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# Pre-harvest Fruit Bagging Enhanced Quality and Shelf-life of Mango (*Mangifera indica* L.) cv. Amrapali

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors MMA and MTI designed the study and wrote the protocol. Author MMA performed the statistical analysis and wrote the first draft of the manuscript. Author MAB managed the chemical analysis of the study. Authors NA and MFA managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

A study was performed during 2016 from January to July for safe mango production by applying the minimum use of pesticides. The mango fruits were bagged at marble stage (45 days after fruit set) with various treatments *viz*: $T_0$: No bagging (control), $T_1$: Brown paper double-layered bag (BPB); $T_2$: White paper single-layered bag (WPB); $T_3$: Perforated polythene bag (PB) and $T_4$: White cloth bag (WCB). In physical parameters, brown and white paper bag recorded the maximum fruit weight (169.10 g and 147.6 g), fruit length (8.57 and 8.33 cm), fruit diameter (5.63 and 5.87 cm) and pulp weight (124.47 g and 105.60 g) respectively, while minimum result was found in the other treatments and control. Meanwhile, in bagging fruits, chemical parameters of total soluble solids,

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ascorbic acid, percent of citric acid, reducing sugars and β- carotene were increased over control. Brown paper bag changed fruit color. The sensory qualities in fruits of brown and white paper bags were improved over control. Fruit retention was significantly improved by pre-harvest fruit bagging with a brown paper bag (95.90%), white paper bag (95.50%), and control (90.00%) over polythene bag (80.00%). Fruits with brown paper bags showed shelf life up to 18 days with good physical quality and the lowest weight loss against 15 days of control fruits. The sensory attributes were better in fruits of brown, white paper and white cloth bags over control. Bagging at marble stage also reduced the occurrence of spongy tissue and the incidence of mealy bugs. These results indicate that fruit bagging can improve the quality and the shelf life of mango cv. Amrapali through the reduction of disease and insect-pest attack.

*Keywords: Mango; fruit bagging; physico-chemical composition; sensory evaluation.*

## 1. INTRODUCTION

Mango (*Mangifera indica* L.) is a popular tropical fruit, especially in Asia. In Bangladesh, it is one of the most important choice fruit for all age people. Currently, there are about 41.678 hectares of land under mango orchard and produce about 1288315 tons [1]. The area under mango fruit is increasing day by day but safe and quality mango production not increased accordingly. Mango fruits trees are subject to several diseases. The target mango yield is reduced every year due to outbreak of different mango diseases and insect-pest attack. To control these diseases, farmers are using pesticides 15-62 times in their orchard and it is increasing at an alarming ratio [2]. Because of the favorable environment during fruit maturity, the mango fruit fly is a major pest of different varieties of mango. Sarker et al. [3] reported that a considerable quantity of mango fruits may be lost due to the fruit fly infestation every year. An attractive, spotless and pest free fruits of this variety bring a premium rate in the market. In recent years, climatic aberrations such as a sudden increase in temperature and relative humidity, excessive rains especially during fruit development are often experienced. It had affected not only the external appearance of the fruit but also increased the pest such as mealybugs and physiological disorders like spongy tissue which in next added in the losses. The affected fruits gain little prices in the market and such fruits are also rejected by industry for processing. Several good agricultural practices are becoming popular throughout the world for preventing the losses of fruits caused by both biotic and abiotic factors [4]. Among several such alternatives, the pre-harvest fruit bagging technique has been adopted widely in several fruit crops to improve skin color in the same time, to reduce the incidence of diseases, insect pests, mechanical damages, sunburn of the skin, agrochemical residues on the fruits, and bird damages [5,6,7,8,9,10,11,12,13]. Therefore, the present study has been undertaken.

## 2. MATERIALS AND METHODS

The research was conducted at the mango orchard near Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh from March to July, 2016. The experiment was conducted in a Randomized Complete Block Design (RCBD) with five treatments replicated three times with a unit of 50 fruits per treatment per replication. The treatments were $T_0$: No bagging (control), $T_1$: Brown paper double-layered bag (BPB), $T_2$: White paper single-layered bag (WPB), $T_3$: Perforated polythene bag (PB) and $T_4$: White cloth bag (WCB). Uniformly grown fruits (45 days after fruit set) were selected for bagging. The size of the bags was 25×20 cm. Before bagging, two perforations (≤ 4 mm diameter) were made for proper ventilation at the bottom of the polythene bag and white cloth bag unless proper aeration would not occur. White and brown paper bags were not perforated because those types of bags were automatically allowed proper aeration. The particular bags were wrapped properly at the stalk of each fruit so that it would not fall down as well as there would not be open space. The observations viz. fruit retention (%) and days required 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

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 Total soluble solids (TSS)

Total soluble solids content was measured by Erma Hand Refractometer (0 to 32°Brix) and expressed in Brix [14]. 5 g pulp was crushed in mortar and pestle which was transferred to 100 ml beaker and diluted in 1:2 proportions with distilled water.

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

Ascorbic acid was estimated as described by McHenry & Graham [15]. Mango pulp (5 g) was mixed with 5 ml of 20% metaphosphoric acid solution and was filtered through Whatman No. 1. 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 the pink color was developed. Ascorbic Acid (Vitamin C) content was calculated according to the following equation:

$$\text{Vitamin C}\left(\frac{\text{mg}}{100}\text{g}\right) =$$

$$\frac{0.5\times \text{Titrate value unknown soln}\times \text{Made volume of unknown sample}}{\text{Titrate value of known soln}\times \text{Aliquot taken}\times \text{Sample weight}}$$

### 2.2.3 Citric acid (%)

Ten-gram mango pulp was crushed in a mortar and pestle and transferred in a 100 ml volumetric flask. The volume was made up to 100 ml by adding distilled water. Then the sample was filtered and 10 ml filtrate was taken in a conical flask. The filtrate was titrated against 0.1 N NaOH using phenolphthalein as an indicator. The result was expressed in percent of citric acid [16].

$$\%\ \text{Citric acid} =$$

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

### 2.2.4 Reducing sugars

It was determined according to the method described by Haq [17] & Santini et al. [18] with slight modification. Twenty gram of the mango pulp was crushed in a mortar and pestle then transferred in a 200 ml volumetric flask. The volume was adjusted to 150 ml by adding purified water. After a few minutes to allow the sugar dissolution, 10 ml of lead acetate solution and the minimum amount of potassium oxalate solution were added. The volume of the resulting solution was adjusted to 200 ml, and the solution shacked, filtered and transferred in a burette for the titration. 5 ml of Fehling solution A, 5 ml of Fehling solution B and 40 ml of purified water were transferred in a flask. The solution was heated up to the boiling point and the solution was added drop by drop till the nearly complete de-coloration of the Fehling reagent. Two drops of methylene blue were added, and the boiling continued for 3 minutes. The solution from the burette was added till the disappearance of blue coloration of the indicator and the solution turned into a red color. Reducing sugar was calculated using the following equation:

$$\%\ \text{Reducing sugar}$$

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

### 2.2.5 Non-reducing sugars

Non-reducing Sugars was estimated by

% non-reducing sugar

= % total sugar -%reducing sugar

### 2.2.6 Total sugars

An aliquot of 50 ml of the clarified, de-leaded filtrate was pipetted to a 100 ml volumetric flask. 5 ml concentration HCL and allowed to stand at room temperature 24 hours. It was neutralized with concentrated NaOH solution followed by 0.1 N NaOH solutions. The volume was made up to the mark and transferred to a 50 ml burette having an offset tip and performed the titration on Fehling's solution similar to the procedure described in the determination of reducing sugar [19].

$$\%\ \text{Total sugar}$$

$$= \frac{\text{Fehling factor}\ \times\ \text{Dilution}\ \times 100}{\text{Weight of sample}\ \times\ \text{Titre}}$$

### 2.2.7 β-carotene (µg/100 g of pulp)

β-carotene in mango pulp was determined according to the method of Nagata & Yamashita, [20]. One gram of pulp was mixed with 10 ml of acetone: hexane mixture (4:6) and vortexed 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 /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 percent maturity. After harvest twenty fruits of each treatment were taken into the laboratory and ripened at ambient temperature by using plastic crates with perforation and traditional paddy straw as ripening material. At the bottom, a 2.5 cm layer of rice straw was made on which fruits were arranged. Simultaneously, two more layers were kept on the first layer. The shelf life was calculated when 50% of fruits were spoiled.

## 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, appearance 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 [21].

## 2.5 Statistical Analysis

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

## 3. RESULTS AND DISCUSSION

The practice of fruit bagging at marble stage has been widely used in several fruit crops, such as mango [22,23,7,24,8,9,10], apple [25], pear [26,27], peach [28], longan [29], to promote the commercial value of the fruit, improving fruit color [30], decreasing mechanical damage [31] and sunburn [32] of the skin. Pre-harvest bagging also reduces the use of pesticide in the fruit [31] and improves insect [3], disease [25] and bird damage control [31]. Therefore, fruit bagging at marble stage had been necessary technical measure to enhance the commercial value and promoting the export of the fruits [33].

Fruit retention was significantly increased by pre-harvest bagging with a brown paper bag (95.90%), white paper bag (95.50%) and white cloth bag (94.70%) over control (90.00%) while polythene bag showed the lowest fruit retention (80.00%). This happening due to the fact of polythene paper bag warmed rapidly in the day time and inside temperature was higher compared to other bags. High temperature also promotes the development of the abscission layer. The harvesting time was significantly increased in brown paper bag, white paper bag, white cloth bag and in control, whereas in polythene bag, it was significantly reduced (52.00 days). The brown paper bag took maximum days (58.00 days) for harvest after bagging because; microclimate helps in fruit growth and development in brown paper bag. The ripening process occurs delay by brown paper bag but in polythene bag, inside temperature increases rapidly and high temperature enhances the ripening process (Table 1).

Pre-harvest fruit bagging with brown paper bag improved physical parameters viz: Fruit weight, length, diameter, pulp weight, stone weight and pulp to stone ratio over control fruits and the variation was statistically significant (Table 2). The smallest fruits were found in polythene bag having fruit weight (100.93 g), pulp weight (67.37 g) and pulp to stone ratio (3.64) over control (135.40 g, 98.50 g and 4.97, respectively). The brown paper bag showed the highest fruit weight (169.10 g), length (8.57 cm), pulp weight (124.47 g), stone weight (22.22 g) and pulp to stone ratio (5.72) while, white paper shows the highest fruit diameter (5.87 cm) because of, favorable microclimate exist inside the brown paper bag and the days required for harvesting were more in brown paper bag than controlled fruits which might have helped to record the highest fruit weight, fruit size, length, weight, pulp weight compare to other bags. Previous studies on the effects of fruit bagging on fruit size and weight showed that it might be due to differences in the type of bag used, fruit and cultivar responses [4]. Bagging fruit with two-layer paper bags, newspaper or golden paper bags increased fruit weight in 'Nam Dok Mai 4' mango [34]. Bagging promotes fruit growth and development, resulting in more weight and larger-sized fruit over control [35]. 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 [29].

The pre-harvest fruit bagging at the harvesting stage, had a significant effect on ascorbic acid (mg), reducing sugars (%), total sugars (%) and β-carotene (µg) content of fruits (Table 3). The highest citric acid content (1.23%) and TSS (5.27°Brix) were recorded in controlled fruits which significantly superior over all bagging treatments because, controlled fruits exposed to direct sunlight and sugar conversion process was rapidly occured compare to bagged fruits therefore, TSS is high. The white paper bag fruits had significantly highest non-reducing sugar (13.57%) and total sugars (15.07%) over control (12.47%, 13.90%) on the other hand, brown paper bag fruit showed the highest ascorbic acid (74.37 mg/100 g), β- carotene content (534.40 µg/100 g) and reducing sugars (1.57%) (Table 3). This result suggested that the fruits with brown paper bag are not directly exposed to the sunlight which ensures higher xanthophylls content therefore, stored more ascorbic acid and β-carotene compared to control.

The fruits bagging in Zill mango recorded the highest content of vitamin C, sucrose, glucose and fructose over control [36]. Fruits bagging in date palm improved the total sugars [37]. Bagging promotes carotenoid content in mango [38]. The bagging led to lower contents of chemical components (such as sugar, phenols and organic acids) in most of the peach varieties [39]. Bagging treatments were increased the fruit firmness slightly but soluble solids content was decreased in apple [40].

At the ripening stage, brown paper bagged fruits showed the highest TSS (17.53ºBrix), citric acid content (1.07%), reducing sugars (5.93%), total sugars (25.13%) and β-carotene (7507.87 µg/100 g) (Table 3). At the ripe stage, the oxidative degradation was higher and the favorable condition for fruit growth and development was exist inside the brown paper bag compare to others especially the β-carotene content was significantly raised with the advancement of the storage period, likely due to the breakdown of chlorophyll and increase in carotenoids content by chlorophyllase enzyme during the storage period. The highest content of ascorbic acid (34.30 mg/100 g) was found in control fruit due to, it has a lower shelf life, we know with increasing storage time, ascorbic acid gradually reduces.

Sensory evaluation concerning color, there was a significant difference among various treatments while flavor and texture were non-significant. Besides, control fruits showed the lowest appearance and overall expression value. It indicated that the organoleptic qualities of fruits were affected by pre-harvest fruit bagging in mango (Table 4).

The fruits harvested from the polythene bag had the lowest shelf life of 14.00 days (Table 5). The fruits of brown paper bag (18.00 days), white paper bag (17.00 days) and white cloth bag (16.00 days) had a higher shelf life than control (15.00 days). Brown paper bags showed the maximum shelf life because, this bagged fruits is 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. Polythene and white cloth bag treatments showed less spongy tissue compared to control whereas the fruits with brown paper and white paper bags were free from mealybugs as well as spongy tissue (Table 5). This may be due to 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

**Table 1. Pre-harvest fruit bagging on fruit retention and days required for harvesting after bagging in mango cv. Amrapali**

| Treatments | Fruit retention (%) | Days required for harvesting after bagging |
|---|---|---|
| $T_1$ | 95.90±0.02a | 58.00±0.08a |
| $T_2$ | 95.50±0.03b | 57.00±0.08ab |
| $T_3$ | 80.00±0.02e | 52.00±0.08d |
| $T_4$ | 94.70±0.03c | 56.00±0.08b |
| $T_0$ | 90.00±0.03d | 54.00±0.08c |
| CV (%) | 6.80 | 4.30 |
| LSD | 0.01 | 0.84 |

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

**Table 2. Pre-harvest fruit bagging on physical attributes of mango cv. Amrapali**

| Treatments | Fruit weight (g) | Fruit length (cm) | Fruit diameter (cm) | Pulp weight (g) | Stone weight (g) | Pulp: Stone |
|---|---|---|---|---|---|---|
| $T_1$ | 169.10± 2.13 a | 8.57 ± 0.03 a | 5.63 ± 0.06 b | 124.47 ± 2.93 a | 22.22 ± 0.79 a | 5.72 ± 0.21 a |
| $T_2$ | 147.60 ± 1.22 b | 8.33 ± 0.03 b | 5.87 ± 0.06 a | 105.60 ± 1.22 b | 21.76 ± 0.96 ab | 5.13 ± 0.24b |
| $T_3$ | 100.93 ± 2.13 e | 7.57 ± 0.03 d | 4.70 ± 0.00 d | 67.37 ± 2.15 d | 19.23 ± 0.62 ab | 3.64 ± 0.22 d |
| $T_4$ | 123.43 ± 6.10 d | 7.77 ± 0.03 c | 5.53 ± 0.06 c | 103.50 ± 1.89 bc | 20.83 ± 1.69 ab | 4.75 ± 0.20 c |
| $T_0$ | 135.40 ± 1.51 c | 7.13 ± 0.03 e | 5.57 ± 0.06 bc | 98.50 ± 0.87 c | 18.5 ± 0.76 b | 4.97 ± 0.53b |
| CV (%) | 4.07 | 0.40 | 0.97 | 3.39 | 8.99 | 11.97 |
| LSD | 10.36 | 0.06 | 0.06 | 6.37 | 3.45 | 1.04 |

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

**Table 3. Pre-harvest fruit bagging on chemical composition of mango cv. Amrapali at harvesting and ripening stage**

| Treatments | TSS ($^0$Brix) | | Ascorbic acid (mg/100 gm) | | Citric acid (%) | | β-carotene (µg/100 g) | |
|---|---|---|---|---|---|---|---|---|
| | At harvest | At ripe | At harvest | At ripe | At harvest | At ripe | At harvest | At ripe |
| $T_1$ | 4.97±0.03ab | 17.53±0.03a | 74.37± 0.03a | 24.20±0.29d | 1.13 ± 0.03b | 1.07±0.07a | 534.40 ± 0.29a | 7507.87±3.73a |
| $T_2$ | 4.87 ± 0.03b | 16.60±0.06c | 69.23±0.03b | 34.10±0.29ab | 0.93 ± 0.03c | 0.97±0.07a | 524.80 ± 0.23b | 4784.40±1.81b |
| $T_3$ | 4.63 ± 0.18b | 16.50±0.06c | 63.10 ± 0.06d | 29.50±0.29c | 1.10 ± 0.00b | 0.80±0.00b | 428.30 ± 0.35e | 2222.03±3.27d |
| $T_4$ | 4.83 ± 0.03b | 14.00±0.06d | 64.10 ± 0.06c | 33.20±0.29b | 1.07 ± 0.06b | 1.00±0.06a | 508.00 ± 0.46c | 1982.23±3.37e |
| $T_0$ | 5.27 ± 0.12a | 17.20±0.06b | 53.93 ± 0.03e | 34.30±0.29a | 1.23 ± 0.03a | 0.90±0.00ab | 488.20 ± 0.11d | 3361.10±5.35c |
| CV (%) | 3.83 | 0.16 | 0.13 | 0 | 3.12 | 8.84 | 0.12 | 0.05 |
| LSD | 0.47 | 0.03 | 0.13 | 0.26 | 0.14 | 0.08 | 0.11 | 0.09 |

**Table 3. Contd.**

| Treatments | Reducing sugar (%) | | Non-reducing sugar (%) | | Total sugar (%) | |
|---|---|---|---|---|---|---|
| | At harvest | At ripe | At harvest | At ripe | At harvest | At ripe |
| $T_1$ | 1.57 ± 0.03a | 5.93±0.03a | 10.33 ± 0.06e | 13.56±0.75c | 11.90 ± 0.11c | 25.13±0.18a |
| $T_2$ | 1.50 ± 0.01a | 2.77±0.20b | 13.57 ± 0.06a | 19.18±0.18a | 15.07 ± 0.07a | 21.73±0.27b |
| $T_3$ | 1.17 ± 0.17b | 1.43±0.03c | 7.60 ± 0.03d | 16.50±1.47b | 8.77 ± 0.03e | 19.10±1.56c |
| $T_4$ | 1.07 ± 0.03b | 2.60±0.25b | 9.36 ± 0.00b | 18.96±0.15a | 10.43 ± 0.07d | 22.10±0.20b |
| $T_0$ | 1.43 ± 0.07ab | 3.00±0.06b | 12.47± 0.06c | 19.11±0.16a | 13.90 ± 0.06b | 15.00±0.71d |
| CV (%) | 11.95 | 9.06 | 0.79 | 6.06 | 0.98 | 5.81 |
| LSD | 0.11 | 0.03 | 0.12 | 0.07 | 0.09 | 0.07 |

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

**Table 4. Pre-harvest fruit bagging on sensory evaluation on mango cv. Amrapali at ripening stage**

| Treatments | Color | Flavor | Texture | Appearance | Sweetness | Overall expression |
|---|---|---|---|---|---|---|
| $T_1$ | 8.33±0.33a | 8.67±0.33a | 7.67±0.33a | 8.67±0.33a | 8.00±0.00ab | 8.67±0.33a |
| $T_2$ | 7.00±0.00b | 7.67±0.33a | 7.67±0.33a | 7.67±0.33ab | 8.67±0.33a | 7.66±0.33a |
| $T_3$ | 7.00±0.00b | 8.67±0.33a | 7.67±0.33a | 7.67±0.33ab | 8.00±0.00ab | 7.33±0.33a |
| $T_4$ | 7.00±0.00b | 8.67±0.33a | 7.67±0.33a | 6.67±0.33b | 8.00±0.00ab | 7.67±0.33a |
| $T_0$ | 7.00±0.00b | 8.67±0.33a | 7.67±0.33a | 5.67±0.33c | 7.33±0.33b | 4.67±0.17b |
| CV (%) | 8.17 | 7.56 | 6.36 | 16.00 | 6.68 | 21.43 |
| LSD | 0.49 | 0.45 | 0.05 | 0.84 | 0.77 | 0.82 |

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

**Table 5. Pre-harvest fruit bagging on shelf life, mealy bug incidence and spongy tissue of mango cv. Amrapali at ripening stage**

| Treatments | Shelf life (Days) | Mealy bugs (%) | Spongy tissue (%) |
|---|---|---|---|
| $T_1$ | 18.00±0.58a | 0.00±0.00 a | 0.00±0.00 d |
| $T_2$ | 17.00±0.58ab | 0.00±0.00 a | 0.00±0.00 d |
| $T_3$ | 14.00±0.58d | 0.00±0.00 a | 4.33±0.33 b |
| $T_4$ | 16.00±0.58bc | 0.00±0.00 a | 3.00±0.58 c |
| $T_0$ | 15.00±0.49cd | 25.00±2.87b | 6.00±0.58 a |
| CV (%) | 10.56 | 44.72 | 9.47 |
| LSD | 0.52 | 0.48 | 0.69 |

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

were not directly exposed with convective heat and sunlight. Similar results were found in Katrodia [41], Om & Prakash [42]. The maximum incidence of mealy bugs (9.33%) and spongy tissue content (6.17%) was recorded in control because control fruits faced the 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 insisted 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 universally accepted in some fruit production [43].

## 4. CONCLUSION

Thus, an investigation revealed that pre-harvest fruit bagging at marble stage (45 days after fruit set) with various types of bag modified fruit retention, the period required for harvesting, physico-chemical properties, the occurrence of spongy tissue, the incidence of mealy bug and shelf life in mango cv. Amrapali. Finally, it can be concluded that the result of this experiment on pre-harvest fruit bagging in mango cv. Amrapali is quite effective in improving physico-chemical properties and maintaining fruit quality. It will also be beneficial for both growers and consumers because it is a simple, cost-effective and eco-friendly technology that has positive effects on mango cv. Amrapali.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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