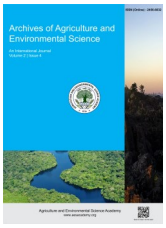
Archives of Agriculture and Environmental Science 7(2): 255-260 (2022)
https://doi.org/10.26832/24566632.2022.0702014

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE

Improvement of postharvest quality and shelf life of banana cv. Malbhog using different plant extracts and modified atmosphere packages in Chitwan, Nepal

Umesh Timilsina[1*] and Arjun Kumar Shrestha[2]

[1]Assistant Professor, Department of Horticulture Agriculture and Forestry University, Chitwan, Nepal
[2]Professor, Department of Horticulture Agriculture and Forestry University, Chitwan, Nepal
[*]Corresponding author's E-mail id: umeshtimilsina7@gmail.com

ARTICLE HISTORY

Received: 23 April 2022
Revised received: 06 June 2022
Accepted: 18 June 2022

Keywords

Banana
Modified atmosphere package
Plant Extracts
Postharvest life
Quality

ABSTRACT

Banana has a very short storage life. It is highly perishable, and therefore susceptible to several diseases resulting in extensive postharvest losses. A research entitled "Improvement of Postharvest Quality and Shelf life of Banana cv. Malbhog using different Plant Extracts and Modified Atmosphere Packages in Chitwan, Nepal" was conducted at the Post-Harvest Horticulture laboratory of Agriculture and Forestry University, Rampur, Chitwan, Nepal. The main objective of the research is to know the appropriate plant extracts and modified atmosphere package (MAP) for banana ripening and to now the effect of different plant extract on disease incidence and severity of banana. The experiment was laid out in Completely Randomized Design which consisted of eight treatments viz. Control, Garlic extracts, Neem extracts, Onion extracts, Sesamum oil, Ginger extract, Unperforated low-density polyethylene (50 µm) containing cotton soaked with $KMnO_4$ and perforated low-density polyethylene (50 µm) containing cotton soaked with $KMnO_4$ respectively and replicated thrice. Different post-harvest parameters were recorded at three days intervals for 15 days. From the experiment, the lowest firmness (0.467kg/cm^2) and the highest pulp (4.075) to peel ratio was noted with control. The maximum vitamin C content (6.633 mg/100 g) was recorded with the Neem extract. Regarding the organoleptic test, the index value of overall acceptability (0.87), sweetness (0.80) and flavor (1.0) were depicted highest with control whereas the low-density polyethylene containing cotton dipped in $KMnO_4$ resulted in minimum spoilage loss (43.77%). The minimal disease incidence was noticed with the unperforated LDPE containing $KMnO_4$ (25%) followed by Neem extracts. From the experiment, it was concluded that the low-density polyethylene-containing cotton dipped in $KMnO_4$ and Neem extract performed significantly better in terms of post-harvest parameters and disease incidence. Further studies regarding the use of other plant extracts and modified atmospheric packages were recommended.

Citation of this article: Timilsina, U., & Shrestha, A.K. (2022). Improvement of postharvest quality and shelf life of banana cv. Malbhog using different plant extracts and modified atmosphere packages in Chitwan, Nepal. *Archives of Agriculture and Environmental Science*, 7(2), 255-260, https://dx.doi.org/10.26832/24566632.2022.0702014

INTRODUCTION

Banana has a very short storage life. It is highly perishable, therefore susceptible to several diseases resulting in extensive postharvest losses (Basel *et al*., 2002). Among the postharvest diseases, anthracnose caused by *Colletotrichum musae* which is the most important disease-causing and massive economic losses of bananas (Ranasinghe *et al*, 2003). Being a latent infection the fungus infects immature bananas in the field but the symptoms appear only after ripening (Gonzalez *et al*., 2003). Thus for extending the shelf life, any potential control measure, which can be effectively used to delay symptoms expression would have a significant influence. In many countries, chemical treatments are used highly for the extension of shelf life and quality

of bananas. With the continuous use of these fungicides, the *Collectotrichum musae* has developed resistance and reduced the effectiveness of these synthetic chemicals (Mari *et al.*, 2003). From the above facts, to avoid the early ripening and use of those fungicides, some alternatives and efficient methods are used to delay ripening and control the disease. Alternatives are plant extract viz. Neem, Garlic, Onion, Potato, Mahogoni, Allamanda, Datura, coating with Sesame oil, Cinnamon oil, etc. are reported to have some fungicidal properties against certain postharvest diseases of tropical fruits which will delay ripening and increase the shelf life. It is also safer for the environment. Shelf life is the period that starts from the time of harvesting and extends up to the start of the rotting of fruit (Mondal, 2000) and it is the basic quality of fruit as well as is the most important parameter in the loss of reduction biochemical reaction of fruit. The ethanolic extracts of onion and garlic cloves are also used for the control of the black rot disease and other diseases of fruits. As a result, some scientists started using different promising botanical or plant extracts viz. Neem, Garlic, Onion, Mahogoni, Allamanda, Sesame oil and other so many low prices extract as a postharvest treatment for storage.

The postharvest losses of bananas can be reduced considerably by applying improved technologies. The use of synthetic chemicals for the reduction of postharvest losses and extrusion of shelf life of perishables is a threat to human health and the environment. Efforts should be made to optimize or develop suitable alternatives such as the application of different plant extracts for postharvest loss reduction, shelf-life extension along with quality retention.

With these viewpoints, the experiment was undertaken to know the appropriate plant extracts and modified atmosphere package (MAP) on banana ripening, to study the physico-chemical changes of banana fruit during storage and ripening under different postharvest treatments and to study the effect of different plant extract on disease incidence and severity of banana fruit during storage.

MATERIALS AND METHODS

Selection of site

The banana fingers for the study were brought from Mangalpur which is 10 km away from Narayangadh, Chitwan, Nepal.

Selection of the cultivar

The cultivar selected was Jhapli Malbhog which is one of the most popular and cultivated variety in that locality.

Location and time of the experiment

The post-harvest analysis was carried out in the post-harvest horticulture laboratory, AFU, Rampur, Chitwan, Nepal. Geographically, Rampur is located in the Terai belt at 27° 40' N Latitude and 84° 19' E Longitude at an altitude of 228 masl. This place has a humid subtropical climate where summers are hot and winters are cold with total annual rainfall reported as 1582.6 mm. Monsoon rain occurs from July to September. This experiment was conducted from 21st September to 16th of October 2016.

Harvesting of banana

The bunch was dehanded and divided into fingers with a help of a knife. The fruits will be selected for uniformity of size and freedom from blemishes. Fruits were washed with tap water to remove latex and dust, treated with sodium hypochlorite (500ppm) to reduce fungal infection, and air-dried.

Preparation of the plant extracts

Garlic, Neem leaves, Onion and Ginger are first of all peeled and crushed in a churner separately and the paste of pulp so obtained was taken in separate containers containing 1 litre of water in each and stirred properly. Then the banana fingers are dipped in individual solution of plant extracts and Seasmum oil.

Design of experiment

The experiment was laid out in Completely Randomized Design (CRD) with eight treatments and each treatment will be replicated three times.

Treatments details

T1 = (Control: distilled water)
T2= Garlic Extracts
T3= Neem Extracts
T4= Onion Extracts
T5= Sesamum oil
T6= Ginger Extracts
T7= Unperforated low-density polythene (LDPE) bag containing cotton soaked with $KMnO_4$
T8= Perforated low-density polythene (LDPE) bag containing cotton soaked with $KMnO_4$

Layout of the experiment

T1R1	T4R1	T5R1
T3R1	T2R1	T3R3
T5R2	T6R1	T4R3
T2R2	T7R1	T1R3
T4R2	T2R3	T3R2
T7R3	T3R1	T5R3
T6R3	T8R1	T8R3
T8R2	T1R1	T7R2

Statistical method

The Analysis of variance (ANNOVA) for all parameters was carried out as per the procedures given in GEN STAT (12th Edition). The Duncan's multiple range test (DMRT) for mean separation was done from the reference of Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

Effect of Plant Extract and MAP on Firmness

The data related to the firmness of postharvest treated fruits and their mean values are presented in Table 1. The finger became less firm with the advancement of ripening in all the

treatments. The highest firmness was observed with unperforated low-density polyethylene containing cotton soaked in $KMnO_4$ (0.833 Kg/cm^2) and the lowest firmness was observed on control (0.467 Kg/cm^2) on 15th Day after storage (DAS). This result is as per the reports of (Khatun, 2012) who reported that modified atmosphere packaging with un-perforated plastic bags showed lower firmness. Islam *et al.* (2014) also reported that the fastest rate of firmness changes was observed in the control bananas, whereas all other $KMnO_4$ treatments contributed to the reduction in firmness. The rapid firmness changes were found in bananas under control. The firmness change was due to the conversion of starch to sugars. The decrease in firmness, during ripening, may be due to the breakdown of insoluble protopectin into soluble pectin or by cellular disintegration leading to membrane permeability Brinston *et al.* (1988). The hard or semi-hard banana fruits are not liked by most consumers. A decrease in the firmness of fruits during ripening was also indicated by Acedo and Bautista (1991b).

Effect of plant extract and MAP on the pulp to peel ratio

The data relating to the pulp-to-peel ratio of postharvest treated fruits and their mean values are presented in Table 2. The highest pulp to peel ratio was observed with control (4.075) and the lowest with unperforated low-density polyethylene with cotton soaked in $KMnO_4$ (3.007) followed by Neem extracts (3.087) on 15th DAS. This study is in harmony with the reports that were presented by Hailu *et al.* (2013). Habiba *et al.* (2012) reported that the highest pulp to peel ratio was recorded from control treatment at 9th DAS. Mimi (2013) reported that the lowest pulp to peel ratio with modified atmosphere packaging with $KMnO_4$.

The increased ratio during storage may be related to a change in sugar concentration in the pulp compared to the peel, thus contributing to different changes in osmotic pressure. Water is lost from the peel of bananas both by transpiration and osmosis. As a result, the peel weight is reduced and pulp to peel ratio increases. Pathak and Sanwal (1999) studied the regulation of the ripening of banana fruits by chemicals and found that the pulp to peel ratio of banana fruits increased during ripening. The pulp-to-peel ratio was related to the change in sugar concentration in the tissues. Sugar increased more rapidly in the pulp than in the peel and thus due to top change in osmotic pressure, water was withdrawn from the peel and the pulp to peel ratio increased. Simmonds (1996) reported the reasons for an increase in pulp to peel ratio. Sugar formation takes place more rapidly in pulp than in the peel during ripening and the difference is reflected in a

Table 1. Firmness of banana under different post-harvest treatments during storage at ambient room temperature (30±5° C), Rampur, Chitwan, 2016.

Treatments	The firmness of the banana (Kg/cm^2) on days indicated				
	3	6	9	12	15
Control	3.533 ^{abc}	3.033 ^{a}	2.400 ^{a}	1.800 ^{ab}	0.467 ^{d}
Garlic extract	3.233 ^{c}	2.460 ^{c}	2.223 ^{a}	1.450 ^{bc}	0.600 ^{bc}
Neem extract	3.867 ^{a}	3.567 ^{a}	2.633 ^{a}	1.333 ^{c}	0.567 ^{cd}
Onion extract	3.367 ^{bc}	2.833 ^{bc}	2.533 ^{a}	1.600 ^{abc}	0.733 ^{bc}
Sesamum oil	3.833 ^{ab}	3.487 ^{a}	2.573 ^{a}	1.967 ^{a}	0.700 ^{ab}
Ginger extract	3.883 ^{ab}	3.583 ^{a}	2.717 ^{a}	1.533 ^{bc}	0.700 ^{a}
Unperforated LDPE+$KMnO_4$	3.400 ^{bc}	3.133 ^{ab}	2.567 ^{a}	1.533 ^{bc}	0.833 ^{a}
Perforated LDPE+$KMnO_4$	3.733 ^{ab}	3.433 ^{a}	2.467 ^{a}	1.500 ^{bc}	0.567 ^{bc}
LSD (5%)	0.3801	0.5425	0.6348	0.3801	0.2060
SEM±	0.1268	0.1810	0.2117	0.1268	0.0687
CV (%)	6.1	9.8	14.6	13.8	16.0
Grand Mean	3.606	3.191	2.514	1.590	0.742

Means within the same column followed by the same letter do not differ significantly at 5% level by DMRT.

Table 2. Pulp-to-peel ratio of banana fruit under different post-harvest treatments during storage at ambient room temperature (30±5°C), Rampur, Chitwan, 2016.

Treatments	Pulp to peel ratio on days indicated				
	3	6	9	12	15
Control	2.028	2.058 ^{a}	3.154 ^{a} b	3.337 ^{a}	4.075 ^{a}
Garlic extract	2.044	2.368 ^{a}	2.634 ^{ab}	2.870 ^{bc}	3.566 ^{abc}
Neem extract	2.032	2.255 ^{a}	2.579 ^{ab}	2.683 ^{c}	3.087 ^{c}
Onion extract	1.978	2.326 ^{a}	2.682 ^{a}	3.202 ^{ab}	3.993 ^{a}
Sesamum oil	1.965	2.304 ^{a}	2.477 ^{ab}	2.920 ^{abc}	3.672 ^{ab}
Ginger extract	1.659	2.088 ^{a}	2.653 ^{ab}	3.144 ^{abc}	3.809 ^{a}
Unperforated LDPE+$KMnO_4$	1.820	2.058 ^{a}	2.402 ^{b}	2.712 ^{c}	3.008 ^{c}
Perforated LDPE+$KMnO_4$	1.787	2.086 ^{b}	2.134 ^{b}	2.714 ^{c}	3.220 ^{c}
LSD (5%)	NS	0.4968	0.6349	0.4234	0.5319
SEM±	0.1348	0.1657	0.2118	01412	0.1774
CV (%)	12.3	13.9	14.2	8.3	8.6
Grand Mean	1.914	2.193	2.589	2.948	3.554

Means with in the same column followed by the same letter do not differ significantly at 5% level by DMRT.

differential increase in osmotic pressure. The result is the withdrawal of water from the skin by the pulp and a natural rise in pulp-to-peel ratio. The reduced ripening of bananas in LDPE plastic might be the reason for the slower change in pulp to peel ratio. Reduced water loss as a result of higher relative humidity might also be the other reason for the lowest pulp-to-peel ratio of bananas kept in LDPE plastic. An increase in the pulp-to-peel ratio is related to water loss from the peel to the pulp and the atmosphere. The faster increase in sugar content of the pulp leads to the movement of water from the pulp to the peel as a result of osmotic differences (Dadzie and Orchard, 1997).

Effect of plant extract and MAP on vitamin C content

Vitamin C content of banana pulp was considerably influenced by the various post-harvest treatments. The vitamin C content of fresh bananas ranged from 7.4 to 8.0 mg/100 g, where their value decreased from 5.1 to 6.63 mg/100g at the advanced stages of ripening. There was a decreasing trend in vitamin C content of fruit pulp throughout the storage (Table 3). The maximum vitamin C content (6.633) was recorded with neem extract and minimum Vitamin C content (5.105 mg/100g) with unperforated LDPE-containing cotton dipped in $KMnO_4$ on 15th DAS. This result is in harmony with the reports of (Islam *et al*., 2014) who reported that the highest vitamin C content was observed with the Neem extract and the lowest vitamin C content with the unperforated LDPE containing $KMnO_4$. The maximum retention of ascorbic acid (6.633 mg /100 g) with Neem leaf extracts treatment because the neem leaf extract also reduces the respiration rate as well as oxidation in the fruits (Bhardwaj *et al*., 2005). The results indicated that the rates of degradation of vitamin C were greatly retarded by the $KMnO_4$.

Effect of plant extract and MAP on the organoleptic test

The parameters taken for an organoleptic test such as sweetness, flavor, astringency and overall acceptability were influenced by different treatment combinations of plant extracts and MAP using a hedonic scale is displayed in Table 4. The respondents who participated in the organoleptic test gave the highest index value of overall acceptability (0.87), sweetness (0.80) and flavor (1.0) to control fruits on the 15th DAS. Therefore, the control fruits were evaluated better in comparison to other treatments by taste panels. This result is in line with the result of

Table 3. Vitamin C content of banana fruit under different post-harvest treatments during storage at ordinary room temperature (30±5° C), Rampur, Chitwan, 2016

Treatments	Vitamin C content of the pulp on days indicated				
	3	6	9	12	15
Control	7.524 ^{ab}	7.033 ^{ab}	6.524 ^{bc}	6.790 ^{a}	6.114 ^{ab}
Garlic extract	7.648 ^{ab}	7.476 ^{a}	6.900 ^{ab}	6.133 ^{ab}	6.233 ^{ab}
Neem extract	7.857 ^{a}	7.480 ^{a}	7.214 ^{a}	6.724 ^{a}	6.633 ^{a}
Onion extract	7.571 ^{ab}	6.862 ^{b}	7.010 ^{ab}	6.395 ^{ab}	6.243 ^{ab}
Sesamum oil	7.857 ^{a}	7.229 ^{ab}	6.867 ^{abc}	6.648 ^{ab}	6.093 ^{a}
Ginger extract	7.429 ^{b}	6.986 ^{ab}	6.752 ^{abc}	6.295 ^{ab}	6.105 ^{ab}
Unperforated LDPE+$KMnO_4$	7.524 ^{ab}	7.229 ^{ab}	6.333 ^{c}	5.857 ^{b}	5.105 ^{c}
Perforated LDPE+$KMnO_4$	7.667 ^{ab}	7.405 ^{a}	7.143 ^{a}	6.229 ^{ab}	5.568 ^{bc}
LSD (5%)	0.3580	0.5067	0.6132	0.7554	0.7523
SEM±	0.1194	0.1548	0.1690	0.2520	0.2509
CV (%)	2.7	3.7	4.3	6.8	7.2
Grand Mean	7.667	7.212	6.843	6.348	6.072

Means with in the same column followed by the same letter do not differ significantly at 5% level by DMRT.

Table 4. Organoleptic test of banana for different parameters as influenced by different post-harvest treatments in ordinary room condition (30±5°C), Rampur, Chitwan, 2016.

Parameters	Organoleptic Test on the 15th Days of Storage								
	Ratings	T1	T2	T3	T4	T5	T6	T7	T8
Sweetness	Index value	0.80	0.73	0.73	0.73	0.533	0.733	0.60	0.600
	Rank	I	II	II	II	V	IV	III	III
Flavor	Index value	1.0^{a}	0.67^{b}	0.53^{b}	0.73^{b}	0.53^{b}	0.73^{ab}	0.67^{b}	0.73^{ab}
	Rank	I	III	IV	II	IV	II	III	II
Astringency	Index value	0.40	0.60	0.60	0.67	0.60	0.60	0.60	0.60
	Rank	III	II	II	I	II	II	II	II
Overall acceptability	Index value	0.87^{a}	0.67^{ab}	0.73$^{a}_{b}$	0.77$^{a}_{b}$	0.60^{b}	0.67^{ab}	0.67^{ab}	0.73^{ab}
	Rank	I	IV	III	II	VI	IV	V	III

Means with in the same column followed by the same letter do not differ significantly at 5% level by DMRT.

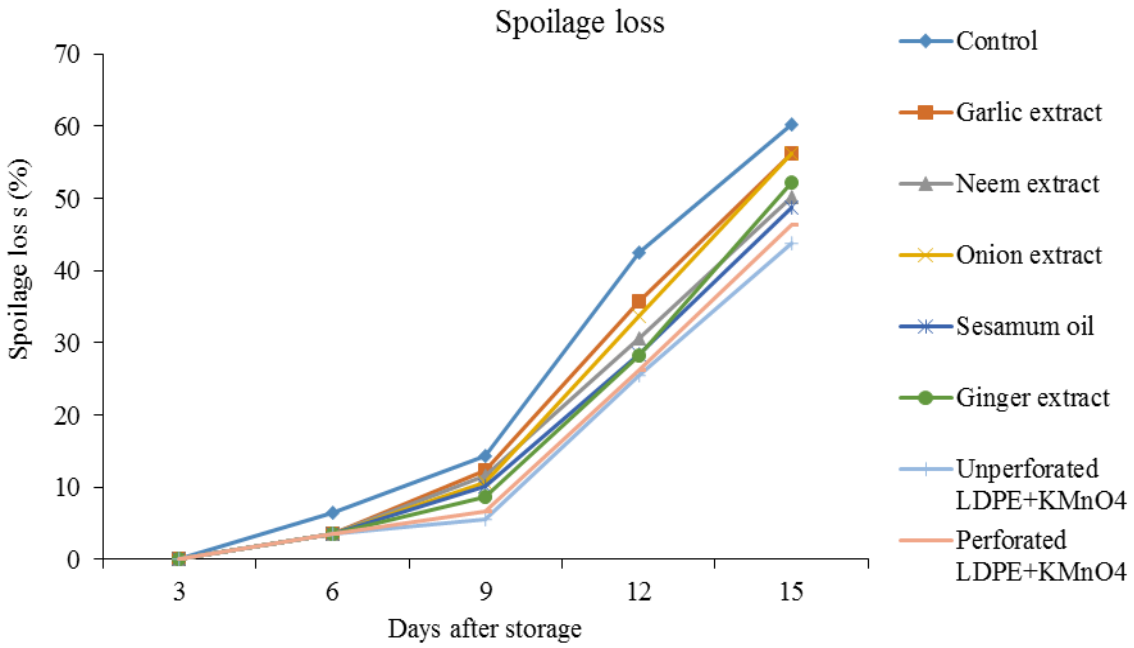


Figure 1. *Spoilage loss percentage of banana in different post-harvest treated bananas during storage ordinary room condition, Rampur, Chitwan, 2016.*

Table 5. Disease incidence on banana under different post-harvest treatments during storage at ordinary room temperature (30±5° C), Rampur, Chitwan, 2016.

Treatments	Disease incidence (%) on days indicated				
	3	6	9	12	15
Control	0	25.00 ^{a}	50.00 ^{a}	62.50 ^{a}	87.50 ^{a}
Garlic extract	0	12.50 ^{b}	25.00 ^{c}	50.00 ^{ab}	62.50 ^{bc}
Neem extract	0	12.50 ^{b}	12.50 ^{d}	16.67 ^{de}	29.17 ^{e}
Onion extract	0	8.33 ^{bc}	12.50 ^{d}	41.67 ^{bc}	54.17 ^{cd}
Sesamum oil	0	4.17 ^{cd}	12.50 ^{d}	29.17 ^{cd}	70.83 ^{b}
Ginger extract	0	12.50 ^{b}	25.00 ^{c}	33.33 ^{c}	45.80 ^{c}
Unperforated LDPE+$KMnO_4$	0	0.00 ^{d}	4.17 ^{e}	12.50 ^{e}	25.00 ^{e}
Perforated LDPE+$KMnO_4$	0	12.50 ^{b}	37.50 ^{b}	62.50 ^{a}	45.83 ^{d}
LSD (5%)	0	6.246	4.416	13.97	14.65
SEM±	0	2.083	1.473	4.66	4.89
CV (%)	0	13.3	11.4	20.9	16.1
Grand Mean	0	10.94	22.40	38.5	52.6

Means with in the same column followed by the same letter do not differ significantly at 5% level by DMRT.

(Khatiwada, 2005). There was a significant increase in the aroma of fruit and juice of passion fruit during ripening due to the increase in certain volatile compounds which act as a precursor for aroma in the fruit cells (Kishore, 2006). In artificially ripened fruits, the internal chemical changes, though slower also occurred side by side as peel color changes, thus tasting sweeter (Khatiwada, 2005). The subsequent softening of texture, and production of more sugars and volatile compounds during the ripening period are responsible for high acceptability (Mahajan *et al.*, 2008).

Effect of plant extract and MAP on spoilage loss

The data concerning the influence of the post-harvest treatment on spoilage loss of bananas is presented in Figure 1. The maximum spoilage loss occurred in the untreated fruit (60.33%) and minimum with the low-density polyethylene-containing cotton dipped in $KMnO_4$ (43.77%). The maximum spoilage loss in control might be due to the infection of fungal pathogen and minimum spoilage loss on unperforated polyethylene might be due to the hastening of the ethylene production which delays the ripening process and also may be due to the prevention entry of fungal pathogen inside the polyethylene bag.

Effect of Plant Extract and MAP on Disease incidence

The data concerning the influence of the post-harvest treatment on disease incidence of bananas is presented in Table 5. Data related to disease incidence was recorded from the 3rd DAS up to the 15th DAS, on the 3rd DAS, there was no infection by any disease. The maximum disease incidence was observed with the control (70.33 %) and minimum with unperforated LDPE containing $KMnO_4$ (25 %) followed by Neem extracts (29.17 %). This finding is in harmony with the reports of (Khatun, 2012) who reported that the maximum disease severity level was observed in control during assessing the post-harvest life of

a banana. (Singh *et al*., 1993) reported that leaf extracts of *Azadirachta indica* may delay the appearance of initial disease symptoms of infected bananas. This result of less disease is possible due to the delayed pathogenic growth and development in fruits treated with neem extracts and unperforated LDPE containing $KMnO_4$. The maximum disease occurrence in control may be due to the infection of the fungal pathogen during the storage period and the minimum with unperforated polyethylene may be due to the prevention of entry of fungal pathogens in the banana surface.

CONCLUSION

Plant extracts and modified atmospheric packages can be beneficial for the prolongation of the post-harvest fruit quality and post-harvest disease reduction in case of bananas. From this experiment, the lowest firmness and the highest pulp to peel ratio was noted with control. The maximum vitamin C content was recorded with neem extract. Regarding the organoleptic test, the index value of overall acceptability, sweetness and flavor were depicted highest with control whereas the low-density polyethylene containing cotton dipped in $KMnO_4$ resulted in minimum spoilage loss. The minimal disease incidence was noticed with the unperforated LDPE containing $KMnO_4$ followed by the Neem extracts. From the experiment, it was concluded that the low-density polyethylene-containing cotton dipped in $KMnO_4$ and Neem extract performed significantly better interms of post-harvest parameters and disease incidence. Further studies regarding the use of other plant extracts and modified atmospheric packages were recommended.

Conflict of the interest

The authors of the research affirmed no encounter of attentiveness.

ACKNOWLEDGEMENT

It is our pleasure to express our deepest acknowledgment, profound gratitude and sincere appreciation to my Advisory committee, friends, all concerned people, farmers and different governmental and non-governmental institutions for their contribution and support during this research work.

REFERENCES

Acedo, A. L., & Bautista, O.K. (1991). Enhancing ripening of 'Saba' banana (Musa, BBB group) fruits with Gliricidia leaves as ethylene source. *Philippine Agriculturalist*, 71, 351-365.

Basel, R. M., Racicot, K., & Senecal, A. G. (2002). Long shelf life banana storage using MAP storage coupled with postharvest MCP treatment. In *Annual Meeting and Food Expo-Anaheim, California, USA*.

Bhardwaj, R. L., Sen, N. L., & Mukherjee, S. (2005). Effect of benzyladenine on Physico-chemical characteristics and shelf-life of mandarin cv Nagpur Santra. *Indian Journal of Horticulture*, *62*(2), 181-183.

Brinston, K., Dey, P. M., John, M. A., & Pridham, J. B. (1988). Post-harvest changes in Mangifera indica mesocarp cell walls and cytoplasmic polysaccharides. Phytochemistry, 27(3), 719-723

Dadzie, B.K., & Orchard, J.E. (1997). Routin postharvest screening of banana/plantain hybrids criteria and methods. International network for banana and plantain (Inibap), Technical Guidelines. Rome, Italy. pp 75-76.

Gomez, K. A., & Gomez, A. A. (1984). *Second Edition / I* (second, Vol. 6).

Gonzalez, A., G. A., Buta, J. G., & Wang, C. Y. (2003). Methyl jasmonate and modified atmosphere packaging (MAP) reduce decay and maintain postharvest quality of papaya 'Sunrise'. Postharvest Biology and Technology, *28*(3), 361-370.

Habiba, U. (2012). Effects Of Different Plant Extracts On Shelf Life And Quality Of Banana (Doctoral Dissertation).

Hailu, M., Workneh, T. S., & Belew, D. (2013). Review on postharvest technology of banana fruit. African Journal of Biotechnology, *12*(7): 635-647

Islam, M.,& Rul, K. (2014). Effects of Different Levels of Ethylene Scavenging Compound on Shelf Life and Quality of Banana (Doctoral Dissertation, Myensingh University, Bangladesh).

Khatiwada, B. P. (2005). Ripening regulation of banana (Musa sapientum L.) cv. Malbhog using chemicals and indigenous plant materials. Msc thesis. Department of horticulture. Institute of Agriculture and Animal Science. Rampur, Chitwan, Nepal. 88 pp.

Kishore, K., Bharali, R., Pathak, K. A., & Yadav, D. S. (2006). Studies on ripening changes in purple passion fruit (Passiflora edulis Sims). Journal *of Food Science and Technology-Mysore*, *43*(6), 599-602.

Khatun, M.M. (2012). Effects of different postharvest treatments on storage behavior and Physico-chemical properties of Banana (Doctoral Dissertation).

Mahajan, B. V. C., Singh, G., & Dhat, A. S., (2008). Studies on ripening behavior and quality of winter guava with ethylene gas and ethephon treatment. J. Food Sci. Technol., *45*(1): 81-84

Mari, M., Bertolini, P.,& Pratella, G. C. (2003). Non conventional methods for the control of post harvest pear diseases. *Journal of Applied Microbiology*, 94(5), 761-766.

Mimi, M. A. (2013). Study of shelf life and quality of different banana varieties (doctoral dissertation).

Mondal, M. F. (2000). Production and storage of fruits (in Bangladesh). Published by Mrs. Afia Mondal, BAU Campus, Mymensingh-2202, 312.

Pathak, N., & Sanwal, G. G. (1991). Regulation of the ripening of banana (*Musa acuminata*) fruits by chemicals. *Indian Journal of Agricultural Science*, *69*(1), 17-20.

Ranasinghe, L., Jayawardena, B.,& Abeywickrama, K. (2003). Use of waste generated from cinnamon bark oil (Cinnamomum zeylanicum Blume) extraction as a post-harvest treatment for Embul banana. J. Food Agric. Environ, *1*, 340-344.

Simmonds NW (1999). Bananas. Webster printing service Ltd Bristol. Imperial College of Tropical Agriculture. Trop. Agric. 453-461.

Singh, H. N. P., Prasad, M. M., & Sinha, K. K. (1993). Efficacy of leaf extracts of some medicinal plants against disease development in bananas. *Letters in Applied Microbiology*, 17(6), 269-271.