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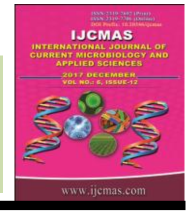

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Effect of Packaging Materials with Ethylene Absorbents on Quality of Banana Fruits Cv. Martaman

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A B S T R A C T

An experiment was conducted during the period of 2014-15 at the Department of Post-Harvest Technology of Horticultural Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, West Bengal to study the effect of treatments on quality of banana fruits. Banana fruits cv. Martaman were packed in different plastic packages (1% perforated HDPE, 2% perforated HDPE, un-perforated HDPE, 1% perforated LDPE, 2% perforated LDPE and un-perforated LDPE) with ethylene absorbents and placed in ambient condition whereas control was without packaging. The fruits were examined for physiological parameters *i.e.*, physiological loss in weight (PLW), shelf life, ripening and biochemical characteristics viz., TSS, titratable acidity, ascorbic acid, total and reducing sugar. The results revealed that fruits cv. Martaman packed in un-perforated LDPE with ethylene absorbent under ambient condition proved to be the better treatment than rest of the treatments. The treatment effectively reduced PLW %, also rich in ascorbic acid and there is more gradual decrease in TSS, total and reducing sugar than other treatments up to 12^{th} day. But as per sensory quality the maximum score was attained in 2% perforated LDPE (T_5) for cv. Martaman. These treatments enhanced shelf life and maximum retention of nutritional quality.

Introduction

Banana (*Musa paradisiaca* L.) belonging to the family Musaceae, is one of the most important fruit crop of the world. It is a tropical, herbaceous, monocotyledonous and monocarpic fruit crop. In India banana is predominant and popular among the people as they are relished and consumed by all kind of people. Considering the nutrition and fruit values of banana it is believed to be the "Poor Man's Apple" (Patel *et al.*, 2010) and it is the cheapest among all the fruits in the country. India is the largest banana producer and consumer country in the world followed by China, contributing about 39% of the total world production. The post-harvest losses of fresh banana fruits go up to 30-40% due to improper handling, storage (Patil and Hulamani, 1998) and other reasons like browning, abrasion, senescence, skin discoloration, fungal decay etc. Banana is a very perishable fruits and it possess very short shelf life nearly 10-12 days under ambient condition, both ripe and unripe banana is very susceptible to mechanical damage. Banana is hardly compatible with other crops in mixed load in storage or during transport because it produces high amount of ethylene and also susceptible to chilling injury. Lack of storage facilities, limited access to transportation and risk of high losses, growers are often forced to dispose off their produce over a short period of time (Haidar and Demisse, 1999) which causes an economic loss of banana.

When fruits approach maturity, they release ethylene which promotes to ripening. Among the many changes that ethylene causes is the destruction of chlorophyll. Thus ethylene plays an essential role in the ripening of climacteric fruit. Banana being climacteric fruit, control of ethylene will solve many of the problems. Use of ethylene absorbent at such temporary storage will postpone the untimely climacteric process. Ethylene absorbent acts as oxidizing agent, which oxidized ethylene to acetaldehyde (CH_3CHO), which in turn is oxidized to acetic acid (CH_3COOH). Acetic acid is further oxidized to carbon dioxide (CO_2) and water (H_2O). This loss can be kept at minimum by improving postharvest handling techniques through the use of packaging materials or through improving traditional packaging practices. Use of ethylene absorbent during transport will retard the chances of untimely ripening during transport. The study was undertaken with a view to make this technology available to regional farmers at a reasonable price, to enhance shelf life of banana by using ethylene absorbent and storing in different packaging materials.

Materials and Methods

The present experiment was carried out under the laboratory conditions in the department of Post-Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during the year of 2014-15. Banana fruits cv. Martaman were harvested at properly matured but unripe stage and brought to the laboratory for post-harvest study. The hands were separated from the bunch. Washing of fruits was done in tap water and then in distilled water containing 50 ppm of chlorine ($CaCl_2$) to reduce the microbial load, after that they were kept under fan for surface drying at room temperature. The temperature ranges from 17^0C–33.05^0C and relative humidity 70-92% during the month of October to December. Banana fruits after proper surface drying were packed with different packaging materials *viz*., 1% perforated High Density Polyethylene (T_1), 2% perforated High Density Polyethylene (T_2), un-perforated High density polythene (T_3), 1% perforated Low Density Polyethylene (T_4), 2% perforated Low Density Polyethylene (T_5), un-perforated Low Density Polythene (T_6) and one ethylene absorbent sachets (4gm $KMnO_4$/Kg of fruit) was placed in each bag. Fruits without packaging and ethylene absorbent were kept as control (T_7) for comparison. 10 fruits were placed in each polyethylene bag.

Physiological loss in weight was calculated on the basis of initial weight at three days interval and expressed in percent (%). Titratable acidity was measured by titrating fruit juice with 0.1 NaOH with phenolphthalein as an indicator. The data was statistically analyzed as per the method given in A.O.A.C. (1990). Total soluble solid (TSS) was estimated by hand refractometer (0-32°B). The readings obtained were calibrated against a standard temperature at 20°C as per the International Temperature Correction Table and expressed as °Brix. Ascorbic acid was determined by standard method (AOAC, 1990) and results were expressed as percentage citric acid of juice. Total sugars and reducing sugars were measured by the method of Ranganna (2000). Colour, flavor and overall acceptability were assessed based on the hedonic scale (Ranganna, 2000). The analysis of the data obtained in experiment was analyzed by Completely Randomized Design method. Standard error (S.Em ±) and the critical difference (P= 0.05) for all effects were calculated (Gomez and Gomez, 1984).

Results and Discussion

Physiological loss in weight (%) and ripening (%)

The effects of different packaging and ethylene absorbent on PLW % of cv. Martaman in ambient condition are being presented in Table 1 and they were highly significant. It can be seen that in general, weight losses increased considerably in all the treatments with progress of storage period but control fruits recommended higher PLW % throughout the storage period. Whereas fruits packed in un-perforated LDPE (T_6) recommended minimum PLW % throughout the storage period. On 12th day maximum PLW % (10.37%) was observed in control fruits (T_7) and minimum (0.67%) was recorded in un-perforated HDPE (T_3), followed by T_6 (1.31%) after which fruits deteriorates in un-perforated HDPE (T_3) and control (T_7) in storage period. But on 15th day of storage least PLW% was observed in un-perforated LDPE (T_6) with a loss of 1.38 %. Stover and Simmonds (1987) reported that banana fruits loss weight due to respiration and transpiration as a result of the appearance, textural and nutritional qualities of the fruit were negatively affected.

As can be seen from table longest shelf life 18 days was observed in un-perforated LDPE (T_6) followed by 1% perforated LDPE (T_4) *i.e.*, 17 days. The shortest shelf life was seen in T_7 (control) which deteriorated after 12th days of storage. In general, un-perforated LDPE (T_6) extends the shelf life by 6 days over control. The significant increase in the ripening (%) of banana with ethylene absorbent was more pronounced from the starting and the trend continued up to 15 days of storage. Untreated fruits showed 100% ripening on 10th day whereas treated fruit showed after 12th day of storage under ambient condition. In general un-perforated LDPE (T_6) recorded minimum ripe fruit percentage (90%) on 15 days of storage which was statistically different from other packaging products.

Titratable acidity (%)

The data showing change in percentage of titratable acidity in banana due to different packaging materials and ethylene absorbent. Treatments also produced significant effect on 3rd to 12th days of storage at 5% level of critical difference. The acidity contents of the fruits were increased initially from 0 to 3 days which could be due to the synthesis of organic acids from carbohydrate. After that it was decreased this could be due to its utilization of organic acids as a substrate and by conversion of acids into sugars.

Table 2 showed that the acidity content of T_3 (un-perforated HDPE) was significantly superior throughout the period of storage from 3rd to 12th day of storage *i.e.*, at 3rd (0.53%), 6th (0.45%), 9th (0.43%) and 12th day (0.38%) of storage, which was statistically different from the other treatments at 3rd and 12th day of storage but was at par with T_6 at 6th and 9th day of storage. Thus, treated fruits exhibited a tendency to retain more acidity during storage. The lowest value of acidity was observed in T_7 (control) with 0.17% acidity in the 12th day of storage. The result corroborates the findings of Gowen (1995), who reported that in the course of ripening free acidity increases until it reaches fully ripe stage and then free acidity decreased gradually thereafter.

Table.1 Effect of packaging and ethylene absorbent on the physiological loss in weight, Shelf Life and ripening of banana fruits cv. Martaman

Treatment	PLW (%)					Shelf life (days)	Ripening (%)			
	3 days	6 days	9 days	12 days	15days		6 days	9days	12days	15days
T_1	1.91	2.22	2.43	2.56	2.7	16.17	30	55	85	98
T_2	0.94	1.56	3.22	4.63	4.8	15.25	35	60	90	100
T_3	0.04	0.34	0.62	0.67	-	13.55	49	85	100	-
T_4	0.33	1.65	2.89	3.85	3.92	17.18	25	55	80.3	95.3
T_5	0.63	1.57	2.57	3.95	3.99	16.23	30	60	85.3	100
T_6	0.29	0.63	1.20	1.31	1.38	18.35	20	50	75.3	90
T_7	1.32	3.64	6.60	10.37	-	12.13	65	89	100	-
SE.m(±)	0.013	0.045	0.043	0.037	0.035	0.101	1.294	0.634	0.35	0.436
CD (0.05%)	0.038	0.136	0.13	0.113	0.121	0.306	3.924	1.922	1.061	1.324

Table.2 Effect of packaging and ethylene absorbent on titratable acidity and TSS of banana fruits cv. Martaman

Treatment	Titratable acidity (%)					TSS(^{O}B)				
	0 days	3 days	6 days	9days	12days	0 days	3 days	6 days	9 days	12 days
T_1	0.15	0.41	0.33	0.32	0.3	10.5	14.63	19.26	22.17	24.51
T_2	0.15	0.33	0.27	0.27	0.21	10.5	15.96	20.16	22.77	25.17
T_3	0.15	0.53	0.45	0.43	0.38	10.5	14.06	18	21.33	23.83
T_4	0.15	0.39	0.34	0.32	0.27	10.5	14.46	18.93	21.97	24.17
T_5	0.15	0.30	0.28	0.26	0.19	10.5	14.94	19.66	22.50	25.04
T_6	0.15	0.46	0.42	0.4	0.35	10.5	13.83	17.43	21.03	23.33
T_7	0.15	0.25	0.23	0.22	0.17	10.5	16.33	21.16	23.87	25.33
SE.m(±)	-	0.011	0.013	0.012	0.006	-	0.229	0.229	0.214	0.138
CD (0.05%)	-	0.033	0.041	0.036	0.018	-	0.693	0.675	0.65	0.419

Table.3 Effect of packaging and ethylene absorbent on ascorbic acid and total sugar of banana fruits cv. Martaman

Treatment	Ascorbic acid(mg/100g)					Total sugar (%)				
	0 days	3 days	6 days	9days	12days	0days	3days	6days	9days	12days
T_1	4.29	5.77	8.00	6.08	5.25	2.089	4.1	7.80	11.18	17.37
T_2	4.29	5.14	7.05	5.63	4.82	2.089	4.42	8.08	12.25	17.93
T_3	4.29	6.17	8.51	6.33	5.82	2.089	3.41	7.07	10.63	16.42
T_4	4.29	5.43	7.63	5.90	5.04	2.089	3.93	7.33	10.74	16.77
T_5	4.29	4.93	6.73	5.55	4.42	2.089	4.17	7.93	11.93	17.77
T_6	4.29	6.00	8.22	6.22	5.60	2.089	3.08	6.93	10.08	15.97
T_7	4.29	4.67	6.03	5.04	4.37	2.089	4.67	9.63	14.00	18.83
SE.m($\pm$)	-	0.097	0.093	0.155	0.097	-	0.073	0.091	0.15	0.118
CD (0.05%)	-	0.295	0.282	0.471	0.294	-	0.223	0.277	0.455	0.358

Table.4 Effect of packaging and ethylene absorbent on reducing sugar of banana fruits cv. Martaman

Treatment	Reducing sugar (%)				
	0 days	3 days	6 days	9days	12days
T_1	1.085	2.07	2.90	4.90	6.57
T_2	1.085	2.60	3.54	5.63	7.06
T_3	1.085	1.77	2.43	4.08	6.04
T_4	1.085	2.00	2.79	4.67	6.30
T_5	1.085	2.42	3.11	5.22	6.97
T_6	1.085	1.93	2.20	3.90	5.90
T_7	1.085	2.90	4.42	6.73	7.67
SE.m($\pm$)	-	0.059	0.123	0.078	0.094
CD (0.05%)	-	0.18	0.373	0.237	0.286

Table.5 Effect of packaging and ethylene absorbent on sensory score of banana fruits cv. Martaman

Treatment	**Colour (10)**			**Flavour (10)**			**Overall (20)**		
	6 days	9 days	12 days	6 days	9 days	12 days	6 days	9 days	12 days
T_1	6.40	7.60	8.06	5.76	6.46	7.63	12.16	14.00	15.70
T_2	7.40	7.90	8.40	6.60	7.16	8.23	14.00	15.00	16.60
T_3	6.20	7.50	7.70	4.80	5.80	7.10	11.00	13.30	14.80
T_4	6.80	7.30	8.13	6.16	6.80	7.83	12.90	14.10	15.90
T_5	7.20	8.16	8.70	7.00	7.46	8.73	14.20	15.60	17.40
T_6	6.43	7.60	7.90	5.43	6.20	7.20	11.80	13.80	15.10
T_7	7.50	8.60	8.10	7.86	8.33	6.93	15.32	16.90	15.00
SE.m (±)	0.045	0.061	0.062	0.120	0.087	0.098	0.165	0.148	0.160
CD (0.05%)	0.137	0.184	0.188	0.363	0.262	0.298	0.500	0.446	0.486

Total soluble solids (%)

TSS is a major quality parameter, which is correlated with the texture and composition (Kamiloglu, 2011). The data showed a constant increase in TSS value during the course of storage with untreated control maintaining higher values for TSS.

Control fruits (T_7) showed maximum TSS (25.33°Brix) on 12th day, was *at per* with T_2 (25.17 °Brix) and T_5 (25.04 %). Un-perforated LDPE (T_6) and un-perforated HDPE (T_3) showed minimum TSS content of 23.33 and 23.83^{0}Brix, respectively on the same day of storage. Stover and Simmonds (1987) reported that the conversion of starch into sugars to be the most important change in ripening bananas. Un-perforated polyethylene bags are known to reduce loss of moisture and hydrolysis of polysaccharides resulting in less increase in TSS.

Ascorbic acid (mg/100 gm)

Data in the Table 3 shows that there was a significant variation for the effect of different treatments on the ascorbic acid content of cv. Martaman fruits. The ascorbic acid contents of the fruits increased initially from 0 to 6 days after that decreased gradually during the storage in all treatments. The highest retention of ascorbic acid content was seen in treatment T_3(un-perforated HDPE) during storage *i.e.*, at 3rd (6.17 mg/100g), 6th (8.51 mg/100g), 9th (6.33 mg/100 g) and 12th day (5.82 mg/100 g) of storage, which was at par with T_6 at 3rd and 12th day of storage but at 9th day, it was statistically similar with T_1, T_4 and T_6. The maximum loss was observed in T_7 throughout the period of storage. The loss in ascorbic acid content with the progress of storage period could be attributed to rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L-ascorbic acid oxidase (Basir and Abu-Goukh, 2002).

Total sugar (%)

The changes in total sugar content as influence by various treatments was studied and detail given in Table 3. It is observed that total sugar percentage increased with advancement of storage period up to 12th day for all treatments. Total sugar of T_6 (un-perforated LDPE) remained significantly low throughout the storage period *i.e.*, at 3rd (3.08 %), 6th (6.93 %), 9th (10.08 %) and 12th day (15.97%) of storage which was statistically different from the other treatments at 3rd, 9th and 12th day of storage but was at par with T_3 (7.07%) on 6th day of storage. However, the maximum total sugar was seen in T_7 (control) during storage under ambient condition which was statistically different from all the other treatments. The present study was in line with the report of Dadzie and Orchard (1997) that, the most striking postharvest chemical change which occurs during the postharvest ripening of banana is the hydrolysis of starch and the accumulation of sugar (that is, sucrose, glucose and fructose) which are responsible for the sweetening of the fruit.

Reducing sugar (%)

Data given in Table 4 indicates that among the treatments there were significantly differences with respect to reducing sugars. From the result it can be observed that reducing sugar content in all the treatments exhibited a continuous increase throughout the storage period. Maximum reducing sugars was observed in case of control (T_7) in ambient storage and continued upto 12th day of storage which was statistically different with other treatments. Reducing sugars was minimum in T_6 (un-perforated LDPE) which was 5.90% on the 12th day of storage that was significantly at par with T_3 (6.04%) (un-perforated HDPE). Similar results were observed at 6th (2.20 %) and 9th day (3.90 %) of storage which was statistically similar with

T_3. But at 3rd day of storage lowest was in T_3 (1.77 %), was *at per* with T_6 (1.93%). The increase in the reducing sugar content of banana fruits could be due to hydrolysis of starch into soluble sugars as banana fruit ripen (Stover and Simmonds, 1987).

Sensory score for colour, flavour and overall sensory score

The sensory score for colour, flavor and overall sensory score of fruits as affected by various treatments are given in Table 5. The sensory score for colour increased gradually during period of storage. The highest sensory score for colour (8.70) was observed in T_5 (2% perforated LDPE) at about 12th day of storage and T_3 (un-perforated HDPE) had minimum sensory score (7.70) whereas, they are statistically different from the other treatments. An upward trend was noticed in the sensory score for flavour during storage period. T_5 (2% perforated LDPE) obtained the highest sensory score for flavour (8.73) at 12th day of storage. Minimum sensory score (6.93) was recorded in T_7 (control) which was *at per* with T_3 (7.1) and T_6 (7.2). This might be due to lower percentage of relative humidity in the storage room. The overall sensory score of all fruits as affected by various treatments showed an increasing trend. Treatment T_5 (2% perforated LDPE) was able to retain much of its overall quality and recorded a highest overall score (17.4) for cv. Martaman and it was statistically different from other treatments. The treatment T_3 (un-perforated HDPE) was recorded with lowest score (14.8). The loss of green colour is due to chlorophyll degradation, which subsequently reveals the yellow carotenoid pigments (Marriott and Lancaster, 1983; Stover and Simmonds, 1987).

From the results it was observed that different plastic packages with ethylene absorbents significantly enhanced shelf life and also retention of nutritional quality. Results of ambient conditions indicated that, there was upward trend in PLW, ripening, TSS, total and reducing sugar content with the increasing of storage time while titratable acidity was increased initially from 0 to 3 days and then decreased. The ascorbic acid contents of the fruits increased initially from 0 to 6 days after that decreased gradually during the storage time in all treatments. Among the treatments studied, cv. Martaman packed in un-perforated LDPE with ethylene absorbent under ambient condition proved to be the better treatment than rest of the treatments. The treatment effectively reduced PLW, also rich in ascorbic acid and there is more gradual decrease in TSS, total and reducing sugar than other treatments during storage period. But as per sensory quality the maximum score was attained in 2% perforated LDPE (T_5) for cv. Martaman.

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