	At harvest	At ripe
Brown paper bag	23.95±0.02 c	15.45±0.16 a	4.71±0.18b	16.92±0.02 a	2.95±0.11a	1.40±0.01b
White paper bag	31.57±0.29 a	14.57±0.18 b	5.58±0.15 a	15.59±0.06 b	2.66±0.12 a	1.11±0.04 c
No bagging	25.67±0.09 b	12.83±0.01 c	5.96±0.12 a	14.61±0.14 c	2.68±0.02 a	1.71±0.07 a
CV%	4.39	7.95	20.03	6.70	27.38	42.87
LSD	2.09	2.12	2.10	2.45	2.24	1.14

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

Continued table 2.

Treatments	Reducing sugars (%)		Total sugars (%)		β-carotene (µg/100 g)	
	At harvest	At ripe	At harvest	At ripe	At harvest	At ripe
Brown paper bag	0.54±0.04 b	1.05±0.07 a	0.72±0.05 c	3.41±0.01a	240.39±0.00 b	1078.13±62.14 b
White paper bag	0.75±0.01 b	0.96±0.01 a	0.95±0.01 b	3.50±0.02 a	350.39±0.01 a	1251.00±12.23 a
No bagging	1.42±0.11 a	1.05±0.06 a	1.86±0.06 a	2.58±0.07 b	240.08±0.01c	1076.15±107.63 b
CV%	64.76	47.47	80.85	38.45	0.84	0.21
LSD	0.99	0.99	2.03	2.04	3.99	4.61

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

Effect of pre-harvest fruit bagging on Shelf life, mealy bug incidence and spongy tissue of mango

The non-bagged control fruits of Gopalbhog had a shelf life of 12 days (Table 3). The fruits of brown paper bag and white paper bag (17 days) had greater shelf life than control (12 days). Brown paper and white paper bags were totally free from mealy bugs as well as spongy tissue (Table 3. The maximum incidence of mealy bugs (25 %) and spongy tissue content (7.00 %) was recorded in control.

This may be mealy bug could not enter inside the bags as it was tightly tied by GI wire 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). So, fruit bagging was one of the necessary techniques for producing high quality fruits, which had been universally adopted in some fruit production (Zhai *et al.* 2006).

Table 3. Effect of pre-harvest fruit bagging on shelf life, mealy bug incidence and spongy tissue of mango cv. Gopalbhog

Treatments	Shelf life (days)	Mealy bugs (%)	Spongy tissue (%)
Brown paper bag	17.00±0.00 a	0.00±0.00 b	0.00±0.00 b
White paper bag	17.33±0.33 a	0.00±0.00 b	0.00±0.00 b
No bagging	12.66±0.66 b	7.00±0.57 a	6.9±0.58 c
CV%	6.74	25.24	42.07
LSD	2.10	1.60	1.60

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

CONCLUSION

This study shows that pre-harvest fruit bagging is straight forward, cost-effective, and eco-friendly for mango (cv. Gopalbhog). Brown paper bags are best for yellow-colored fruits, whereas white paper bags keep each variety's color. Both bags were effective against major insect-pests and diseases. Exportable mangoes must have high shelf life. However, bagging mangoes with appealing colors would increase market prices. EU, France, Germany, Italy, and other nations want bagged mangoes for their lovely color and nutritional benefits. Thus, commercial mango producers may employ this method.

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