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Original Article

Effects of variety and different coating treatments on postharvest quality and shelf life extension of banana

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ABSTRACT

An experiment was carried out at the Laboratory of Department of Horticulture, Bangladesh Agricultural University, Mymensingh during September to October 2019 to study the effect of different coating treatments on shelf-life and postharvest quality of banana. The experiment comprised of two banana varieties *viz.* V_1: Mehersagar and V_2: Amritsagar and nine coating treatments *viz.* T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC. The two-factor experiment was laid out in completely randomized design with three replications. The data on various parameters were statistically analyzed. Results revealed that between two varieties, V_2 (Amritsagar) showed the longer shelf life (11.66 days) than V_1 (Mehersagar) (9.89 days). Among the different coating treatments, T_7 (Turmeric powder) treatment showed the best performance (14 days) in shelf life extension as compared to control. In combined effect, V_2 (Amritsagar) with T_7 (Turmeric powder) treatment (V_2T_7) gave the superior result (15.0 days). This combination also caused the lowest total weight loss (9.42%), the highest moisture content (82.59%), TSS (23.67%), and pulp to peel ratio (3.20) during the period of investigation.

Introduction

Banana (*Musa* sp, family Musaceae) is the common name for herbaceous plants of the genus Musa and for the fruit they produce. They are native to the tropical region of Southeast Asia, and are likely to be first domesticated in Papua New Guinea. Banana is one of the tallest of the herbaceous plants with a pseudostem and it is possibly the world's oldest cultivated crop (Rahman *et al.*, 2006).

It is one of the most economically important fruits not only in Bangladesh but also around the globe. The climate and soil of Bangladesh are congenial for banana cultivation. Hence, banana is growing throughout the year although there is a distinct harvesting season from September to November. Bangladesh produces 833.309 thousand metric tons of bananas from 48,870 hectares of land (BBS, 2018-19). Varieties of banana grown in Bangladesh are Amritsagar, Mehersagar, Sabri, Champa, ChiniChampa, Kabuli, Jahaji, Agnishwar, Basrai, Seeded banana, Anaji or Kancha Kola and Singapuri, etc. (Haque, 1988). Banana fruits are usually harvested at physiologically mature stage. It does not ripe adequately and uniformly on the tree because of climacteric respiration. Non- uniformly ripened fruits are characterized by poor external color, texture, taste and odor.

Losses of banana occur between harvest and consumption. Banana takes 6-8 days during summer and 13-15 days during winter to ripen. Nowadays, demand of banana consumption is increasing day by day due to its high caloric and nutritional value. It is reported that the postharvest loss of banana could be 24.62% which accounts for 56.7 crore taka annually. This loss occurs during transporting and marketing due to adverse physiological changes, softening of flesh and lack of resistance capacity against microbial attack

Bananas should be harvested at appropriate stage of maturity for transport, handling and storage. Postharvest loss of banana is also occurred due to inappropriate postharvest

handling and very poor knowledge in the field of postharvest technology as well as postharvest pathology. The postharvest losses of banana 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 environment. Efforts should be made to optimize or develop suitable alternatives such as modified atmosphere packaging with or without ethylene scavenging compounds, hot water treatments, cooling, coating with organic compounds etc.

Soft texture and high moisture content of this fruit increases the chance to be wounded and contaminated during handling and transportation and this may be worsened by high temperature and relative humidity. Hence care should be taken to reduce respiration rate during storage especially in tropical and subtropical countries like Bangladesh. Improvement of shelf life may be attained with the application of a good skin coating as it reduces respiration rate and with some physical and chemical measures (Pantastico, 1975). Skin coating to prolong the shelf life of fruits is being practiced in the world. Desai *et al.* (1989) reported that banana treated with wax emulsion and thickener (Tal prolong) gave the best results with regard to shelf life. But information regarding the effect of different coating materials on shelf life of banana in our local context is scanty. Coating the fruit prior to ripening initiation delays the rapid ethylene production, thus delaying the ripening process and the chlorophyll loss which normally accompanies ripening (Banks, 1985).

Therefore, improvement of shelf life of banana is an urgent need to reduce the postharvest losses and contribute to the uplift of the national economy. Based on the above points, this experiment was undertaken to find out the effect of different coatings treatments on postharvest changes and shelf life of banana.

Materials and Methods

Experimental location

The experiment was conducted at Postgraduate Laboratory, Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from September to October, 2019. The data of physical parameters were collected from postgraduate laboratory. The detailed methodology followed to conduct the experiment is described in the following:

Experimental materials

Matured green bananas cv. Mehersagar and Amritsagar of uniform size, shape and colour were used for the study. Freshly harvested bananas of uniform size, shape and color of commercial varieties namely Mehersagar and Amritsagar were collected from BAU Horticulture Farm. Three bunches of each variety were harvested in the morning hours and transferred to the laboratory as early as possible by rickshaw with careful handling to avoid injury and placed in postgraduate laboratory of Horticulture Department of BAU. Immediately after collection, the bunches were pre-cooled by ceiling fan to remove the field heat. Both upper and lower 1-2 hands of each bunch of each cultivar were cut off for getting the experimental unit in uniform size. Two hundred and ten uniform sized fingers of each banana variety were selected.

Experimental design and treatments

The two-factor experiment was laid out in completely randomized design (CRD) with three replications of ten fruits per replication. The experiment comprised of two factors- Factor A: Two banana varieties *viz.* (i) V_1: Mehersagar and (ii) V_2: Amritsagar and Factor B: nine postharvest treatments namely, T_1: Control (untreated), T_2: GA_3 (100 ppm) + CMC (Carboxymethyl cellulose) 1%, T_3: Calcium gluconate coating (1.5%), T_4: Oil coating, T_5: Garlic extract coating, T_6: Neem leaf extract coating (35%), T_7: Turmeric powder coating, T_8: Lemon extract coating and T_9: Moringa leaf extract coating (5%) + 1% CMC.

Application of experimental treatments

The selected banana fruits were randomly assigned in the study for the postharvest treatments. After the application of treatments, the fruits were kept on a brown paper previously placed on laboratory floor at room temperature. Each treatment comprised of three replications of 1 hand. The procedures of preparation and application of the postharvest treatments to the fruits of each variety were as follows:

Control: Thirty fingers of each variety were randomly selected and kept on the brown paper placed on the laboratory table at ambient conditions for observation.

GA_3 + CMC (Carboxymethyl cellulose): For making 100 ppm GA_3 solution 200 mg GA_3 powder was dissolved in two liter distilled water and for preparing 1% CMC 20 g powdered CMC was added. To avoid clumping of CMC precaution measures were taken. The fruits were dipped into it for a period of 5 minutes of ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Calcium gluconate: 30 g Calcium gluconate powder was dissolved in two liter distilled water. The fruits were dipped into solution for a period of 5 minutes of ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Soybean oil: Two liter of Rupchanda Soybean oil packet was collected from local market. The fruits were dipped into oil for a period of 5 minutes to ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Garlic extract: Garlic was collected from local market. Extract was prepared from fresh garlic with the help of an electric blender through maceration process. Garlic extract was prepared by dissolving two kilogram (kg) garlic mash in two liter of distilled water and stirred gently by a glass rod in beaker and then the fruits were dipped into it for a period of 5 minutes to ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Neem leaf extract: Extract was prepared from the fresh leaves with the help of an electric blender through maceration process. Neem leaf extract was prepared by dissolving of 700 g neem leaf extract in two liters of distilled water and stirred gently by a glass rod in beaker and then the

fruits were dipped into it for a period of 5 minutes of ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Turmeric powder: Two kilogram (kg) Turmeric powder was collected from local market. Then the powder was mixed with two liter distilled water. The fruits were dipped into it for a period of 5 minutes of ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Lemon extract: One kilogram (kg) of lemon was collected from local market. Extract was prepared from fresh Lemon with the help of an electric blender through maceration process. Garlic extract was prepared by dissolving one kilogram (kg) garlic mash in two liter of distilled water and stirred gently by a glass rod in beaker and then the fruits were dipped into it for a period of 5 minutes to ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Moringa leaf extract + CMC:
Fresh Moringa leaves were collected from Horticulture farm. Extract was prepared from fresh Moringa leaves with the help of an electric blender through maceration process. Moringa extract was prepared by dissolving 100 gm Moringa leaf mash in two liter of distilled water and stirred gently by a glass rod in beaker. For preparing 1% CMC 20 g powdered CMC was added. To avoid clumping of CMC precaution measures were taken. Then the fruits were dipped into it for a period of 5 minutes to ensure that enough quantity of extract was being absorbed and were allowed to air dry for a period of 15 minutes and then kept on brown paper for observation.

Data collection

Physico-chemical parameters

A hand was collected randomly from each replication and variety out of each replication at the intervals of 3, 6 and 9 days of storage for physico-chemical analysis. The physico-chemical parameters were estimated by using the methods cited in the Manual of Analysis of fruit and vegetable products **(Rahganna, 1979).**

Colour: The changes in skin color were recorded visually during storage by matching the pericarp colors with a standard color chart **(RHS, 1995).**

Determination of percent weight loss: The banana hands used in this study were weighed using a top balance and kept for storage. Percent total weight loss was calculated at intervals of 3, 6 and 9 days of storage using the following formula:

$$\text{Percent weight loss (\%WL)} = \frac{IW-FW}{IW} \times 100$$

here, % WL = Percentage weight loss; IW= Initial fruit weight (g) and FW= Final fruit weight (g)

Pulp to peel ratio

The fruits were peeled at the intervals of 3, 6 and 9 days of storage. After separation of peel from pulp, the peel and pulp weights were also taken separately by using an electric balance and then the pulp to peel ratio was calculated. The pulp was then used for other chemical analysis.

Moisture content

Five grams of banana pulp was weighed in a petridish from each treatment out of each replication. The petridish was placed in an electric oven at 80°C for 72 hours until the weight became constant. It was then cooled and weighed again. Finally, the percent moisture content of banana pulp was calculated using the following formula:

$$\text{Percent moisture} = \frac{IW-FW}{IW} \times 100$$

here, IW = Initial weight of pulp (g); and FW = Final weight of oven dried pulp (g)

Dry matter content:

Percent dry matter content of the pulp was calculated from the data obtained during moisture content estimation using the following formula:

$$\text{Percent dry matter} = \frac{DW}{FW} \times 100$$

Total soluble solids (% Brix):

Total soluble solids (TSS) content of banana pulp was estimated using NR 151 Digital Refractometer. A drop of banana juice squeezed from the fruit pulp was taken into the refractometer and TSS content was recorded as % Brix from direct reading of the instrument. Temperature corrections were made using the temperature correction chart.

Shelf life of banana:

Shelf life of banana fruits as influenced by different post-harvest treatments was calculated by counting the days from harvesting up to last edible stage.

Statistical analysis:

The collected data on various parameters were statistically analyzed using MSTAT statistical package program. The means for all the treatments were calculated and analysis 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 and Discussion

Changes of fruit skin color during storage

Different external features of banana such as size, shape and peel colour of two varieties were under investigation after harvest. Good colour is the sign as the criteria of quality of most of the fruits. The changes in the colour of the banana peel from green to yellow are the most obvious change which occurs during the storage of fruits. Changes in peel colour during ripening and senescence of fruits involved either chlorophyll degradation or qualitative and quantitative alterations of green pigment into other pigment. During colour change pulp become softer and sweeter as the ratio of sugars to starch increases and the characteristics aroma is produced (Robinson, 1996). The fruit character showed a gradual increase in colour development in each of 2 varieties under different coating treatments (Plate 1 to Plate 4). The increasing rate of colour development was faster in Amritsagar and comparatively slower in Mehersagar.

Plate 1. Peel colour of banana (cv. Mehersagar) at 0 day of storage after application of different coating treatments

V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Plate 2. Peel colour of banana (cv. Mehersagar) at 9th day of storage after application of different coating treatments

V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Plate 3. Peel colour of banana (cv. Amritsagar) at 0 day of storage after application of different coating treatments

V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Plate 4. Peel colour of banana (cv. Amritsagar) at 9th day of storage as influenced by different coating treatments

V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Total weight loss

In respect of weight loss of banana less significant variation was observed among the varieties each of the days of storage period. The higher weight loss (5.69, 4.71 and 11.44% at 3, 6 and 9 DAS, respectively) was recorded in V_2 (Amritsagar) to which treatment was applied before ripening. Again, V_1 (Mehersagar) showed the lower %weight loss (5.49, 4.43 and 10.92% at 3, 6 and 9 DAS, respectively) (Fig. 1).

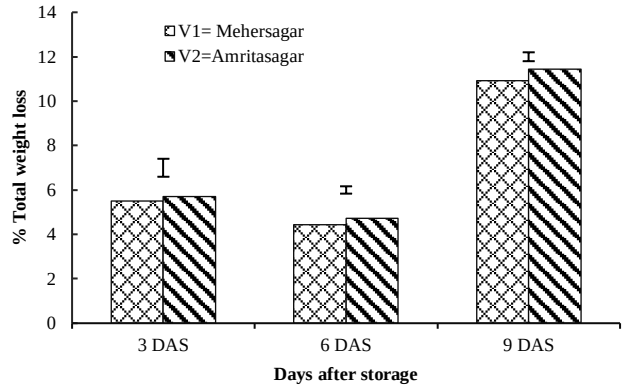

Fig. 1. Effect of variety on total weight loss of banana. Bars represent LSD at 5% level of significance. V_1: Mehersagar, V_2: Amritsagar

The different postharvest treatments showed evidence of more evident effect on weight loss of banana during storage. Variation among the treatments was highly significant during each days of storage (Fig. 2). Total weight loss on treated and untreated banana was increased with the duration of storage. The maximum weight loss (14.68%) in T_1 (Control) treatment at 9th days of storage was recorded. Among the treated banana, T_7 (Turmeric powder coating) gave the best performance on % weight loss and gave the minimum % weight loss (3.88, 3.28 and 8.59% at 3, 6 and 9 DAS, respectively) which was closely followed by T_6 (Neem leaf extract). The weight loss in banana during ripening might be due to substrate loss by respiration and loss of water through various physiological mechanisms (Islam *et al.*, 2001). This reduction in weight loss was probably due to the effects of these coatings as a semi-permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss, and oxidation reaction rates (Baldwin *et al.*, 1995). The obtained results are in accordance with the findings of Garcia *et al.* (1998) who reported that the chitosan film formed on the surface of the fruit delayed migration of moisture from the fruit into the environment, thus reducing weight loss during storage. Earlier studies by some investigators also indicated that postharvest application of Ca^{2+} accelerated ripening of 'Cavendish' bananas (Willis *et al.*, 1982; Huddar *et al.*, 1991).

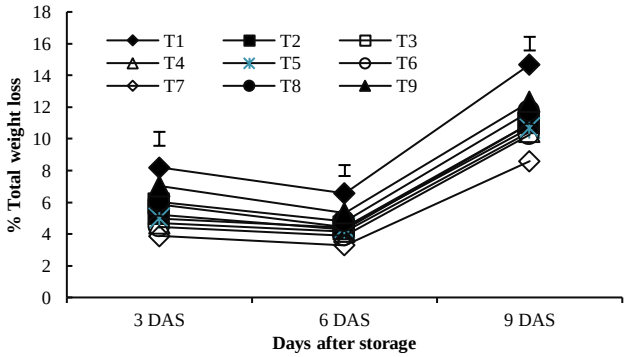

Fig. 2. Effect of treatments on total weight loss of banana. Bars represent LSD at 5% level of significance.
V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

The combined effect of two varieties and postharvest treatments were statistically significant at each day of observation. The higher level of weight loss (14.84%) was recorded in V_2 (Amritsagar) with control treatment (V_2T_1) at 9th days of storage, the maximum weight loss (12.5%) was in V_2 (Amritsagar) with T_9 treated fruits (V_2T_5) followed by (11.89%) in V_2 (Amritsagar) with T_8 treated fruit and minimum (7.76%) was observed in V_1 (Mehersagar) with T_7 treated fruits (V_1T_7) (Table 3).

Pulp to peel ratio

The varieties were found to be less significant at different storage period (Table 4). The variety, V_2 (Amritsagar) had higher pulp to peel ratio (2.16, 2.31 and 2.48 at 3, 6 and 9 DAS, respectively) and the lower pulp to peel ratio was found in V_1 (Mehersagar) (2.08, 2.20 and 2.42 at 3, 6 and 9 DAS, respectively) (Table 1).

The postharvest treatments showed a noticeable effect on pulp to peel ratio and variation among the treatments were statistically significant at different days of storage (Table 2).T_7 (Turmeric powder coating) showed the highest pulp to peel ratio (3.13 and 3.17) at 3rd and 6th DAS) followed by T_6 (Neem leaf extract) where the lowest pulp to peel ratio was achieved by T_1 (Control) (1.87, 1.31 and 1.84 at 3, 6 and 9 DAS, respectively) followed by T_9 (Moringa leaf extract coating).The increase in pulp to peel ratio during ripening was observed by Simmonds (1960) and Tripathi *et al.* (1981). The increased ratio during storage may be related to the change in sugar concentration in the pulp compared to the peel thus contributing to different change in osmotic pressure. Water is lost from the peel of banana both by transpiration and osmosis. As a result, the peel weight is reduced and pulp to peel ratio increases.

The combined effects of varieties and postharvest treatments were statistically less significant). The lowest ratio (1.24) was found in V_1 (Mehersagar) with T_1 (Control) treatment and the highest ratio (3.20) was recorded in V_2 (Amritsagar) with T_7 (Turmeric powder coating) treatment combination (Table 3). The increase in pulp to peel ratio during ripening was recorded by Tripathi *et al.* (1981), Simmonds (1960) . The increased ratio during storage may be related to the change in sugar concentration in the pulp compared to the peel thus contributing to different change in osmotic pressure. Water is lost from the peel of banana both by transpiration and osmosis. As a result, the peel weight is reduced and pulp to peel ratio increases.

Moisture content

The result showed that there were non significant differences between the varieties. The higher % moisture content was recorded in V_2 (Amritsagar) (80.64%, 81.59% and 82.74% at 3, 6 and 9 DAS respectively) and the lower (80.17%, 81.37% and 82.85% at 3, 6 and 9 DAS, respectively) in V_1 (Mehersagar) (Table 1).

During the whole storage period the % moisture content from the pulp of banana decreased. The variation was recorded among the different postharvest treatments and the result was statistically significant at each day of observation (Table 2). The highest % moisture content was recorded in T_7 (82.95%) at 9th day followed by T_6 (Neem leaf extract), while the lowest moisture content was recorded in control treatment (T_1) (79.16% and 77.96% at 6th and 9th DAS, respectively)

The combined effects of varieties and treatments were found to be statistically non significant at all days of storage (Table

3). The highest % moisture content was registered in V_2T_7 (82.59%) at 9th DAS followed by V_1T_7, V_2T_6 and V_1T_6 whereas the lowest (78.99% and 77.79% at 6th and 9th DAS, respectively) was in V_1T_1.

Table 1. Effects of variety on pulp to peel ratio, percent moisture content, percent dry matter content and total soluble solids (TSS) of banana at different days after storage (DAS)

Treatments	Pulp to peel ratio at			% Moisture content at			% Dry matter content at			TSS (%) at			
	3	6	9	3	6	9	3	6	9	0	3	6	9
V_1 (Mehersagar)	2.08	2.20	2.42	82.35	81.37	80.17	7.20	7.42	6.82	4.15	5.60	11.36	20.85
V_2 (Amritsagar)	2.16	2.31	2.48	82.74	81.59	80.64	8.10	7.96	8.20	5.00	6.25	12.25	23.00
LSD (0.01)	0.15	0.24	0.25	0.95	0.96	0.86	0.61	0.79	0.84	0.17	0.65	0.78	1.43
LSD (0.05)	0.11	1.18	0.19	0.71	0.72	0.64	0.46	0.59	0.62	0.13	0.49	0.59	1.07
Level of signi.	NS	NS	NS	NS	NS	NS	**	*	**	**	*	**	**

NS= Non-significant , * = Significant at 5% level of probability, ** = Significant at 1% level of probability,

Table 2. Effects of treatments (different coatings) on pulp to peel ratio, percent moisture content, percent dry matter content and total soluble solids (TSS) of banana at different days after storage (DAS)

Treatments	Pulp to peel ratio at			% Moisture content at			% Dry matter content at			TSS (%) at			
	3	6	9	3	6	9	3	6	9	0	3	6	9
T_1	1.87	1.31	1.84	81.15	79.16	77.96	7.20	7.42	6.82	5.33	7.45	17.27	24.83
T_2	2.04	2.24	2.36	82.84	81.06	79.86	8.10	7.96	8.20	4.50	5.83	11.67	22.50
T_3	2.02	2.20	2.17	82.28	81.79	80.59	7.20	7.42	6.82	4.50	7.06	13.50	24.42
T_4	2.18	2.31	2.60	83.32	82.18	80.98	8.10	7.96	8.20	4.50	5.50	10.67	23.00
T_5	2.16	2.27	2.45	83.17	81.91	80.71	7.20	7.42	6.82	4.83	6.42	13.67	23.75
T_6	2.24	2.78	2.78	83.72	82.65	81.45	8.10	7.96	8.20	4.50	5.33	11.43	23.92
T_7	2.57	3.13	3.17	84.67	83.00	82.95	7.20	7.42	6.82	4.50	5.42	10.50	17.08
T_8	2.09	2.08	2.40	81.35	80.29	79.09	8.10	7.96	8.20	4.50	5.50	11.33	23.67
T_9	1.89	2.01	2.25	80.43	81.27	80.07	7.20	7.42	6.82	4.00	4.83	6.23	14.18
LSD (0.01)	0.32	0.52	0.53	2.01	2.04	2.82	1.30	1.67	1.77	0.36	1.39	1.67	3.03
LSD (0.05)	0.24	0.39	0.40	1.50	1.52	1.37	0.97	1.24	1.32	0.27	1.04	1.24	2.26
Level of signi.	**	**	**	**	**	**	**	**	**	**	**	**	**

**=Significant at 1% level of probability, T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Table 3. Combined effects of variety and treatments and different coating on percent total weight loss, pulp to peel ratio and percent moisture content of banana at different days after storage (DAS)

Treatment combinations	% Total weight loss at			Pulp to peel ratio at			% Moisture content at		
	3	6	9	3	6	9	3	6	9
V_1T_1	8.12	6.49	14.51	1.82	1.24	1.80	80.98	78.99	77.79
V_1T_2	5.32	4.15	10.8	2.08	2.22	2.34	82.78	81.01	79.81
V_1T_3	5.33	4.19	10.35	1.93	2.19	2.17	82.28	81.76	80.56
V_1T_4	4.29	3.85	10.27	2.08	2.28	2.53	83.27	81.89	80.69
V_1T_5	4.97	4.13	10.78	2.17	2.22	2.43	83.05	81.85	80.65
V_1T_6	4.29	3.8	10.1	2.22	2.62	2.73	83.71	82.63	81.43
V_1T_7	4.07	3.36	7.76	2.51	3.08	3.13	83.91	82.50	81.30
V_1T_8	5.73	4.67	11.55	2.04	2.03	2.37	81.30	80.20	79.00
V_1T_9	7.27	5.2	12.16	1.84	1.94	2.23	79.91	81.51	80.31
V_2T_1	8.26	6.64	14.84	1.92	1.38	1.88	81.32	79.33	78.13
V_2T_2	6.41	4.72	11.13	1.99	2.25	2.38	82.90	81.11	79.91
V_2T_3	4.65	4.62	11.01	2.12	2.22	2.17	82.28	81.83	80.63
V_2T_4	5.04	4.45	10.61	2.27	2.33	2.67	83.37	82.47	81.27
V_2T_5	5.47	4.43	11.12	2.14	2.31	2.48	83.29	81.97	80.77
V_2T_6	4.62	3.99	10.43	2.26	2.95	2.82	83.73	82.67	81.47
V_2T_7	3.69	3.2	9.42	2.64	3.18	3.20	85.43	83.50	82.59
V_2T_8	6.33	4.91	11.89	2.15	2.13	2.43	81.41	80.39	79.19
V_2T_9	6.77	5.45	12.5	1.94	2.08	2.27	80.94	81.02	79.82
LSD (0.01)	1.67	1.32	1.63	0.45	0.73	0.76	2.85	2.88	2.58
LSD (0.05)	1.24	0.98	1.21	0.33	0.55	0.56	2.12	2.15	1.92
Level of signi.	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant, V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Dry matter content

The result showed that there were significant differences between the varieties. The higher % dry matter content was recorded in V_2 (Amritsagar) (8.10%, 7.96% and 8.20% at 3, 6 and 9 DAS, respectively) and the lower (7.20%, 7.42% and 6.82% at 3, 6 and 9 DAS, respectively) in V_1 (Mehersagar) (Table 1).

During the whole storage period the % dry matter content from the pulp of banana decreased. The variation was recorded among the different postharvest treatments and the result was statistically significant at each day of observation (Table 2). The highest % dry matter content was recorded in T_6 (Neem leaf extract) (8.20%) at 9th day followed by T_8 (Lemon extract), while the lowest moisture content was recorded in control treatment (T_1) (7.20%, 7.42% and 6.82% at 3rd 6th and 9th DAS, respectively).

The combined effects of varieties and treatments were found to be statistically non-significant at all days of storage (Table 4). The highest % dry matter content was registered in V_2T_1 (11.50%) at 9th DAS followed by V_2T_9, V_2T_5 and V_2T_3 whereas the lowest (6.83% and 4.79% at 6th and 9th DAS, respectively) was in V_1T_6.

Total soluble solids (TSS)

The different varieties used in the investigation showed statistically significant effect on total soluble solids content of banana. The variety, V_2 (Amritsagar) had higher TSS content (5.0%, 6.25%, 12.25% and 23.00% at 0, 3, 6 and 9 DAS, respectively) and the variety V_1 (Mehersagar) had lower TSS content (4.15%, 5.60%, 11.36% and 20.85% at 0, 3, 6 and 9 DAS, respectively) (Table 1).

The different treatments used in the investigation showed statistically significant variation in relation to percent TSS at different days of storage (Table 2). Control treatment, T_1 showed the highest TSS content (24.83%) at 9th DAS. But under the treated terms, T_3 (Carboxymethyl cellulose) showed the highest TSS content (24.42%) at 9th DAS followed by T_6 (Neem leaf extract) where the lowest TSS content was achieved by T_9 (Moringa leaf extract + CMC) (6.23% and 14.18% at 6 and 9 DAS, respectively) followed by T_7 (Turmeric powder coating). This observation is somewhat similar to Pinaki *et al.* (1997). The increase in TSS content is due to the conversion of complex carbohydrates into simple sugars.

It was found that the combined effects of varieties and postharvest treatments were statistically significant (Table 4). It was found that control treatment with V_1 (Mehersagar) and V_2 (Amritsagar) showed the highest TSS content at 3rd and 6th DAS. At 9th day the highest value was recorded in V_2T_8 (25.67%). Results also revealed that the lowest TSS content was found from V_2T_9 (6.73% and 14.20% at 6 and 9 DAS, respectively) followed by V_1T_4. (Table 6) This observation is somewhat similar to Pinaki *et al.* (1997).

Table 4. Combined effects of variety and treatments and different coating on percent dry matter content and Total Soluble Solids (TSS) of banana at different days after storage (DAS)

Treatment Combinations	% Dry matter content at			TSS (%) at			
	3	6	9	0	3	6	9
V_1T_1	8.70	8.00	7.77	5.00	6.40	16.60	24.33
V_1T_2	6.69	6.23	7.12	4.00	5.17	11.33	21.33
V_1T_3	6.73	7.74	5.70	4.00	5.17	11.27	22.50
V_1T_4	6.09	6.84	6.35	4.00	5.07	9.67	17.00
V_1T_5	6.29	6.70	5.51	4.33	6.17	13.33	22.17
V_1T_6	5.95	6.83	4.79	4.00	6.78	13.33	22.17
V_1T_7	4.09	5.27	5.79	4.00	5.17	10.00	22.33
V_1T_8	7.22	7.85	6.77	4.00	5.5	11.00	21.67
V_1T_9	8.39	8.48	7.36	4.00	5.00	5.73	14.17
V_2T_1	11.72	10.56	11.50	5.67	8.50	17.93	26.67
V_2T_2	8.55	8.19	8.68	5.00	6.50	12.00	23.67
V_2T_3	9.04	8.33	9.30	5.00	5.50	11.60	25.33
V_2T_4	7.34	6.56	7.29	5.00	5.77	11.33	17.17
V_2T_5	7.62	7.03	9.41	5.33	6.67	14.00	25.33
V_2T_6	7.07	7.74	4.93	5.00	7.33	13.67	25.33
V_2T_7	6.39	7.54	8.59	5.00	5.83	11.33	23.67
V_2T_8	9.05	8.82	7.75	5.00	5.50	11.67	25.67
V_2T_9	10.72	9.65	10.58	4.00	4.67	6.73	14.20
LSD (0.01)	1.84	2.36	2.51	0.52	1.97	2.36	4.29
LSD (0.05)	1.37	1.76	1.87	0.39	1.46	1.76	3.20
Level of signi.	NS	NS	*	*	NS	NS	*

NS = Non-significant, * = Significant at 5% level of probability, V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Shelf life

Shelf life is the period of time which start from the time of harvesting and extend up to the start of rotting of fruit and it is the basic quality of fruit as well as it is the most important parameter in loss of reduction biochemical reaction of fruit. Result showed that there were significant differences among the varieties. The longer shelf life (11.66 days) was observed in V_2 (Amritsagar) and lower (9.89) in V1 (Mehersagar) (Fig. 3).

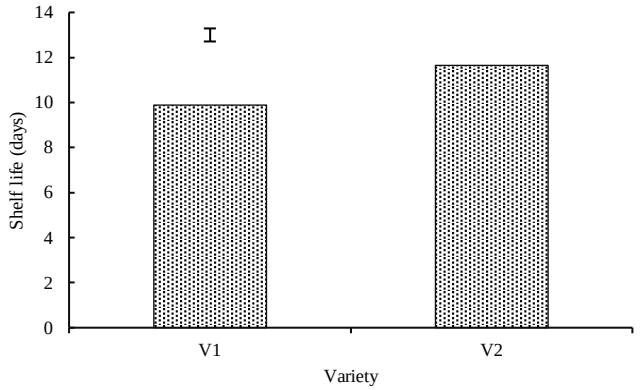

Fig. 3. Effect of variety on shelf life of banana. Bar represents LSD at 5% level of significance. V_1: Mehersagar, V_2 :Amritsagar

The effect of different postharvest treatments used in the present study was highly significant in respect of shelf life of banana (Fig. 4). The longest shelf life (14 days) was recorded in T_7 (Turmeric Powder) treated fruits whereas shortest shelf life (8.5 days) was recorded in control (T_1) followed by T_9 (Moringa leaf extract) treated fruits (7.17 days). Use of edible coatings is a common issue that is beneficial to protect nutrients of food, especially fruits and vegetables, and provide a long durability. Edible coatings have long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping retain volatile flavor compounds, and reducing microbial growth (Debeaufort *et al.*, 1998).

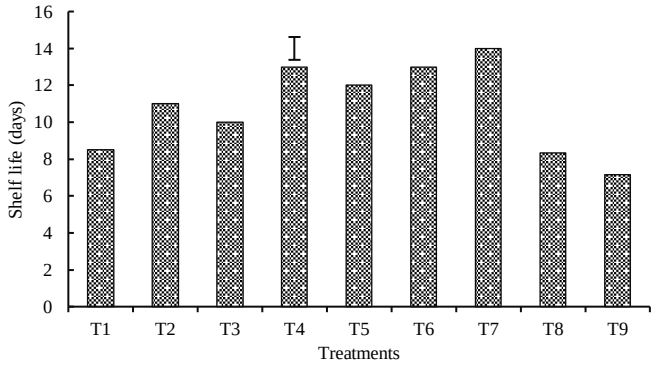

Fig. 4. Effect of different treatments on shelf life of banana. Vertical bar represents LSD at 5% level of significance. T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

The combined effect of varieties and treatments were significant in case of shelf life of banana (Fig. 5). The maximum shelf life (15.0 days) was found in V_2 (Amritsagar) with T_7 (Turmeric powder coating) treated fruits combination (V_2T_4) followed by V_2T_6, V_2T_5, V_1T_7 and V_1T_6. The minimum shelf life (6.33 days) was recorded in V_1 (Mehersagar) with control treatment (V_1T_1) (Table 18) followed by V_1T_8, V_2T_9 and V_2T_8.

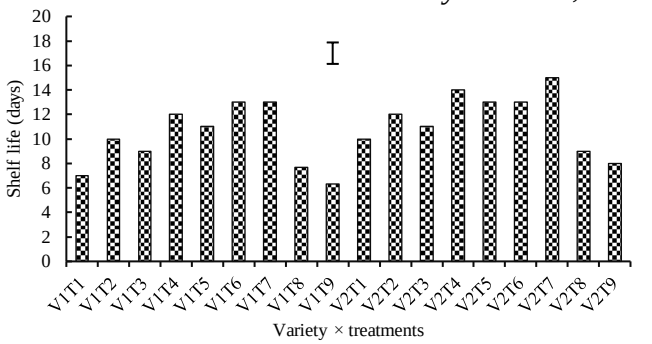

Fig. 5. Combined effect of variety and treatment on shelf life (days). Bar represents LSD at 5% level of significance.
V_1: Mehersagar; V_2: Amritsagar; T_1: Control (Untreated), T_2: GA_3 (100 ppm) + Carboxymethyl cellulose (CMC) 1 %, T_3: Calcium gluconate, T_4: Soybean oil, T_5: Garlic extract, T_6: Neem extract, T_7: Turmeric powder, T_8: Lemon extract and T_9: Moringa leaf extract (5%) + 1% CMC.

Conclusions

Results indicated that variety and different coating materials had significant effects on shelf-life and postharvest quality of banana. Considering varietal performance, in maximum cases V_2 (Amritsagar) gave better performance than V_1 (Mehersagar) for all the parameters studied. V_2 (Amritsagar) gave the higher total weight loss (11.44%), higher moisture content (82.59%), higher dry matter content (11.50%), higher Total Soluble Solids (TSS) (23.00%) and higher pulp to peel ratio (2.48) where V_1 (Mehersagar) gave the lower total weight loss (10.92%), lower moisture content (77.79%), lower dry matter content (4.79%), lower TSS (20.85%) and lower pulp to peel ratio (2.42). In view of shelf life, V_2 (Amritsagar) was better than V_1 (Mehersagar).

In case of different treatments for increasing shelf life, T_7 (Turmeric Powder Coating) gave the best performance for all the parameters studied compared to control. Banana treated with T_7 (Turmeric Powder Coating) gave the lowest total weight loss (8.59%), highest moisture content (92.95%), TSS (17.08%) and Pulp to peel ratio (2.78) where control treatment gave the lowest performance in several cases such as higher weight loss (8.59%), lower moisture content (87.96%) lower pulp to peel ratio (1.80). Under the treated banana, T_7 (Turmeric powder coating) showed the best performance where T_9 (Moringa extract) gave the lowest performance. Considering shelf life, T_7 (Turmeric Powder coating) showed highest result (14 days) where T_9 (Moringa leaf extract) showed only 7.17 days of shelf life.

In terms of combination of variety with coating treatments, the lowest total weight loss (7.76%), TSS (22.33%) and lowest Pulp to peel ratio (3.13) of banana was obtained from V_1 (Mehersagar) with T_7 (Turmeric powder) treatment (V_1T_7) compared to control with V_1 (Mehersagar) and V_2 (Amritsagar) where V_2T_9 (Moringa leaf extract) gave the lowest performance among the treatment combination and also observed that with this treatment combination (V_2T_1) shelf life of banana was continued 10^{th} day where V_2T_7 showed the highest shelf life (15 days)

From the above discussion it can be concluded that coating showed significant performance on shelf life of banana. Among the two tested variety, V_2 (Amritsagar) with coating T_7 (Turmeric powder coating) gave longer shelf life (15.0 days) where control treatment with V_2 (Amritsagar) gave the lowest (10 days) shelf life. Treatment T_5 (Garlic extract) and T_6 (Neem leaf extract) with V_2 (Amritsagar) also showed promising result on shelf life of banana.

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