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Effects of preharvest fruit bagging on postharvest quality and shelf life of mango cv. Amrapali

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ABSTRACT

Fruit fly and other organisms attack during growth and development of mango fruits which causes severe postharvest losses. Therefore, it is necessarily important to explore some technologies to protect fruits and reduce postharvest losses. This experiment was conducted in order to study the effects of preharvest fruit bagging on the postharvest quality and shelf life of mango cv. Amrapali. Five bagging materials *viz.*, i) non-bag, control, ii) brown paper, iii) white paper, iv) white polythene and v) black polythene bag were used in this study. The single factor experiment was laid out in randomized complete block design with three replicates. Significant variations were noticed among the preharvest bagging materials in relation to physio-chemical quality attributes and shelf life of mango cv. Amrapali. The attributes such as weight and size of fruits, skin color, moisture, dry matter, vitamin C, sugar (reducing, non-reducing and total), total soluble solids (TSS) contents and shelf life were significantly influenced by the bagging materials. A significant difference was observed in the shelf life of bagged and non-bagged fruits. The longest shelf life (15 days) was found in brown paper bagged whereas the shortest shelf life (8 days) was in non-bagged control fruits. Considering the findings it was observed that brown and white paper bagged fruits appeared to be the superior in respect of skin color, moisture, dry matter, vitamin C, TSS, titratable acidity and extending shelf life in mango cv. Amrapali.

Introduction

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae is considered as the king of fruit of the tropics and sub-tropics and one of the most common, widely cultivated fruit of Bangladesh. The mango is native to south Asia, from where it has been distributed to worldwide to become one of the most cultivated fruit in tropics. During the period of 2017-2018, it occupied 0.44 million hectares of land and total production was 1.17 million tons and ranks first in terms of total area and production among the fruit crops in Bangladesh (BBS, 2018). But the yield is very low compared to India, Pakistan and other countries of the world (Hossain and Ahmed, 1994).

Mango is grown in almost all districts of Bangladesh, but it is commercially cultivated in the greater districts of Chapainawabganj, Rajshahi, Dinajpur, Natore, Rangpur, Kushtia, Jessore and Satkhira. The world mango fruit market is very competitive, with quality and price being the determinants. Producers should aim at producing high quality mango fruits and reducing postharvest damages to survive in the competition. Preharvest cultural practices and environmental conditions during fruit development profoundly influence postharvest performance and final quality (Lechaudel and Joas, 2007). Mango fruit skin, flesh and stone have specific compositions that appear to accumulate water and dry matter at different rates, depending on environmental conditions (Lechaudel and Joas, 2007). Mango fruit is harvested at early or late mature green stage depending on the distance of the market (Esguerra and Lizada, 1990).

After harvest, mango fruit ripens by undergoing many physicochemical changes that determine the quality of the fruit. Appearance and eating quality are the major attributes of mango that determine consumer acceptance (Mtebe *et al.*, 2006). Fruit appearance is influenced by absence/presence of physical, pathological and physiological disorders. These disorders are also the main causes for postharvest loss of fruits and vegetables due to their detrimental effect on the physiological and biochemical changes during postharvest handling. The disorders induce rotting and early senescence leading to poor flavor and aroma (Mtebe *et al.*, 2006).

The magnitude of postharvest losses in fresh fruit ranging from 5 to 25% in developed countries and 20 to

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50% in developing countries. For example, Hassan (2010) found 27.4% postharvest loss of mango in Bangladesh. The postharvest loss in terms of quality and quantity of fruits occur in all stages of the postharvest system from harvesting to consumption. Mango showed highly prominent postharvest loss because of its high perishability and climacteric pattern of respiration. Postharvest loss of mango fruits varied from 0 to 16.3% with an average loss of 12.5% from variety to variety (Quroshi and Meah, 1991). It also depends on transport distance from production site to retail location.

Mango is known to be the suitable host for fruit fly. It adversely affects mango fruit especially during April-May. Usually premature fruits (at about ten weeks old) are vulnerable to fruit fly infestation (Vayssieres *et al.,* 2010). Moreover, intensity of fruit fly infestation in mango fruit varied based on agro-ecological zones, varieties, physical, biochemical and ecological factors (Nankinga *et al.,* 2014). Besides, some fungal diseases (anthracnose, stem end rot, powdery mildew etc.) and bacterial fruit rot also affects mango (Ploetz, 2003; Sharma *et al.,* 2009; Sarwar, 2015). As a result, the quality and shelf life of mango fruits deteriorates after harvest. Postharvest diseases cause considerable losses of harvested fruits during transportation and storage (Sharma *et al*., 2009). Bagging, a physical protection technique, not only protects fruits from pests and diseases but also affects the quality of the produce by changing microenvironment of fruit during development (Hofman *et al.,* 1997; Amarante *et al.,* 2002; Leite *et al.,* 2014; Sharma *et al.,* 2014; Zhang *et al.,* 2015). The preharvest bagging reduces agrochemical residual effects, prevents sunburn, decreases the mechanical damage and controls insect pest infestation in fruits (Sharma *et al.,* 2014; Ehteshami *et al.,* 2015). However, no noticeable research works have been conducted on the effect of different bagging materials on postharvest quality and shelf life of mango in Bangladesh. Considering the above facts this study has been undertaken to find out the effects of different bagging materials on postharvest quality of mango and to reduce the postharvest spoilage and increase the shelf life of mango.

Materials and Methods

Experimental site

The study was conducted at Bangladesh Agricultural University Germplasm Centre (BAU-GPC), Mymensingh, during February to July 2016. The experimental area was under the sub-tropical climate characterized by heavy rainfall during May-September and scanty rainfall during the rest period of the year.

Experimental design and treatments

The experiment was conducted following randomized complete block design with three replications. Five bagging treatments were applied in this study namely T_0: non-bag, control; T_1: brown paper bag; T_2: white paper bag; T_3: white polythene bag and T_4: black polythene bag. The size of bags was 25cm × 20cm. Before bagging a small perforations (≤ 4 mm diameter) were made at the bottom of all bags for proper ventilation. The particular bag was stapled properly at the stalk of each fruit of respective treatment so that it would not be fall down as well as there would not be open space. The white and black polythene bags were tied with the help of thread. Five uniformly grown fruits (30 days after fruit set) were selected for bagging.

Fruits were harvested at full mature stage and transferred to the postgraduate laboratory of the Department of Horticulture for study different physico-chemical traits during storage. Chemical analyses were carried out in the laboratory of the Department of Biochemistry & Molecular Biology, Bangladesh Agricultural University, Mymensingh.

Methods used for measuring different parameters

Skin color of fruits was measured using color chart. Fresh weight of fruits was measured using digital balance (KERN, PCB 250-3, KERN & Sohn GmbH, Germany) and expressed in gram (g). Fruit length and breadth were measured by slide calipers in centimeter (cm).

Moisture and dry matter content

Fruit samples were taken in porcelain crucible and oven dried at 80°C till the weight become constant. Percent moisture content was calculated according to the following formula:

$$\% \text{ moisture} = \frac{\text{Fresh weight (g) - Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

Dry matter content was calculated according to the following formula:
Dry matter content = 100- %moisture

TSS (%Brix)

TSS content was determined by Hand-Held Refractometer (ATAGO Company Ltd., Japan). A drop of juice was squeezed on the surface of the prism of the refractometer and percent total soluble solids were obtained from direct reading of the instrument. Temperature corrections were made by using the temperature correction chart.

Titratable acidity

Titratable acidity of fruit was determined by titration method described by Ranganna (1986).

Total sugar content

Total sugar content of mango fruit was determined colorimetrically by the anthrone method (Jayaraman, 1981).

Reducing sugar

Reducing sugar content of mango fruit was determined by dinitro salicylic acid (DNS) method (Miller, 1972).

Vitamin C (Ascorbic acid) content

It was determined by titration method. In brief, ten grams of fresh pulp was taken in 100 ml beaker with 50 ml 3% metaphosphoric acid and then it was transferred to a blender and homogenized with same concentration of metaphosphoric acid. After blending, it was filtered and transferred to a 100 ml volumetric flask and was made upto the mark with 3% metaphosphoric acid. Then 5 ml of the aliquot was taken in a conical flask and titrated with 2, 6- dichlorophenol indophenol dye. Phenolphthalein was used as indicator which gave a pink coloured end point and persisted at least 15 seconds. The ascorbic acid content of the sample was calculated by following formula:

Vitamin C content (mg/100g)

$$= \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up (ml)}}{\text{Aliquot volume (ml)} \times \text{Weight of sample (g)}} \times 100$$

Shelf life

Shelf life of mango fruits as influenced by different postharvest treatments was calculated by counting the number of days required to ripen fully with retained optimum marketing and eating qualities.

Statistical analysis

Data on various parameters were statistically analyzed using MSTATC statistical package. The means for all the treatments were calculated and analyses of variances (ANOVA) for all the parameters were performed by F-test. The significance of difference between the pairs of means was compared by least significant difference (LSD) test at the 1% and 5% levels of probability (Gomez and Gomez, 1984).

Results

Skin colour

Apparently significant variations were observed in respect of skin colour among the fruits of bagged and non-bagged before and after storage.

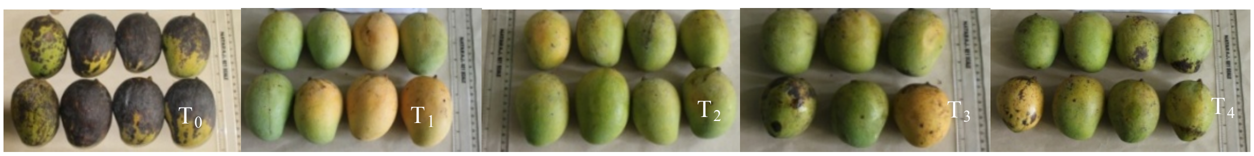

Plate 1. External appearance of fruits after a week of storage in the laboratory

Table 1. Effects of preharvest bagging on changes in skin colour of fruit at harvesting and ripening stage.

Treatment	After harvesting	After ripening
T_0 (Non-bag, Control)	Green	Yellow green
T_1 (Brown paper bag)	Yellow green	Dark orange yellow
T_2 (White paper bag)	Light green	Yellow green
T_3 (White polythene bag)	Green	Light yellow green
T_4 (Black polythene bag)	Green	Brown green

The most attractive colour was found in brown paper bagged fruits and the worst colour was found in non-bagged control fruits at the harvesting and at 12th day of storage (Plate 1 and Table 1).

Fresh weight, length and breadth of fruit

Preharvest fruit bagging had significant influence on fresh weight, length and breadth of fruit. The maximum fruit fresh weight, length and breadth were found in black polythene bag (175.54g, 8.77 cm and 6.63 cm, respectively) followed by white paper bag (162.81g, 8.67 cm and 6.38 cm, respectively), white polythene bag (162.08 g, 8.55 cm, and 6.27 cm, respectively), brown paper bag (160.66 g, 8.40 cm and 6.29 cm, respectively) and the lowest fruit fresh weight, length and breadth were recorded in non- bagged control fruit (149.18g, 8.23 cm and 5.94 cm, respectively) (Table 2).

Moisture content

It was observed that the statistically significant variations were found in moisture content after storage due to different treatments. The highest moisture content of mango fruit was observed in white polythene bag (82.90 %) and the lowest moisture content was recorded in white paper bag (79.37%) (Fig. 1).

Table 2. Effects of preharvest fruit bagging on fresh weight, length and breadth of fruits

Treatments	Fresh weight (g)	Length (cm)	Breadth (cm)
T_0 (Non-bag, Control)	149.18	8.23	5.94
T_1 (Brown paper bag)	160.66	8.40	6.29
T_2 (White paper bag)	162.81	8.67	6.38
T_3 (White polythene bag)	162.08	8.55	6.27
T_4 (Black polythene bag)	175.54	8.77	6.63
Level of significance	**	**	**

** = Significant at 1% level of probability

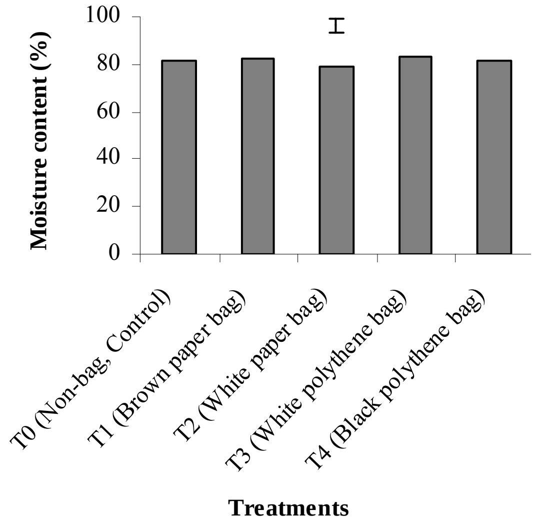

Fig. 1. Effect of preharvest fruit bagging on moisture content of mango. Vertical bar represents the significance at 1% level of probability

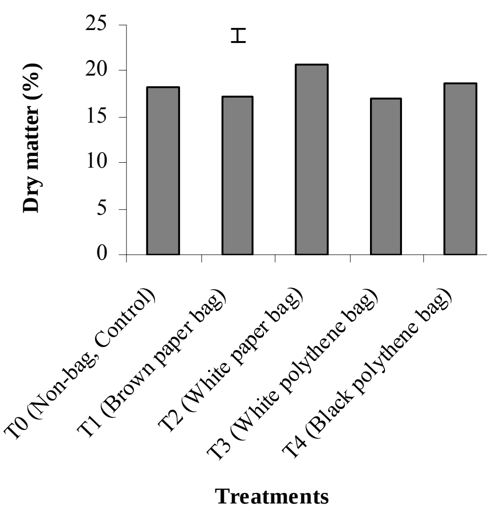

Fig. 2. Effect of preharvest fruit bagging on dry matter content of mango. Vertical bar represents the significance at 1% levels of probability

Dry matter content

Dry matter content of mango varied significantly due to the effect of different preharvest fruit bagging treatments. The highest dry matter content was found in white paper bagged fruit (20.63%) and the lowest dry matter content was in white polythene bagged fruit (17.10%) (Fig. 2).

TSS content

Preharvest fruit bagging treatments also showed significant effect on TSS content of mango. The maximum TSS content (22.87% Brix) was found in non-bagged control fruits while the minimum TSS content (17.97% Brix) was found in white polythene bagged after ripening (Fig. 3).

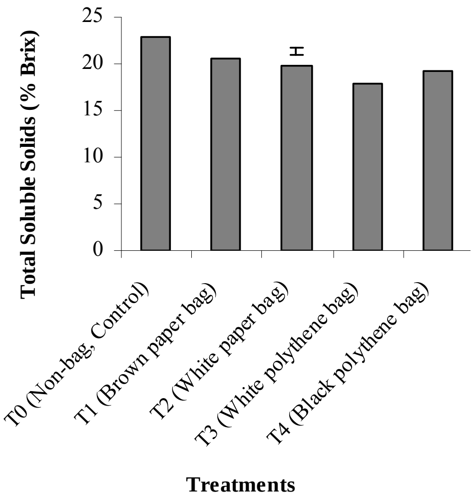

Fig. 3. Effect of preharvest fruit bagging treatments on TSS content of mango at ripening stage. Vertical bar represents the significance at 1% level of probability

Vitamin C content

After ripening vitamin C content of mango pulp was significantly influenced by preharvest bagging treatments of mango. The highest vitamin C content (29.72mg/100g) was found in non-bagged control fruit and the lowest vitamin C content (19.67 mg/100g) was in brown paper bag (Fig. 4). There was a decreasing trend in vitamin C content of fruit pulp in bagged fruit than that of non-bagged control fruit. The white paper bag, black polythene bag and white polythene bag showed 24.49, 23.31 and 22.29mg/100g, respectively (Fig. 4).

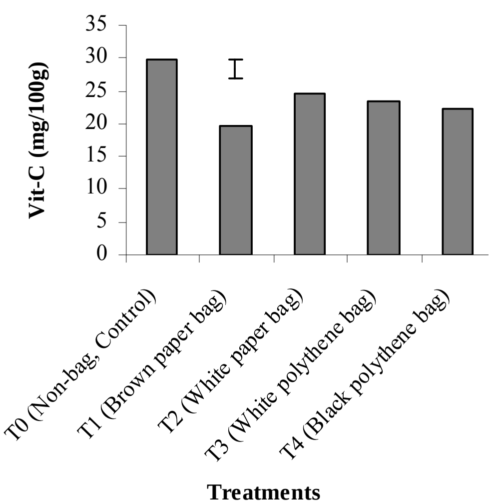

Fig. 4. Effect of preharvest bagging treatments on Vitamin C content of mango pulp at ripening stage Vertical bar represents the significance at 1% level of probability

Reducing sugar content

The preharvest bagging treatments used in this study showed statistically significant effect on reducing sugar content of mango during storage.

The maximum reducing sugar content (10.68%) was recorded in white polythene bagged fruit at the 12th day of storage while the minimum reducing sugar content (8.99%) was found in white paper bagged fruit at the same day of storage (Table 3).

Non-reducing sugar content

It was noticed that non-reducing sugar content increased at storage. The preharvest fruit bagging treatments showed significant variation in non-reducing sugar content during storage period. At 12th day of storage, the highest non-reducing sugar content (11.21%) was observed in non-bagged control fruits while the lowest non-reducing sugar content (10.15%) was found in brown paper bagged fruit (Table 3).

Table 3. Effects of preharvest fruit bagging on total sugar, non-reducing sugar and reducing sugar in mango fruit

Treatments	Total sugar (%)	Non-reducing sugar (%)	Reducing sugar (%)
T_0 (Non-bag, Control)	21.13	11.21	9.92
T_1 (Brown paper bag)	19.32	10.15	9.17
T_2 (White paper bag)	19.31	10.32	8.99
T_3 (White polythene bag)	20.89	10.21	10.68
T_4 (Black polythene bag)	20.24	10.78	9.46
$LSD_{0.01}$	1.15	0.62	0.53
Level of significance	**	**	**

** = Significant at 1% level of probability

Total sugar content

The preharvest fruit bagging treatments showed significant variation in respect of total sugar content during storage. Results showed that the higher amount of total sugar content (21.13%) was present in non-bagged control fruits followed by white polythene bagged fruit (20.89%), black polythene bagged fruits (20.24%), brown paper bagged fruit (19.32%), while the lower amount of total sugar (19.31%) was recorded in white paper bagged fruit (Table 3).

Titratable acidity

The preharvest fruit bagging showed statistically significant difference in terms of titratable acidity content at storage. It was observed that white paper bagged fruit contained the highest amount of titratable acidity (2.58%) and black polythene bagged fruit contained the lowest (1.78%) at storage period (Fig. 5).

Shelf life

The effects of different preharvest fruit bagging treatments were statistically significant in respect of extending shelf life of mango cv. Amrapali. The shelf life of mango fruits ranged from 10 to 15 days. The shortest (8 days) and longest (15 days) shelf life was observed in non-bagged control fruits and brown paper bagged fruits, respectively. The shelf life of mango fruits were extended by 2.40, 3.27, 4.33 and 7.00 days in white polythene bag, black polythene bag, white paper bag and brown paper bag treatments, respectively over non-bag control (Fig. 6).

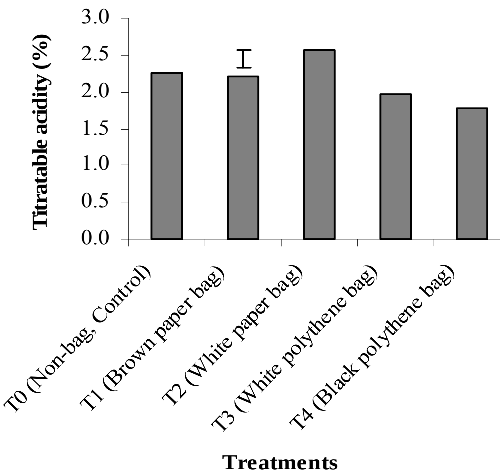

Fig. 5. Effect of preharvest bagging treatments on titratable acidity at ripening stage. Vertical bar represents the significance at 1% level of probability

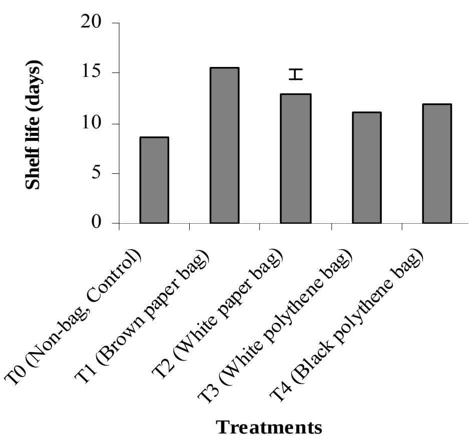

Fig. 6. Effect of preharvest fruit bagging treatments on shelf life of mango. Vertical bar represents the significance at 1% level of probability

Discussion

Fruit skin colour is the key factor of any fruit that attracts consumers. An attractive skin colour improves the physical appearance of fruit, which enhance to get better price in the domestic and export markets. Several studies have indicated that preharvest fruit bagging improve or inhibit fruit skin colour development. The changes in colour of mango skin from green to breaker are the most obvious change which occurs during storage of fruits. Change of skin colour during ripening and senescence of fruits involves chlorophyll degradation or qualitative and quantitative alteration of the green pigment into other pigments. In this study, we observed that brown paper bagged fruits showed the most attractive yellow green and dark orange yellow colour at harvest and after ripen, respectively. It is reported that bagging improves the skin colour of fruit by increasing their anthocyanin content. In litchi, semi-transparent-CP bags resulted in excellent skin colour in fruit (Tyas *et al.*, 1998; Chen and Li, 1999). In earlier studies, fruit bagging had been reported to inhibit colour development in apple. However, it has now been recognized that fruit bagging is an effective way to improve fruit colour in apple (Fallahi *et al.*, 1997).

Preharvest fruit bagging with different bagging materials significantly improved physical traits of fruit *viz*., weight, length, diameter and pulp weight over non-bagged control fruits. The bagged fruits produced the highest fruit weight (175.54 g), length (8.77 cm) and breadth (6.63cm) as compared to non-bagged control fruit. Covering fruit with a bag at a particular developmental stage (30 days after fruit setting) may influence their growth and size. It is reported that fruit size and weight are determined by the type of bag used, fruit and cultivar (Sharma *et al*., 2014). Bagging of ‘Nam Dok Mai’ mango fruit with two-layer paper bags, newspaper, and golden paper bags increased fruit weight (Watanawan *et al.,* 2008). In this study we also noticed that fruit bagging significantly increases fruit weight and size. Chonhenchob *et al.* (2011) claimed that fruit bagging increased fruit weight, size over non-bagged control fruits. Fallahi *et al.* (2001) reported that preharvest fruit bagging significantly increase fruit weight of BC-2, Fuji Apple. Bagging promoted longan fruit development, resulting in larger-sized fruit (Yang *et al.,* 2009).

It was reported that bagged fruit retained higher moisture content during storage period (Yang *et al.,* 2009). In our experiment we found that the moisture content was higher (82.90%) in polythene bagged fruit. Dry matter content (20.63%) was also higher in white paper bagged fruit. The dry matter content was higher might be due to fruit bagging. The result of the present study is in support of the findings of Hofman (1997). He stated that due to preharvest bagging dry matter content increased from 17.14 to 20.83% during storage.

TSS of all bagged mango fruits showed lower value than non-bagged control fruits. The result is in agreement with the finding of Signes *et al.* 2007, they found lower TSS in bagged grape. In our study, we observed higher TSS content (22.87 % Brix) in non-bagged control fruit and lower (19.10 % Brix) in black polythene bagged fruit.

We recorded higher vitamin C content (29.72mg/100g) in non-bagged control fruit as compared to bagged fruits. The bagging led to lower content of chemical components such as Vitamin C, phenols and organic acids in most of peach varieties (Lima *et al.*, 2013). The preharvest bagging showed significant effect on total sugar, reducing sugar and non-reducing sugar content of fruits at harvest. White polythene bagged fruit showed the highest reducing sugar content (10.69%). The variation observed in chemical composition of mango fruits can be attributed to the changed microenvironment around fruit during its growth and development. The bagged fruits showed highest content of vitamin C, sucrose, glucose and fructose over non-bagged control in Zill mango (Hongxia *et al*., 2009); date palm (Harhash and Al-Obeed, 2010).

Ding and Syakirah (2010) reported that different colour bag did not affect the titratable acidity of mango. But in this study, we found variations in titratable acidity content in bagged fruits. The maximum titratable acidity (2.58%) was reported in white paper bag while the minimum (1.98%) in black polythene bagged fruits.

The shelf life of mango fruits was found to be extended by 7.00, 4.33, 2.40 and 3.27 days in bagging with brown paper, white paper, white polythene and black polythene, respectively as compared to non-bagged fruits. It is assumed that non-bagged fruits affected by insects and diseases earlier giving the shortest shelf life during storage. The greater storability of the bagged fruits was might be due to the reduced level of disease both in terms of incidence and severity. And this reduced disease may be due to the effects of antimicrobial components in sap that were not allowed to remove from the fruits. The antimicrobial properties of sap had been extensively investigated by Hassan (2010). Singh *et al.* (2007) reported that pre harvest bagging delayed ripening resulting in extended shelf life of Perla, a black grape. The bagging modified the microenvironment near fruit especially in respect to air temperature and humidity (Yang *et al.,* 2009). The longer shelf life of bagged fruits indicated that the effect of bagging persisted during ripening of fruits in storage. Hofman *et al*. (1997) noticed that the infestation of anthracnose and stem end rot reduced in mango cv. Keitt with white paper bag used at approximately 100 days before harvest. Bagging provided physical barrier between fruit and pests which resulted in longer shelf life of mango.

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References

Amarante, C.; Banks, N.H.; Max, S. 2002. Effect of preharvest bagging on fruit quality and postharvest physiology of pears (Pyrus communis). *New Zealand Journal of Crop and Horticultural Science*, 30(2): 99-107. https://doi.org/10.1080/01140671.2002.9514204

BBS, 2018. Year Book of Agricultural Statistics. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Chen, D. and Li, P. 1999. Effect of bagging on fruit colouration of litchi (Litchi chinensis Sonn. cv. Feizixiao). Journal of *South China Agricultural University*, 20: 65-69.

Chonhenchob, V., Kamhangwong, D., Kruenate, J., Khongrat, K., Tangchantra, N., Wichai, U. and Singh, S.P. 2011. Pre-harvest bagging with wavelength-selective materials enhances development and quality of mango (*Mangifera indica* L.) cv. 'nam dok mai'. *Journal of the Science of Food and Agriculture*, 91: 664-671. https://doi.org/10.1002/jsfa.4231

Ding, P. and Syakirah, M. N. 2010. Influence of fruit bagging on postharvest quality of 'Harumanis' mango (*Mangifera indica* L.). *Acta Horticulturae*, 877: 169-174. https://doi.org/10.17660/ActaHortic.2010.877.15

Ehteshami, S., Hassan, S., Ahmad, E. and Jafar, A.P. 2015. Effect of bagging on fruit quality and reducing of sunburn in Pomegranate cv. Rabab Neiriz. *Iranian Journal of Horticultural Sciences*, 45:353-360.

Esguerra, E.B. and Lizada, M.C.C. 1990. The postharvest behaviour and quality of Carabao mangoes subjected to a vapour heat treatment. *ASEAN Food Journal*, 5(1): 6-11.

Fallahi, E., Colt, W.M., Baird, C.R., Fallahi, B. and Chun, I. J. 2001. Influence of nitrogen and bagging on fruit quality and mineral concentrations of BC-2 Fuji Apple. *Hort Technology*, 11(3): 462-465. https://doi.org/10.21273/HORTTECH.11.3.462

Fallahi, E., Conway, W. S., Hickey, K. D. and Sams, C.E. 1997. The role of calcium and nitrogen in postharvest quality and disease resistance of apples. HortScience, 32:831-835. https://doi.org/10.21273/HORTSCI.32.5.831

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research (2nd edition). Willey International Science Publication, pp. 28-192.

Harhash, M.M. and Al-Obeed, R.S. 2010. Effect of bunch bagging colour on yield and fruit quality of date palm. American-*Eurasian Journal of Agricultural and Environmental Science*, 7:312-319.

Hassan, M.K. 2010. Final Report: Postharvest loss assessment: A Study to Formulate Policy for Postharvest Loss Reduction of fruits and Vegetables and Socio-Economic Uplift of the Stakeholders. P. 188 (USAID-EC and FAO-FPM Project under the National Food Programme Capacity Strengthening Programme (NFPCSP).

Hofman, P. J. 1997. Production factors influence fruit quality and response to postharvest treatments. In: Coates, L.M., Hofman, P.J. and Johnson, G.I. (Ed). Disease Control and Storage Life Extension in Fruit. Australian Centre for International Agricultural Research (ACIAR) Proceedings, 81: 6-18.

Hofman, P.J., Smith, L.G., Joyce, D.C., Johnson, G.I. and Meiburg, G.F. 1997. Bagging of mango (Mangifera indica L. Cv. Keitt) fruit influences fruit quality and mineral composition. *Postharvest Biology and Technology*, 12(1): 83-91. https://doi.org/10.1016/S0925-5214(97)00039-2

Hongxia, W., Wang, S.B., Shi, S.Y, Ma, W.H., Zhou, Y.G and Zhan, R. L. 2009. Effects of bagging on fruit quality in Zill mango. *Journal of Fruit Science*, 26(5): 644-648.

Hossain, A.K.M.A. and Ahmed, A. 1994. A monograph on mango varieties in Bangladesh. HRC-BARI and FAO/UNDP Mango Improvement Project. p. 3.

Jayaraman, J. 1981. Laboratory Manual in Biochemistry. 1st edition, Wiley Eastern, New Delhi, India.

Lechaudel, M. and Joas, J. 2007. An overview of pre harvest factors influencing mango fruit growth, quality and postharvest behaviour. *Brazilian Journal of Plant Physiology*, 19: 287-298. https://doi.org/10.1590/S1677-04202007000400004

Leite, G.L.D., Fialho, A., Zanuncio, J.C. and Junior, R.R. 2014. Bagging tomato fruits: A viable and economical method of preventing diseases and insect damage in organic production. *The Florida Entomologist*, 97(1): 50-60. https://doi.org/10.1653/024.097.0106

Lima, A.D., Boari, J., Angelo, A., Alvarenga, M., Ribeiro, M., Deyse, G. and Elisa, B.D. 2013. Chemical evaluation and effect of bagging new peach varieties introduced in Southern Minas Gerais-Brazil. *Food Science and Technology*, 33(3): 434-440. https://doi.org/10.1590/S0101-20612013005000077

Miller, G.L. 1972. Use of dinitro salicylic acid reagent for determination of reducing sugar. *Analytical Chemistry*, 31: 426-428. https://doi.org/10.1021/ac60147a030

Mtebe, K., Mamiro, P. and Fweja, L. 2006. Sensory attributes, microbial quality and aroma profiles of off vine ripened mango (*Mangifera indica* L.) fruit. *African Journal of Biotechnology*, 5:201-205.

Nankinga, C. M., Isabirye, B.E., Muyinza, H., Rwomushana, I., Stevenson, P.C., Mayamba, A., Aool, W. and Akol, A. M. 2014. Fruit fly infestation in mango: A threat to the horticultural sector in Uganda. *Uganda Journal of Agricultural Sciences*, 15(1):1-14.

Ploetz, R.C. 2003. Diseases of mango. In: Diseases of Tropical Fruit Crops. R. C. Ploetz, Ed. CABI Publishing, Oxford, UK. https://doi.org/10.1079/9780851993904.0000

Quroshi, S.U. and Meah, M.S. 1991. Postharvest loss in mango owing to stem-end rot. *International Tropical Agriculture*, 9(2): 98-105.

Ranganna, S. 1086. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill Publishing Company Ltd., New Delhi, India, 1112p

Sarwar, M. 2015. Parctices for integrated control of mango (*Mangifera indica* L.) diseases to protect in preharvest as well as postharvest phases. *Bioscience and Bioengineering*, 1(3): 57-62.

Sharma, R.R., Singh, D. and Singh, R. 2009. Biological control of postharvest diseases of fruits and vegetables by microbial antagonists: A review. *Biological Control*, 50(3):205-211. https://doi.org/10.1016/j.biocontrol.2009.05.001

Sharma, R.R.; Reddy, S.V.R.; Jhalegar, M.J. 2014. Pre-harvest fruit bagging: A useful approach for plant protection and improved post-harvest quality-A review. *The Journal of Horticultural Science and Biotechnology*, 89(2): 101-113. https://doi.org/10.1080/14620316.2014.11513055

Signes, A.J., Burlo, F., Martinez-Sanchez, F. and Carbonell-Barrachina, A.A. 2007. Effects of preharvest bagging on quality of black table grapes. *World Journal of Agricultural Sciences*, 3(1): 32-38.

Singh, S., Chonhenchob, V., Chantanarasomboom, Y. and Singh, J. 2007. Testing and evaluation of quality changes of treated fresh-cut tropical fruits packaged in thermoformed plastic containers. *Journal Testing Evaluation*, 35: 17-22. https://doi.org/10.1520/JTE100166

Tyas, J.A., Hofman, P.J., Underhill, S.J. and Bell, K.L. 1998. Fruit canopy position and panicle bagging affects yield and quality of 'Tai So' lychee. *Scientia Horticulturae*, 72: 203-213. https://doi.org/10.1016/S0304-4238(97)00125-8

Vayssieres, J.F., Adandonon, A., Sinzogan, A. and Korie, S. 2010. Diversity of fruit fly species (Diptera:Tephritidae) associated with citrus crops (Rutacea) in Southern Benin in 2008-2009. *International Journal of Biochemical Science*, 4(6):1881-1897. https://doi.org/10.4314/ijbcs.v4i6.64966

Watanawan, A., Watanawan, C. and Jarunate, J. 2008. Bagging 'Nam Dok Mai' mango during development affects color and fruit quality. *Acta Horticulturae*, 787: 325-330. https://doi.org/10.17660/ActaHortic.2008.787.40

Yang, W.H., Zhu, X.C., Bu, J.H., Hu, G.B., Wang, H.C. and Huang, X.M. 2009. Effects of bagging on fruit development and quality in cross-winter off-season longan. *Scientia Horticulturae*, 120: 194-200. https://doi.org/10.1016/j.scienta.2008.10.009

Zhang, B.B., Guo, J. Y., Ma, R. J., Cai, Z. X., Yan, J. and Zhang, C.H. 2015. Relationship between the bagging microenvironemnt and fruit quality in 'Guibao'peach [*Prunus persica* (L.) Batsch]. *The Journal of Horticultural Science and Biotechnology*, 90(3): 303-310. https://doi.org/10.1080/14620316.2015.11513187