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Effect of pre-harvest fruit bagging on biotic stresses and postharvest quality of banana

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Abstract

A study was conducted to determine the impact of pre-harvest fruit bagging on banana maturity, pest and disease management, and postharvest quality. The bunch was wrapped in a variety of bags, including white polythene bag, blue polythene bag, muslin cloth bag, gunny bag, brown paper bag and non-bagging (control). The study was designed as a randomized complete block design (RCBD) with three replicates. The results showed that banana bunch covered with brown paper bags were ready to harvest 16 days earlier than those in the control. In addition, bagging increased fruit length, diameter, weight, and pulp weight in comparison to non-bagged fruit. Moreover, the brown paper bag treatment significantly reduced pest infestation (15-fold), disease infection (12-fold) and physiological disorder (6.5-fold) compared to control. The firmness, total soluble solids, and total sugar content were found maximum with brown paper bagged fruit, while Vitamin C content was higher in control fruits. Brown paper bagged fruit exhibited the longest shelf life (12 days) as compared to the control (09 days). Bagging presented a significant effect on the color and overall expression of the fruit, although it did not influence the flavour of the fruit. In conclusion, brown paper bags can help to prevent diseases and insect infestation and improve the fruit quality of bananas.

Key words: Bunch covering, pests management, maturity, shelf life, quality, banana

Introduction

Banana (*Musa sapientum* sp.) is one of the most important fruit crops in the tropics and subtropics. In Bangladesh, it is considered as an important commercial fruit crop and is available throughout the year. The consumption rate of this fruit is higher than any other fruit due to it's sweet taste, attractive color, fascinating flavor, and nutritive value. Bangladesh produces 826.15 thousand tons of bananas from 49.45 thousand ha of land (BBS, 2021). Bananas have a significant economic value; thus, their cultivation area and production constantly expand. However, despite this trend, the availability of high-quality, unadulterated bananas remains stagnant.

Various physical and chemical changes throughout fruit growth make it vulnerable to insect and disease infestations, bird attacks, and mechanical damage (Sharma *et al.,* 2014), resulting in lower market value and economic losses. Pests and diseases like banana weevil and anthracnose are greatly influenced by extreme changes in temperature, humidity, and irregular rains that occur during fruit growth and a substantial decrease in yield. In addressing these challenges, growers resort to spraying pesticides (ranging from 15 to 61 times) in their orchards (Uddin et al., 2015), thereby posing significant risks to human health and the environment.

Around the world, several good agricultural practices (GAP) are becoming popular day by day as a means of minimizing losses brought on by biotic and abiotic factors. Among them, fruit bagging is commonly used for many fruits by different countries, which can effectively reduce the use of pesticides, protect against diseases and insects, and improve fruit colour (Yuemming *et al.,* 2005; Pal *et al.,* 2016; Ali *et al.,* 2021; Chaiwong *et al.,* 2021). The quality of bagged fruits is influenced by the type of bag, variety, and time of bagging (Sharma *et al.,* 2014; Santosh *et al.,* 2017). Usually, researchers have used polyethylene, gunny, and waste fabric bags of varying colors and thicknesses extensively for banana cultivation (Chaiwong *et al.,* 2021; Santosh *et al.,* 2017). Scientists have found that the quality of mango, litchi, and grapes produced in brown paper bags has been higher than that of polyethylene and gunny bags (Islam *et al.,* 2017; Joshi *et al.,* 2016; Karajeh, 2018). There has been no research on banana production using brown paper bags as well as the effects of bagging on the 'Amritsagar' variety. The banana cultivar 'Amritsagar' is popular in Bangladesh. The demand for "Amritsagar" bananas has recently increased in Bangladesh's domestic and international markets. Bananas must be produced at a high quality to be competitive on the export market. Keeping this in mind, the current study was conducted to find out the effects of fruit bagging materials on maturity, pest and disease control, shelf life, and quality of 'Amritsagar' bananas.

Materials and methods

Experimental site and materials: The present experiment was performed at the banana orchard located near Hajee Mohammad Danesh Science and Technology University, Dinajpur (25.13° N latitude, 88.23° E longitude, and 34.5 m altitude) from July 2019 to October 2020. Average temperature, rainfall and humidity was 22.9°C, 210 mm and 85%, respectively. For this study, Banana (*Musa sapientum* sp.) cv. Amritsagar plants with similar size and vigor were selected. The brown paper bag was collected from

Ispahani Agro limited, Rangpur and other fruit bags from the local market in Dinajpur Sadar, Bangladesh.

Treatments and experimental design: The experiment was conducted following a randomized complete block design (RCBD) with three replications. Five types of fruit bagging materials were used: White polythene bag, blue polythene bag, muslin cloth bag, gunny bag, brown paper bag and non-cover (control). The size of the bags was 1.2 x 0.7 m^2. Bagging was applied to all treatments approximately three weeks after inflorescence emergence when the bracts dropped down from the bunch and the fingers curled upwards (Chaiwong *et al.,* 2021). The bagging was knotted to the peduncle and hanged about 15 cm below the last hand of fruit. Bagging was left over bunches until harvest.

Days to the first harvest from bagging, size and weight of fruit and moisture content of fruit: Bunches were harvested at the physiological maturity stage when the ridges on the fruit surface turned from angular to round shape and the skin color of upper finger became yellowish from green, at different times for each treatment as they matured. Then the number of days required for 80% maturity was observed. The fruits' length and diameter were measured using a digital vernier calliper and expressed in centimetres (cm). The weight of the fruit and pulp was measured with the help of an electronic balance and was expressed in grams (g). The firmness of fruits was determined by Force Gauge (HANDPI HP-200, China) and expressed in percentage (%). The moisture content of banana pulp was calculated using the following formula: Moisture content (%) = {Initial weight (g)- Final weight (g)/ Initial weight}x100.

Insect and disease incidence and physiological disorder at harvesting: Insects (specifically fruit beetles) and disease (anthracnose) infested fruits were detected by visually observing symptoms and estimating their prevalence in terms of percentage (%). The incidence of insects and disease in the fruits was determined using the following formula:

Insect incidence=(Number of fruit infested/Total no of fruit) x 100.

Diseases incidence=(Number of fruit infected/Total no of fruit) x 100.

Physiological disorders of banana include chilling injury, finger drop, and peel splitting, which were identified carefully. The physiological disorder of fruits was calculated using the following formula:

Physiological disorder= (Number of fruit affected/Total no of fruit) x 100.

Determination of quality characteristics: The soluble solids content was quantified by an Erma Hand Refractometer and expressed in percentages (%). Vitamin C was measured by the 2, 6-dichlorophenol-indophenol dye method and expressed in mg/100g according to Ranganna *et al.* (1997). The total sugar content was determined and expressed in % according to AOAC (2000) as described by Islam *et al.* (2017). Reducing sugar was estimated using the method described by Haq and Rab (2012) and Santini *et al.* (2014). The following formula was used for calculate non-reducing sugar**:**

Non-reducing sugar (%)= Total sugar (%)- Reducing sugar (%).

Shelf life of fruits (days): Ripening of ten mature fruits from each treatment was done at room temperature (25±°C, 80-95% RH) on perforated plastic crates using traditional paddy straws. The consummation of shelf life was noted in a stored condition.

Sensory evaluation: The sensory attributes of the mature fruits, both bagged and unbagged, were also evaluated by a panel of five judges using the nine-point Hedonic Scale for rating color, flavour and overall expression. In the scorecard, nine-point hedonic scale factors included: 1- Dislike extremely, 2- Dislike very much, 3- Dislike moderately, 4- Dislike slightly, 5-Neither like nor dislike, 6- like slightly, 7- Like moderately, 8- Like very much, 9- Like extremely (Kumar and Badgujar, 2018).

Statistical analysis: The collected data on various parameters were analyzed using SPSS (Statistical Package for Social Science). The comparison among the means was done by Duncan's multiple range test (DMRT) at $P < 0.05$.

Results and discussion

First harvest from bagging (Days): The harvesting period was significantly lowered (16 days) under brown paper bagging compared to control (Fig.1). Usually, bagging generates a microclimate that aids in the growth and development of fruit; hence, all bagging treatments shorten the period between planting and harvesting. Early fruit maturation in bananas has been associated with an increase in carbon dioxide (CO_2) levels inside the bag, which in turn may boost up the transpiration rate, ethylene synthesis, and chloroplast-to-chromoplast transition (Patel *et al.,* 2020; Fagundes *et al.,* 2015).

Physical attributes of fruits: The length and diameter of fruit, weight of fruit, pulp moisture percentage, and firmness of the fruit significantly differed using different pre-harvest fruit

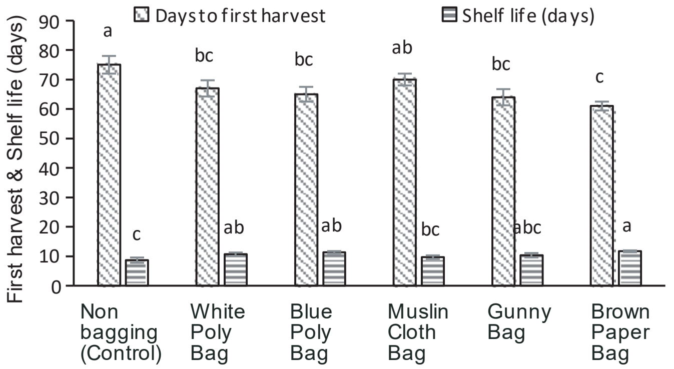

Fig. 1. Effect of bagging materials on the days to harvest and shelf life (days) of banana. a-c Means followed by different alphabets within graphs significantly differ by DMRT at P<0.05. Error lines represents ± standard deviation of the mean.

Table 1. Effects of pre-harvest fruit bagging on physical parameters of banana cv. Amritsagar

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Weight of fruit (g)	Pulp weight (g)	Moisture (%)	Firmness kg/cm^2
Non bagging (control)	21.80b	3.83c	176.33c	123.67c	73.35b	3.2c
White polythene bag	24.33ab	4.12abc	227.33abc	159.33abc	77.45a	4.3a
blue polythene bag	23.67ab	4.25a	235.00ab	164.67ab	78.29a	3.7b
Muslin cloth bag	22.33ab	3.95abc	192.00abc	134.67abc	73.57b	3.6b
Gunny bag	22.00b	3.90bc	184.33bc	128.67bc	76.61a	3.8b
brown paper bag	25.17a	4.18ab	242.33a	169.67a	77.98a	4.4a
CV (%)	4.39	2.86	9.42	9.42	0.98	5.72
LSD (0.05)	2.88	0.32	55.86	39.13	2.11	0.21

Means followed by different alphabets within column significantly differ by DMRT at P<0.05

bagging (Table 1). The fruit length was increased by 15.45% because of brown paper bag compared to the control. Besides the bagging material, the blue polythene bag resulted in 10.96% increased fruit diameter than the control (Table 1). This result was supported by the previous study, which reported that fruit bagging would have helped increase the fruit size by improving the microclimate around the fruit (Krieeti *et al.,* 2016).The use of brown polythene bags to cover fruits resulted in a 37% increase in fruit weight and a 37.06% increase in pulp weight compared to the control group (Table 1). The variability in fruit and pulp weight observed under different bags could be attributed to differences in microclimate within the bags. Chonhenchob et al. (2011) found that pre-harvest bagging had a positive impact on fruit weight compared to un-bagged fruit, using various wavelength-selective bags for bananas.

Furthermore, during the ripening stage, fruits stored in blue paper bags exhibited the highest moisture content (78.29%), while those in the control group had the lowest (73.35%). This study suggests that bagging contributed to a 27.27% increase in firmness compared to un-bagged fruits (Table 1). Fruit bagging enhances firmness by creating a favorable microclimate and reducing blemishes (Zhang et al., 2015). Similar increases in firmness have been observed in "Royal Delicious" apple fruits (Sharma et al., 2013), guava (Sharma et al., 2020), and mango fruits (Nadeem et al., 2022).

Percent of insect and diseases infestation during harvesting: Biotic stress can be described as damage to crops caused by several living organisms, especially bacteria, fungi, viruses, insects, and weeds. Banana fruits are seriously infested by fruit beetle and anthracnose during growth and development which can result in significant losses for the growers. Fruits are protected from biotic stresses using a variety of pesticides. The residual effect of these pesticides is harmful for human (Sharma *et al.,* 2014). Pre-harvest bagging significantly impacted insect and disease infestation of banana fruit (Fig. 2). A sharp decrease (15-fold) in insect infestation was observed in brown paper-bagged fruits compared to unbagged fruits. This may be due to the fact that bagging may act as a mechanical barrier between environment and the fruit that protected fruits from insects and diseases (Sharma *et al.,* 2014). Several reports have shown that bagging decreased the incidence of fruit flies in mango (Sarker *et al.,* 2009), guava (Sharma *et al.,* 2020) and fruit borer in litchi (Debnath and Mitra, 2008). The application of brown paper bag treatment significantly lowered disease infection (12-fold) than the control. The lowest disease infection in bagged fruit might be due to the absence of disease inoculum in fruit. The incidence of anthracnose in mango (Chonhenchob *et al.,* 2011) and guava (Sharma *et al.,* 2020) has been decreased when the fruit was bagged.

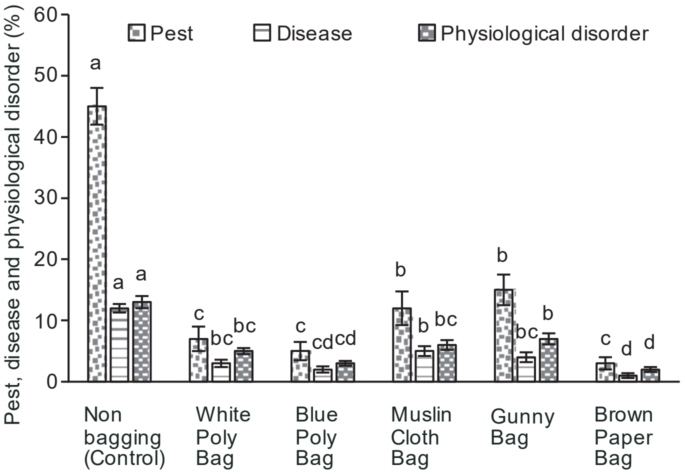

Fig. 2. Effect of bagging materials on the percent of pest, disease infestation and physiological disorder of banana. Means followed by different alphabets within graphs significantly differ by DMRT at

Percent of physiological disorder during harvesting: Pre-harvest bagging treatment had a considerable impact on physiological disorders of fruits (Fig. 2). Brown paper bagging had lower (6.5-fold) physiological disorders than those of control. According to previous research, fruit bagging may be used to prevent the occurrence of certain fruit physiological disorders. Therefore, fruit bagging has been used extensively in some countries to reduce the problems of sunburn in cavendish banana (Chaiwong *et al.,* 2021) and fruit cracking in pomegranate (Hamedi, 2019; Asrey *et al.,* 2020).

Quality attributes: The pre-harvest fruit bagging had a significant effect on total soluble solids, vitamin C, reducing sugar, non-reducing sugar and total sugar content of fruits during the ripening stage (Table 2). The highest (20.03%) total soluble solids (TSS) content was recorded in the brown paper bag than the control (16.10%). This might be due to the changes in enzymatic activities (Nadeem *et al.,* 2022). Improvement in the TSS has also been reported in mango (Islam *et al.,* 2017; Nadeem *et al.,* 2022), guava (Sharma *et al.,* 2020), banana (Rubel *et al.,* 2019), apple (Sharma *et al.,* 2013). However, some conflicting results suggest that fruit bagging may lower TSS while having no effect on certain fruits (Sharma *et al.,* 2014).

Table 2. Effects of pre-harvest fruit bagging on chemical parameters of banana cv. Amritsagar

Treatments	TSS (% Brix)	Vitamin C (mg/100 g)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
Non bagging (Control)	16.10c	13.12a	12.85b	13.08a	25.92 b
White Polythene Bag	17.40bc	11.85ab	14.59ab	11.58a	26.15b
Blue Polythene Bag	18.80ab	11.60ab	15.94ab	15.56a	28.67ab
Muslin Cloth Bag	17.35bc	10.61ab	18.15a	11.01a	29.28ab
Gunny Bag	17.55bc	8.75b	13.11b	12.41a	28.35ab
Brown Paper Bag	20.30a	11.25ab	15.45ab	14.83a	30.14a
CV (%)	17.93	9.87	9.02	13.27	4.51
LSD (0.05)	2.08	3.13	3.84	4.91	3.58

Means followed by different alphabets within column significantly differ by DMRT at P<0.05

The highest vitamin C content (13.12 mg/100g) was found in non-bagged fruits compared to bagged fruits. The variation in vitamin C under different bagging treatments was attributed to the variation of microclimate developed inside bags. According to Lima *et al.* (2013), bagging decreased the level of chemical components such as vitamin C, phenols and organic acids in most fruit types. The above findings are similar to those of Islam *et al.* (2020) in mango.

All bagging materials improved the reducing sugar content over the control. Using a muslin cloth bag, the increase in reducing sugar by 41.25% was calculated when compared to the control (Table 2). However, there was no significant difference in fruits reducing sugar content among the blue polythene bag, brown paper bag, and white polythene bag.

The non-reducing sugar content was higher (15.56%) in fruits covered with blue polythene bag compared to control (13.08%). However, the values were not significantly different with each other. Brown paper bags accelerated a considerable increase in total sugar by 16.28% compared to the control. Bagged fruits had more sugar due to reduced sucrose breakdown enzyme (acid invertase) and increased sucrose synthesis enzyme activities (sucrose synthase and sucrose-phosphate synthase).

Shelf life: Significant variation was observed regarding shelf life between pre-harvest bagging and non-bagging banana (Fig. 1). Bagging with brown paper increased storage life by 50% compared to the control. It is considered that non-bagged fruits might have a faster metabolic rate than bagged fruits, resulting in a shorter shelf life during storage. Singh *et al.* (2007) observed that the increased storage life of bagged fruits may be attributable to microenvironmental changes within the bag. In addition, pre-harvest fruit bagging in apple reduced postharvest weight loss compared to non-bagged fruits (Sharma *et al.,* 2013).

Sensory evaluation: Color, sweetness, texture, and scent are the main factors customers use to judge the quality of any product (Nunes *et al.,* 2007). Bagging significantly improved sensory scores for fruit color and overall expression compared with the control. There was no significant difference between scores of bagging and control in terms of flavour (Fig. 3). Brown Paper bagged fruit showed a maximum colour score (9) over non-bagged fruit (4). The sensory score for overall expression (9) was using brown paper bag compared to the control (5). There may have been an increase in TSS, sugar, and visual qualities like colour and firmness, which could have led to a rise in the overall expression of bagging. Studies have shown that bagged mango and apple fruits had better sensory evaluation than non-bagged fruits (Islam *et al.,* 2020; Sharma *et al.,* 2013).

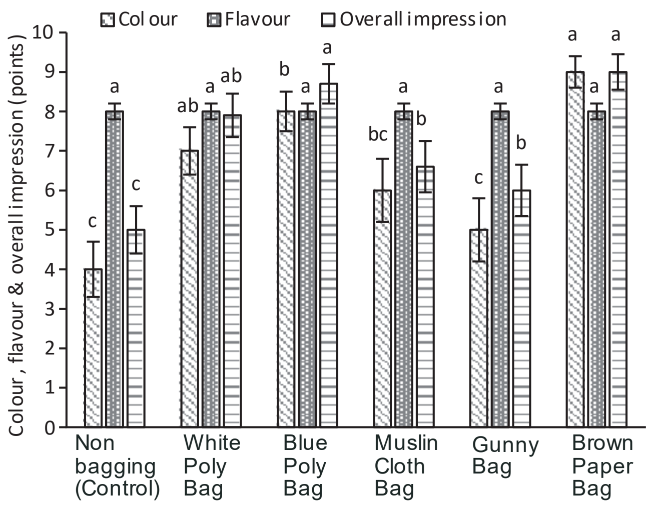

Fig. 3. Effect of bagging materials on the color, flavor and overall impression of banana. a-c Means followed by different alphabets within graphs significantly differ by DMRT at $P<0.05$. Error lines represents ± standard deviation of the mean.

The study examined the impact of various pre-harvest fruit bagging methods on banana plants, focusing on their ability to mitigate biotic stress and enhance quality characteristics. The findings revealed that fruit subjected to bagging exhibited accelerated maturity, larger size, and greater weight compared to the control group. Notably, brown paper bags proved to be more effective in controlling pests and diseases than other bagging materials and the control samples. While brown paper bags positively influenced most quality attributes of bananas, they did not enhance vitamin C content. In conclusion, the results suggest that brown paper bags can enhance fruit quality by reducing the incidence of pests and diseases, thereby potentially increasing profits for growers.

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Conflicts of Interest: The authors declare no conflict of interest.

References

Ali, M.M., R. Anwar and A.F. Yousef, 2021. Influence of bagging on the development and quality of fruits. *Plants,* 10: 358.

AOAC. 2000. *Official Methods of Analysis*. 17th Edition. Association of Official Analytical Chemists. EUA. Washington, DC, USA.

Asrey, R., K. Kumar, R.R. Sharma and N.K. Meena, 2020. Fruit bagging and bag color affects physico-chemical, nutraceutical quality and consumer acceptability of pomegranate (*Punica granatum* L.) arils. *J. Food Sci. Tech.*, 57(4): 1469-1476.

BBS, 2021. *Yearbook of Agricultural Statistics of Bangladesh 2021*. Bangladesh Bureau of Statistics, Statistics Division, Planning Division, Ministry of Planning. Government of the People's Republic of Bangladesh. 1: 210.

Chaiwong, S., R. Saengrayap, J.M. Ogunsua, H. Kitazawa and C. Prahsarn, 2021. Performance of different bunch cover materials to improve quality of cavendish banana cultivated during winter and summer in Thailand. *Agronomy*, 11(3): 610.

Chonhenchob, V., D. Kamhangwong, J. Kruenate, K. Khongrat, N. Tangchantra, U. Wichaiand and S.P. Singh, 2011. Pre-harvest bagging with wavelength-selective materials enhances development and quality of mango (*Mangifera indica* L.) cv. namdokmai. *J. Sci. Food Agric.*, 91: 664-671.

Debnath, S. and S.K. Mitra, 2008. Panicle bagging for maturity regulation, quality improvement and fruit borer management in litchi (*Litchi chinensis*). *Acta Hortic.*, 773: 201-208.

Fagundes, C., K. Moraes, M.B. Pérez-Gago, L. Palou, M. Maraschin and A.R. Monteiro, 2015. Effect of active modified atmosphere and cold storage on the postharvest quality of cherry tomatoes. *Postharvest Biol. and Technol.*, 109: 73-81.

Haq, I.U. and A. Rab, 2012. Characterization of physico-chemical attributes of litchi fruit and its relationship with fruit skin cracking. *J. Anim. Plant Sci.,* 11(1): 141-147.

Hamedi Sarkomi, F., F. Moradinezhad and M. Khayat, 2019. Pre-harvest bagging influences sunburn, cracking and quality of pomegranate fruits. *J. Hortic. Postharvest Res.,* 2: 131-142.

Islam, M.T., M.S. Rahman, M. Shamsuzzoha and R. Alom, 2017. Influence of pre-harvest bagging on fruit quality of mango (*Mangifera indica* L.) cv. Mishribhog. *Intl. J. Biosci.*, 11(3): 59-68.

Islam, M.T., M.S. Zoha, M.S. Uddin, M.A. Bari, M.H. Rahman, M.M. Akter and N. Akter, 2020. Effect of different time of bagging for ensuring quality mangoes Cv. Mishribhog. *J. Biosci. Agr. Res.*, 25(02): 2114-2121.

Joshi, K.K., V.P. Singh, D. Saxena, D.S. Mishra and R. Kumar, 2016. Effect of Pre-Harvest Bagging on Fruit Quality of Litchi (*Litchi chinensis* Sonn) cv. Rose Scented. *Annals of Horticulture*, 9(1): 41-44.

Karajeh, M.R. 2018. Pre-harvest bagging of grape clusters as a non-chemical physical control measure against certain pests and diseases of grapevines. *Organic Agric.*, 8(3): 259-264.

Krieeti, A., P.M. Haldankar, M.R.V. Babu and Y.R. Parulekar, 2016. Effect of pre harvest bagging on mango fruit quality. *Res. Environ. Life Sci.,* 9(11): 1366-1369.

Kumar, Y. and P.C. Badgujar, 2018. Sensory evaluation of seaweed-coffee infusions using fuzzy logic. *Pharm. Innov.*, 7(11): 567-572.

Lima, A.D.J.B., A.A. Alvarenga, M.R. Malta, D. Gebert and E.B.D. Lima, 2013. Chemical evaluation and effect of bagging new peach varieties introduced in southern Minas Gerais-Brazil. *Fd. Sci. Technol.,* 33: 434-440.

Nadeem, A., Z.F.R. Ahmed, S.B. Hussain, A.E.D.K. Omar, M. Amin, S. Javed, A. Ali, S. Ullah, K. Razzaq, I.A. Rajwana, S. Nayab, V. Ziogas, S.M.A. Eldein and A.M. Mira, 2022. On-tree fruit bagging and cold storage maintain the postharvest quality of mango fruit. *Hortic.,* 8(9): 814.

Nunes, M.C.N., J.P. Emond, J.K. Brecht, S. Dea, and E. Proulx, 2007. Quality curves for mango fruit (cv. Tommy Atkins and Palmer) stored at chilling and non-chilling temperatures. *J. Food. Qual*., 30:104–120.

Pal, M., R.L. Lal, P. Nautiyal and P. Joshi, 2016. Effect of chemicals and physical means on harvesting span, yield and quality of litchi (*Litchi chinensis* Sonn.) cv. Rose Scented. *J. Appl. Hortic*., 18:71–75.

Patel, D.P., P. Deb and Y.K. Patel, 2020. Effect of fruit bagging on yield and quality of tomato (*Solanum lycopersicum* L.). *Intl. J. Commun. Sci.,* 8(5): 2191-2197.

Ranganna, B., A.C. Kushalappa and G.S.V. Raghavan, 1997. Ultraviolet irradiance to Control dry rot and soft rot of potato in storage. *Can. J. Plant Pathol.,* 19: 30-35.

Rubel, M.H.K., M.M. Hossain, M.M.H. Hafiz, M.M. Rahman and M.R. Khatun, 2019. Effect of banana bunch covering technology for quality banana production in Bangladesh. *Prog. Agr.*, 30(3): 238-252.

Santini, A., R. Romano, G. Meca and A. Raiola, 2014. Antioxidant activity and quality of apple juices and puree after *in vitro* digestion. *J. Food. Res.,* 3(4): 41-50.

Santosh, D.T., K.N. Tiwari, and R.G. Reddy, 2017. Banana bunch covers for quality banana production – A review. *Intl. J. Curr. Microbiol. Appl. Sci.,* 6(7): 1275-1291.

Sarker D., M.M. Rahman and J.C. Barman, 2009. Efficacy of different bagging materials for the control of banana fruit fly. *Bd. J. Agril. Res.,* 34: 165-168.

Sharma R.R., R.K. Pal, R. Asrey, V.R. Sagar, M.R. Dhiman and M.R. Rana, 2013. Pre-harvest fruit bagging influences fruit color and quality of apple cv. Delicious. *J. Agril. Sci.,* 4(9): 443-448.

Sharma, R.R., A. Nagaraja, A.K. Goswami, M. Thakre, R. Kumar and E. Varghese, 2020. Influence of on-the-tree fruit bagging on biotic stresses and postharvest quality of rainy season crop of 'Allahabad Safeda' guava (*Psidium guajava* L.). *Crop Protection,* 135: 105-216.

Sharma, R.R., S.V.R. Reddy and M.J. Jhalegar, 2014. Pre-harvest fruit bagging: a useful approach for plant protection and improved postharvest fruit quality –A review. *J. Hortic. Sci. Biotechnol.,* 89(1): 101-113.

Singh, B.P., R.A.G. Singh and B. Killadi, 2007. Response of bagging on maturity, ripening and storage behaviour of winter guava. *Acta Hortic.,* 735: 597-601.

Uddin, M.S., M.S. Islam, M.Z. Uddin, M.A. Alam, M.M. Hossain and M.H. Rashid, 2015. Modern production technology of mango and its marketing system. *Regional Horticulture Research Station,* BARI, Chapainawabganj, 46.

YueMing, J., S. XinGuo, J. YueLin, L. YueBiao and L. WenBin, 2005. Preharvest bagging of litchi fruits influence their storage potential. *J. Appl.Hortic.*, 7(2): 105-107.

Zhang, B.B., J.Y. Guo, R.J. Ma, Z.X. Cai, J. Yan and C.H. Zhang, 2015. Relationship between the bagging microenvironment and fruit quality in 'Guibao' peach (*Prunus persica* L.) Batsch. *J. Hortic. Sci. Biotechnol.,* 90(3): 303-310.

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