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Influence of pre-harvest bagging on fruit quality of Mango (*Mangifera indica* L.) cv. Mishribhog

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Abstract

Bagging of mango fruits prior to harvest is the preeminent alternative to avoid adverse effect by causing physical damage and improve the commercial value of the fruit, namely, improving fruit coloration, reducing splitting mechanical damage, sunburn of the skin etc. An investigation was performed during the year 2016 from March to June for safe mango production by applying minimum use of pesticide entitled influence of bagging on physico-chemical properties and shelf life of mango cv. Mishribhog. The mango fruits were bagged at marble stage 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. Fruit retention was significantly enhanced by pre-harvest bagging with brown paper bag (91.00%) and white paper bag (87.00%) over control (81.33%). The harvesting time was significantly deferred (65.67 days) in brown paper bag over control. Pre-harvest bagging also reduced occurrence of spongy tissue and the incidence of mealy bugs. These results specify that fruit bagging can improve fruit quality through diminution in disease and insect-pest infestation and shelf life of mango cv. Mishribhog.

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Introduction

Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae, commonly known as the 'King of fruits' (Singh, 1996), is a popular tropical fruit, especially in Asia. In Bangladesh, it's one of the most important commercial fruits and choice fruit for all age's people. Currently, there are about 25100 hectares of land occupied with mango orchard and produced about 10.18 lac ton (BBS, 2015). The area under mango cultivation is increasing every year but safe and quality mango production not increased. Mango fruits and trees are subject to several animate and inanimate diseases. The outbreak of different mango diseases and insect-pest attack reduce the target mango yield every year. To control these problems farmers are using 15-62 times pesticides in their mango orchard and it's increasing as alarming ratio (Uddin *et al.,* 2015). To prevent the losses caused by biotic and abiotic factors, several good agricultural practices are becoming popular throughout the World (Sharma *et al.,* 2009] 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 (Sharma, 2009). 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, the pre-harvest bagging technique of fruits has been used extensively in several fruit crops to improve 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 (Xu *et al.,* 2010; Nagaharshitha *et al.,* 2014; Sharma *et al.,* 2014; Jakhar and Pathak, 2016).Therefore, this study was undertaken to produce safe and quality mango fruit with minimum spraying of pesticides.

Materials and methods

This research was conducted at the Department of Horticulture, HSTU, Dinajpur, Bangladesh during January to July, 2016. Uniformly grown 10 years old Mishribhog 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.

Physical parameters

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

Chemical composition

Total soluble solid (TSS):Total soluble solids were found out by using Erma Hand Refract meter (0 to 32°Brix) and expressed in °Brix [AOAC, 2004].

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 (Moffet *et al.,* 2007).

$$\%\ \text{Citric acid} = \frac{0.5 \times \text{Titrate value unknown soln} \times \text{Made volume of unknown sample}}{\text{Titrate value of known soln} \times \text{Aliquot taken} \times \text{Wt. of sample}} \text{X } 100$$

Reducing sugars (%): It was determined according to the method described by(Haq and Rab, 2012) and (Santini *et al.,* 2014) with slight modification. Crushing20g 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 pipetted 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 upto the mark and transferred to 50 ml burette having an offset tip and performed the titration on Fehlings solution(AOAC, 2000).

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

Ascorbic acid (mg/100g of Fruit pulp): Ascorbic acid was estimated as described by [McHenry and Graham, 1935]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 color 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] . 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 453nm, 505nm and 663nm.

β-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 (Amerine *et al.,* 1965).

Statistical analysis

The data were analysed 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).

Results and discussion

Fruit retention (%) and harvesting time (days)

Fruit retention was significantly improved by pre-harvest bagging with brown paper bag (91.00%) and white paper bag (87.00%) over control (81.33%).

The fruit retention found in polythene bag (82.33%), muslin cloth bag (81.67%) also higher than control (no bagging) (81.33%) but the difference were non-significant (Table 1).

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

Treatments	Fruit retention (%)	Days required for harvesting after bagging
Brown paper bag	91.00 ±0.58 a[z]	65.67±0.33 a
White paper bag	87.00±0.58 b	64.67±0.33 ab
Polythene bag	82.33±0.88 c	60.67±0.33 c
Muslin cloth bag	81.67±1.20 c	63.33±1.20 b
No bagging (control)	81.33±0.33 c	63.67±0.33 ab

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

The harvesting time was significantly delayed (65.67 days) in brown paper bag over control (63.67 days). The polythene bag took minimum days (60.67 days) for harvest after bagging (Table 1).

Fruit weight (%)

The fruits of brown paper bag produced the biggest fruit having fruit weight (279.40 g) while in control having fruit weight (165.55 g).

The fruit weight found in white paper bag (172.80 g) also higher than control but the differences were non-significant.

However, minimum fruit weight was recorded in the treatment of polythene and muslin cloth bag (146.87 g and 147.17 g, respectively) (Table 2).

These findings are accordance with some previous reports that the effects of pre-harvest bagging increased fruit growth, size, and weight (Yang *et al.,* 2009; Harhash and Al-Obeed, 2010; Zhou *et al.,* 2012 and Sharma *et al.,* 2014).

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

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	279.40±7.10 a[z]	9.15±0.11 a	8.33±0.33 a	203.64±6.05 a	32.93±0.90 a	6.18±0.19 a
White paper bag	172.80±9.10 b	7.66±0.02 b	6.90±0.05 b	120.31±0.86 b	23.50±0.19 b	5.11±0.01 b
Polythene bag	146.87±2.67 c	7.13±0.06 c	6.17±0.17 c	104.00±1.57 c	20.20±0.41 c	5.14±0.04 b
Muslin cloth bag	147.17±0.44 c	7.10±0.26 c	6.70±0.12 bc	104.67±1.45 c	20.50±0.29 c	5.11±0.12 b
No bagging	165.55±3.41 b	7.40±0.11 b	6.86±0.11 b	117.13±1.92 b	23.59±1.02 b	4.98±0.14 b

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

Bagging '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 weight, size over control fruits(Chonhenchob *et al.,* 2011). Bagging promoted longan fruit development, resulting in larger-sized fruit (Yang *et al.,* 2009). Microenvironment created by different bagging materials might have congenial effect on fruit growth of mango.

Fruit length (cm)

The treatment of brown paper bag (9.15 cm) was gave the maximum fruit length than control (7.57 cm). The fruit length found in white paper bag (7.66 cm) also higher than control but the differences were non-significant. However, minimum fruit length was recorded in the treatment of polythene and muslin cloth bag (7.13 cm and 7.10 cm, respectively) (Table 2).

Fruit diameter (cm)

Pre-harvest fruit bagging with brown paper bag (8.33 cm) gave the maximum fruit diameter over unbagged control (6.86 cm) while polythene bag (6.17 cm) gave the minimum fruit diameter than control (6.86 cm) (Table 2).

Pulp weight (g)

The treatment with brown paper bag (203.64 g) had significantly highest pulp weight over unbagged control (117.13 g) while the polythene bag gave the minimum (104.00 g). The pulp weight was found in the treatment of muslin cloth bag (104.67 g) which is minimum than unbagged control (Table 2).

Stone weight (g)

The maximum stone weight (32.93 g) was recorded in the treatment of brown paper bag over control (23.59 g).The treatments white paper bag (23.50 g), polythene bag (20.20 g) and muslin cloth bag (20.50)were at par with control (23.59 g). The minimum stone weight (20.20 g) was recorded in the treatment of polythene bag (Table 2).

Pulp stone ratio

The treatment of brown paper bag (6.18) gave the maximum pulp stone ratio than control (4.98).There was non-significant difference among the rested treatments. Pre-harvest bagging with different bags recorded superior pulp to stone ratio over unbagged control fruits (Haldankar *et al.,* 2015).

Ascorbic acid (mg/100 g)

The highest ascorbic acid content was recorded in the treatment of white paper bag (33.79 mg/100 g) which was found statistically at par with brown paper bag whilethelowest was recorded in the control (28.10 mg/100 g) (Table 3).

Table 3. Effects of pre-harvest bagging on chemical composition of mango cv. Mishribhog at harvest.

Treatments	Ascorbic acid (mg/100 g)	TSS (°Brix)	Citric acid (%)	Reducing sugars (%)	Total sugars (%)	β-carotene (µg/100 g)
Brown paper bag	32.78±0.05 b[z]	4.92±0.01 b	6.85±0.01 d	0.97±0.01 ab	1.79±0.05 a	158.88±0.02 a
White paper bag	33.79±0.05 a	5.56±0.02 a	7.38±0.03 c	0.99±0.01 a	1.58±0.02 b	114.60±0.01 c
Polythene bag	27.00±0.28 d	4.76±0.14 b	8.13±0.13 b	0.91±0.00 c	1.50±0.00 bc	113.40±0.30 e
Muslin cloth bag	28.10±0.20 c	4.53±0.29 b	7.50±0.11 c	0.94±0.00 bc	1.60±0.05 b	114.10±0.05 d
No bagging	28.22±0.05 c	5.73±0.04 a	10.67±0.09 a	0.94±0.00 bc	1.41±0.01 c	125.28±0.02 b

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

The bagged fruits recorded highest content of vitamin C, sucrose, glucose and fructose over control in Zill mango (Hongxia *et al.,* 2009). The above results are very close to the findings of (Haldankar *et al.,* 2015 and Sharma *et al.,* 2013) in mango.

Total soluble solid (% Brix)

At harvest stage, the significantly highest soluble solids content was recorded in white paper bag and control fruits (5.73% Brix and 5.56% Brix, respectively) over the rest of treatments (Table 3). At ripe stage, the fruits of brown paper and white paper bag showed the highest soluble solids content (19.89% Brix and 19.85% Brix, respectively) while lowest total soluble solids was recorded in control (13.88% Brix) (Table 4). The findings revealed that percent total soluble solids increased sharply from harvest to ripe fruits have got support of (Joshi and Roy, 1988) who mentioned that TSS increase initially and declined later on. Similar finding was recorded in some previous studies (Awad, 2007; Moustafa, 2007; Singh *et al.,* 2007; Haldankar *et al.,* 2015).

Citric acid (%)

The significantly maximum citric acid content at harvest stage was recorded in the non-bagged control fruits treatment (10.67 %) while the minimum was recorded in the treatment of brown paper bags (6.85 %) (Table 3). During ripe stage, maximum citric acid content was recorded in the treatment of muslin cloth bag while the minimum content of citric acid was recorded in control fruit (0.91 %) (Table 4).

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

Treatments	Ascorbic acid (mg/100 g)	TSS (ºBrix)	Citric acid (%)	Reducing sugars (%)	Total sugars (%)	β-carotene (µg/100 g)
Brown paper bag	11.61±0.20 c[z]	19.89±0.08 a	0.92±0.01b	1.31±0.08 a	4.54±0.14 a	1174.23±11.59 a
White paper bag	14.13±0.02 a	19.85±0.04 a	0.89±0.00 b	1.20±0.01 ab	4.44±0.04 a	1173.93±12.00 a
Polythene bag	10.67±0.40 d	15.10±0.26 b	1.13±0.08 a	1.17±0.06 ab	4.00±0.11 b	1070.13±5.88 c
Muslin cloth bag	10.80±0.41 cd	15.10±0.05 b	1.23±0.03 a	1.10±0.05 b	3.86±0.08 b	1129.33±9.90 b
No bagging	12.85±0.05 b	13.88±0.04 c	0.91±0.01b	1.30±0.02 a	4.37±0.00 a	1170.79±9.03 a

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

The findings revealed that percent of citric acid decreased sharply from harvest to ripe fruits have got support by (Hiratsuka *et al.,* 2012). They reported that organic acid content was reduced in Mandarin due to pre-harvest bagging.

Reducing sugars (%)

The highest reducing sugars at harvest stage were recorded in white paper bag (0.99%) over control fruits (0.94%) while the lowest was recorded in polythene bags (0.91%) (Table 3).

During ripe stage, the highest reducing sugars were recorded in brown paper bag (1.31%) while the lowest was recorded in muslin cloth bags (1.10%) (Table 4). Similar findings were found in some previous research (Zhou and Guo, 2005 and Haldankar *et al.,* 2015).

Table 5. Effect of pre-harvest bagging on shelf life, content of spongy tissue and mealy bug incidence of mango cv. Mishribhog.

Treatments	Shelf life (days)	Mealy bugs (%)	Spongy tissue (%)
Brown paper bag	17.33±0.33 a[z]	0.00±0.00 d	0.00±0.00 d
White paper bag	17.00±0.58 ab	0.00±0.00 d	0.00±0.00 d
Polythene bag	15.33±0.33 c	5.67±0.33 c	0.67±00 c
Muslin cloth bag	15.66±0.33 bc	7.33±0.33 b	2.39±0.96 b
No bagging	15.00±0.58 c	10.00±0.58 a	9.00±00 a

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

They reported that fruits of newspaper bag exhibited the maximum reducing sugars at ripe stage in mango and soluble sugar was increased in grape due to pre-harvest bagging treatments.

Total sugars (%)

At harvest stage, the significantly maximum total sugar was recorded in the fruits of brown paper bag (1.79%) over other bagging treatments and control while the minimum total sugar was recorded in the control fruits (1.41%) (Table 3). During ripe stage, the fruits of brown paper bag exhibited maximum total sugar (4.54 %) while the minimum total sugar was recorded in the muslin cloth bag fruits (3.86%) (Table 4) This result was confirmed with (Haldankar *et al.,* 2015). They reported that brown paper bag with polythene coating (7.48%) recorded the maximum total sugars in mango which was significant.

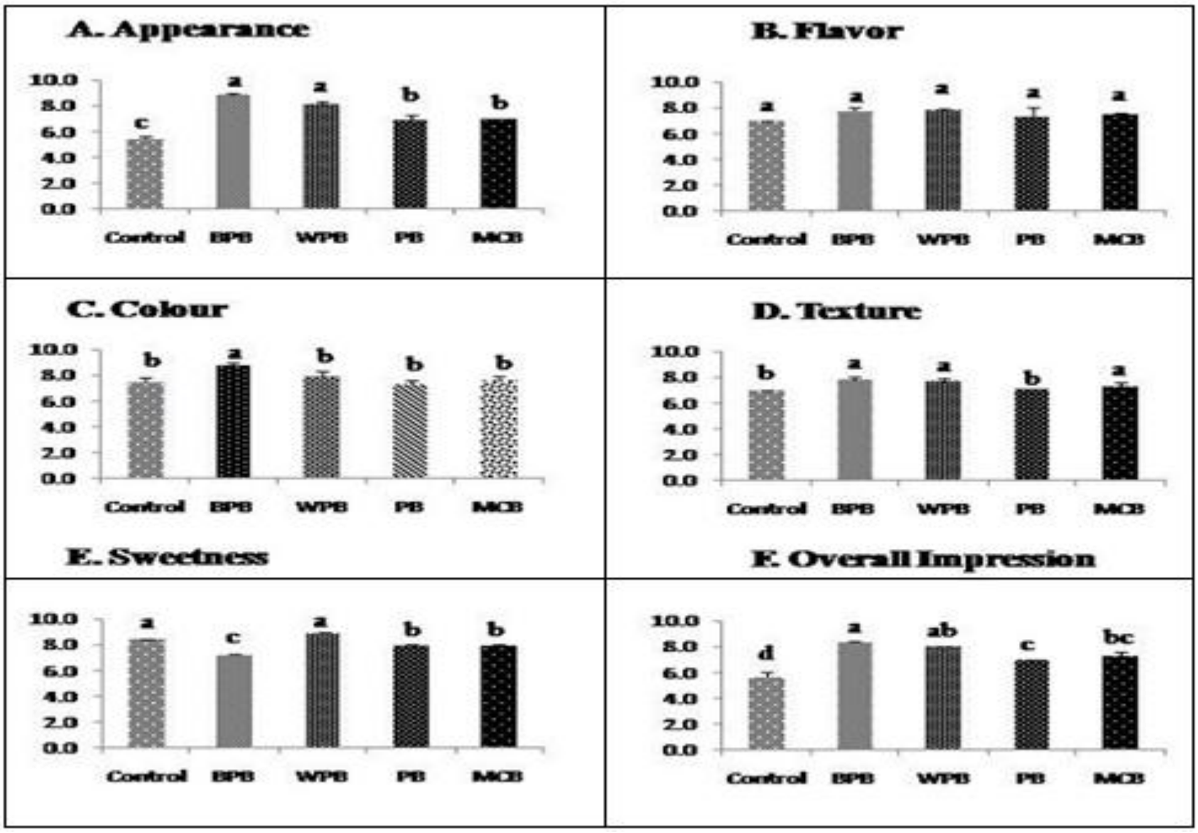

Fig. 1. Appearance (A), flavor (B), Colour (C), texture (D), Sweetness (E), and overall impression (F) of mango cv. Misirivog samples evaluated by 50 native customer in the in the Dinajpur district, Bangladesh. Each sensory aspects of mango was rated a 9-point hedonic scale ranging from 1 ("dislike extremely" to 9 "like extremely"). Mean ratings with different letters within each sensory aspect represent a significant difference between the samples at a standard error of the means. BPB: brown paper bag; WPB: white paper bag; PB: polythene bag; MCB: Muslin cloth bag and control.

β-carotene (μg/100 g)

The significantly highest β-carotene content at harvest and ripe stage was recorded in the treatment of brown paper bag (158.88 μg and 1174.23μg, respectively) over control while the lowest was recorded in the polythene bagged fruits (428.30 μg and 1070.13 μg, respectively) (Table 3 and 4). 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 (Wang *et al.,* 2006; Zhao *et al.,* 2013; Haldankar *et al.,* 2015).

The fruits of brown paper bag and white paper bag were free from mealy bugs as well as free from spongy tissue. The maximum incidence of mealy bugs (10 %) and spongy tissue content (9.00%) was recorded in control (Table 5). Bagging modified the microenvironment near fruit especially in respect to temperature and humidity. The longer shelf life of bagged fruits indicated that the effect of bagging persisted after ripening. Bagging provided physical barrier between fruit and pests. The spongy tissue disorder is associated with convective heat and exposure of fruit to sunlight (Om and Prakash, 2004).

Bagging provides protection against both which helped in reducing occurrence of spongy tissue in fruits. In mango cv. Keitt white paper bags at approximately 100 days before harvest reduced anthracnose and stem end rot (Hofman *et al.,* 1997).

Sensory evaluation with respect to colour, 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 (Fig. 1).

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 each 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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