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Effect of different types of packaging materials to improve quality of Banana (*Musa paradisica* L.) cv. G-9

Sunil Manikpuri, Saket Mishra, Shashi Kant Ekka and Kali Charan

Abstract
A study was conducted at the Post Harvest Laboratory, Department of Horticulture, NAI, SHUATS, Prayagraj (U.P.), during the academic years 2023-2024. The experiment consisted of 9 treatments of diverse materials, including LDPE (40 micron) bag, Aluminium foil, Gunny bag, Plastic box, and Silica gel vial (2 g), replicated three times in a Completely Randomized Design. The primary purpose of the experiment was to determine the effect of various packaging materials on the physical and qualitative characteristics of bananas. According to the results of the current study, Treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found best with, [167.51 (5 days), 165.32 (10 days) and 160.96 (15 days)] g fruit weight, [3.21 (5 days), 2.79 (10 days) and 2.57 (15 days)] Kg/cm^2 fruit firmness, [1.99 (5 days), 3.27 (10 days) and 5.82 (15 days)] % physiological weight loss %, [1.38 (5 days), 2.06 (10 days) and 2.11 (15 days)] pulp to peel ratio, 8.65 days to colour break,[0.00 (5 days), 2.78 (10 days) and 16.67 (15 days)] % spoilage, 17.51 days shelf life. [7.93 (5 days), 12.91 (10 days) and 17.09 (15 days)] ºBrix TSS, [0.95 (5 days), 0.72 (10 days) and 0.63 (15 days)] % acidity, [3.38 (5 days), 3.56 (10 days) and 7.34 (15 days)] % reducing sugar, [6.63 (5 days), 10.35 (10 days) and 14.45 (15 days)] % Total sugar, [3.09 (5 days), 6.45 (10 days) and 6.75 (15 days)] % non-reducing sugar, [12.90 (5 days), 12.05 (10 days) and 11.53 (15 days)] mg/100 g of pulp ascorbic acid and [4.78 (5 days), 5.24 (10 days) and 6.1 (15 days)] pH.

Keywords: Aluminum foil, Banana, Gunny bag, LDPE (40 micron) bag, *Musa paradisica L.*, Plastic box, Silica gel sachet (2 g), Physical and Quality

Introduction

The banana, *Musa paradisiaca* L., is a fruit that grows in humid tropical and subtropical regions. It is a member of the Musaceae family and the Zingiberales order, and is also known as Adam's fig, Apple of paradise, Baby fruit, Kalpataru (A plant of virtue), Tree of paradise, Tree of wisdom, and Test tube fruit. Bananas evolved in the rainforests of Malaysia, Indonesia, and the Philippines in South- East Asia (Stover and Simmonds, 1987).

It is the most economically significant fruit commodity in the world, and mature green bananas are typically harvested and stored. The global banana cultivation area is 4.80 million hectares, and its productivity is 20.8 million tonnes per hectare (Anon, 2016) [2]. India was discovered to be the largest banana consumer and leader in terms of banana area (0.88 million hectares) and production (30.808 million metric tonnes), followed by Mexico in terms of banana area. Tamilnadu is the leading producer of bananas in India, with Andhra Pradesh, Gujarat, Maharashtra, Uttar Pradesh, and Karnataka being important growing areas (Anon, 2016) [2]. As a climacteric fruit, it has a limited storage life and is extremely perishable. It generates sufficient ethylene to induce rapid changes in physicochemical properties, including colour, texture, aroma, chemical composition, respiration rate, and senescence. Consequently, post- harvest losses are greater in terms of both quality and quantity, which diminishes its appeal to consumers. Due to improper post-harvest management practices, there is significant loss of the nutritional value of bananas in many locations, resulting in enormous economic losses (Santosa *et al.*, 2010).

The use of post-harvest treatments to increase the shelf life of banana produce is an enhanced technique that aids in the quality production of many farmers and banana cultivators. Packaging has thus become an integral and decisive component of the industrial and commercial food supply chain. The most recent technique garnering popularity in the Indian food industry is modified atmosphere packaging. Kariyanna *et al.*, 1990, he found that the thickness of polythene sacks affects the shelf life of fruits.

In such a case, bananas may be packaged in LDPE packaging (a modified atmospheric packaging), plastic boxes, aluminum foil, or gunny sacks to increase their shelf life. Due to their elevated respiratory activity and ethylene production during maturation, bananas a exceedingly perishable and climacteric in nature. After harvest, fruits can only remain fresh for seven to eight days under normal conditions. After extraction, the fruit undergoes constant physiological changes. We can effectively increase the storage life of mature fruits by minimizing these changes.

Materials and Methods

The banana cv. 'Grand Naine'which were physiologically mature and verdant, was utilized for this study. To remove field heat, to reduce microbial population, and to eliminate soil particles from the surface of uniform fruits, they were rinsed with faucet water. The experiment was conducted in the post-harvest laboratory of the Department of Horticulture at the Sam Higginbottom University of Agriculture, Technology, and Sciences in Allahabad during the years 2023 and 2024.

The location of the experimental site is on the left side of the Allahabad-Rewa Road, near to the Yamuna River, approximately 8 kilometers from the city of Allahabad. It is located at latitude 25.57°N and longitude 81.51°E.The fruits were treated with different materials, i.e., T_0: Control, T_1: LDEP (40 micron) Polythene bag,T_2: LDEP (40 micron) Polythene bag + Silica gel sachet (2 gm),T_3: Gunny Bag,T_4: Gunny Bag + Silica gel sachet (2 gm),T_5: Aluminum Foil,T_6: Aluminum Foil + Silica gel sachet (2 gm),T_7: Plastic box&T_8: Plastic box + Silica gel sachet (2 gm) Utilizing low density polyethylene bags of 40 gauges (45 30 cm) with 50 evenly spaced pin holes per bag, the upper four centimeters were sealed using an electronic sealing equipment. Bananas were stored in 10 cm × 14 cm gunny bag containers with a top portion that was sealed and a 1L capacity small plastic box with a closed closure. Household aluminum foil with a thickness of 0.016mm was enveloped so as to be airtight for use in packaging. In the experiment, two grams of silica gel were also used as a dehumidifier. These were taken in sachets made of porous cellulose. Each banana unit container was packaged with one sachet.

The experiment was designed using a Completely Randomized Design (CRD) with three replications for each of the nine treatment combinations.

Results and Discussion

The physical and quality attributes of Banana (*Musaparadisica* L.) Cv. Pusa Dwarf were studied statistically. According to the results, the incorporation of various treatments significantly enhanced all characteristics. Since F Cal > F Tab, the evidence indicates that the variances were found statistically significant except at 0 days. At 0 days of storage, the variances for each attribute were found non-significant.

Physical Attributes

Fruit weight (g): According to the above findings in table 1, it was observed the variances were significant except at 0 days which was found non- significant. There was a gradual decrease in the fruit weight (g) of banana as the days of storage of fruit increases. Treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found best and recorded significantly the highest fruit weight (g) i.e., [167.51 (5 days), 165.32 (10 days) and 160.96 (15 days)] g whereas treatment T_0 (Control) was found with lowest fruit weight (g) i.e., [164.43 (5 days) and 158.40 (10 days)] g. At 15 days after storage, fruits under treatment T_0 (Control) were found be not suitable for consumption.

Physiological weight loss %: According to the perusal of data found in table 1, it was observed that the treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found best effective and observed significantly the minimum physiological weight loss % i.e., [1.99 (5 days), 3.27 (10 days) and 5.82 (15 days)]%whereas treatment T_0 (Control) was found least effective with lowest physiological weight loss % i.e., [3.75 (5 days)&7.28 (10 days)] %. Fruits under treatment T_0 (Control) at 15 days after storage were found unconsumable.

Fruit Firmness (kg/cm^2): The perusal of data in table 1, shows that observed the variances were significant except at 0 days which was found non- significant. Treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found best and recorded significantly the maximum fruit firmness i.e., [3.21 (5 days), 2.79 (10 days) and 2.57 (15 days)] Kg/cm^2 whereas treatment T_0 (Control) was observed to have least effect with minimum fruit firmness i.e.,[1.31 (5 days) & 0.97 (10 days)] Kg/cm^2. Fruits under treatment T_0 (Control) at 15 days after storage were found unconsumable.

Pulp to peel ratio: The variances in effect of treatments on pulp to peel ratio was found to be significant except at 0 days of storage. The maximum Pulp to peel ratio table 2, [1.38 (5 days), 2.06 (10 days) and 2.11 (15 days)] pulp to peel ratio was recorded under treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)]. However, the minimum pulp to peel ratio [2.11 (5 days) & 3.02 (10 days)] was recorded in T_0 (Control).At 15 days after storage, fruits under treatment T_0 (Control) were found unconsumable.

Days to color break: The data regarding Days to colour break is shown in table 2, where the variances were found significantly different except at 0 days of storage. From the data it was observed that treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] recorded the maximum i.e., 8.65 days to colour break where-as minimum days to coour breaki.e., 3.03 was recorded in T_0(Control).At 15 days after storage, fruits under treatment T_0 (Control) were found unconsumable.

Spoilage (%): The data regarding Spoilage (%) is shown in table 2. From the data it was observed that treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] recorded the minimum Spoilage (%) [0.00 (5 days), 2.78 (10 days) and 16.67 (15 days)] % where-as the highest spoilage [25 (5 days), 50 (10 days) and 100 (15 days)] % was recorded in T_0 (Control).

Shelf life (days): The perusal of data table 2, shows that the treatment T_2 [LDPE (40 micron) polythene bag + Silica.

Quality Attributes

Total Soluble Solids (ºBrix): According to the above findings Table 3, it was observed the variances were significant except at 0 days which was found non- significant. There was a gradual increase in the Total Soluble Solids (ºBrix) of banana as the days of storage of fruit increases. Treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found best and recorded significantly the lowest Total Soluble Solids (ºBrix) i.e., [7.93 (5 days), 12.91 (10 days) and 17.09 (15 days)] ºBrix whereas treatment T_0 (Control) was found with highest Total Soluble Solids (ºBrix) i.e., [14.55 (5 days) and 20.21 (10 days)] ºBrix. At 15 days after storage, fruits under treatment T_0 (Control) were found be not suitable for consumption.

Ascorbic Acid (mg/100 g of pulp): The variances in effect of treatments on Ascorbic Acid (mg/100 g of pulp) was found to be significant except at 0 days of storage. The ascorbic acid content of banana gradually decreased with increase in no of days of storage. The maximum Ascorbic Acid in table 3, [12.90 (5 days), 12.05 (10 days) and 11.53 (15 days)] mg/100 g of pulp was recorded under treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)]. However, the minimum Ascorbic Acid [8.82 (5 days) & 7.43 (10 days)] mg/100 g of pulp was recorded in T_0 (Control).At 15 days after storage, fruits under treatment T_0 (Control) were found unconsumable.

PH: The data regarding pH is shown in table 4, The pH gradually increased with increase of storage time which were statistically significant except at 0 days of storage. From the data it was observed that treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)]. Recorded the minimum pH [4.78 (5 days), 5.24 (10 days) and 6.1 (15 days)] where-as the highest pH [5.04(5 days) & 6.89 (10days)] was recorded in T_0 (Control).

Reducing sugar %: The data regarding Reducing sugar % is shown in Table 5, From the data it was observed that treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] recorded the minimum reducing sugar [3.38 (5 days), 3.56 (10 days) and 7.34 (15 days)] % where-as the highest reducing sugar i.e., [6.41 (5 days)&8.82 (10 days)]% was recorded in T_0(Control).

Non-Reducing sugar %: According to the data regarding non-Reducing sugar % is shown in Table 5, The variances in effect of treatments were found to be significant except at 0 days of storage. From the data it was observed that treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] recorded the minimum non-reducing sugar [3.09 (5 days), 6.45 (10 days) and 6.75 (15 days)] % where-as the highest reducing sugar i.e.,[8.67 (5 days)&8.81 (10 days)]% was recorded in T_0 (Control).

Acidity (%): The variance in effect of treatments on Acidity (%) was found to be significant except at 0 days of storage. The Acidity (%) of banana gradually decreased with increase in no of days of storage. The maximum Acidity (%) in table 4, [0.95 (5 days), 0.72 (10 days) and 0.63 (15 days)]%was recorded under treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)]. However, the minimum Acidity (%) [0.53 (5 days) & 0.39 (10 days)]%was recorded in T_0 (Control).

Total sugar %: The data regarding total sugar % is shown in table 5, From the data it was observed that treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] recorded the minimum total [6.63 (5 days), 10.35 (10 days) and 14.45 (15 days)] % where-as the highest reducing sugar i.e.,[15.54 (5 days)&18.09 (10 days)]% was recorded in T_0 (Control).

Discussion

All treatments had significant effects on the physical and qualitative characteristics of bananas, but treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found to be the most effective.

Fruit weight (g) & Physiological weight loss % during the entire storage period is one of the most important factors governing the post-harvest quality of fruits and vegetables. Any decrease in produce weight is likely to substantially degrade product quality. The longer the banana was stored, the greater the weight reduction. This is predominantly attributable to continuous water evaporation from fruits and, to a lesser extent, an accelerated decay process over time. The treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] resulted in the least physiologic weight loss % and retention of highest fruit weight (g) during the storage period. Packaging films alter the CO_2 and O_2 concentration inside the packages hence, in a high respiring fruit like banana the respiration rate is reduced by keeping in low O_2 and/or high CO_2 atmosphere (Li and Kader, 1989) [8]. Fruits packed in LDPE with silica gel sachet recorded higher fruit weight (g), which was obvious due to their role in checking rate of transpiration/respiration and maintaining higher humidity inside the wrappers (Ben, 1985) [3]. Moreover, the reduction in percentage of physiological weight loss is directly proportional to the firmness of bananas. The harvest-time firmness of fruit tissue is primarily attributable to the physical properties of the individual cell walls and the middle lamella, which contains the cementing pectic material (Sharma *et al.*, 2012).

The fruit firmness (Kg/cm^2) was found best when LDPE polythene bag with silica get sachet (2 g) was applied. These might have helped in maintaining firmness of papaya better than other packaging materials due to retardation effects on ripening and reduction of water loss. These results are in conformity with Singh *et al.* (2011) in strawberry and Martinez *et al.*, (2006) [6] in sweet cherry. During ripening of banana, pulp increases in weight due to increase in water content, which was obtained from peel. Because of loss of weight in peel changes in pulp to peel ratio occurred.

The narrow ratio of pulp to peel in treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] may be due to slow rate of ripening as well as modified atmosphere created by O_2 depletion and CO_2 accumulation. The results are in confirmation with that of Khaleel (2017) [7] and Rammohan *et al.* (2017) [13]. On the other hand, days to colour break also effects the shelf life of banana. The more the days to colour break the more is the shelf life. Highest days to colour break under T_2 might be due to promotion of chlorophyll synthesis by LDPE polythene bag and silica gel, which would have maintained greenness. This was made possible due to Controlled respiration, reduced ripening and slow degradation of chlorophyll. Similar results are in conformity with those of Mongkon Intalook (2005) [12] in mango & Abd-ei Naby *et al.*, (2010) [1] in banana Physical, physiological, physicochemical and microbiological factors influence the papaya's expiration life and percent of deterioration. Lower respiration and humidity rates, reduced ethylene action, delayed ripening and senescence, and retarding the growth of decay-causing pathogens and insects due to modification of the gas atmosphere inside the LDPE polythene bag with silica gel could be potential reason for extending the storage life and reducing

The spoilage percentage of fruit. The results are in partial agreement with the findings of Sahoo and Munsi (2004) [15] in sapota and Kannan and Susheela (2003) [6] in mango. The fruit's quality is a crucial factor in determining its expiration life and the customers' purchasing decisions. In this experiment, as the fruit ripens, TSS, reducing sugar, non-reducing sugar, and total sugar all increase across all regimens. Initial growth was primarily attributable to the conversion of starch to soluble carbohydrates. Reboucas *et al*. (2013) [14] and Silva *et al*. (2009) [18] found comparable initial increases of these in banana. In the case of Treatment T2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)], the TSS, Reducing sugar, non-Reducing sugar, and Total sugar content of LDPE polythene bag with silica gel-treated fruits increased slowly and steadily as storage progressed, whereas in the case of the control, a rapid increase was observed. Reduced O2 and increased CO2 concentrations in the packaging head space may contribute to the retardation of maturation and senescence processes, thereby delaying the metabolic activity of fruits during storage. Low O2 and high CO2 in the head space reduce respiration and ethylene production during storage, which in turn reduces the physiological and chemical deterioration of produce quality. Janesh and Nair (2001) [4] found comparable outcomes for banana.

The ascorbic acid (mg/100 g of pulp), pH& acidity % is an important parameter for the fruit quality and therefore, maintenance of desirable amount of pH in fruits during storage is necessary. The pH of the banana fruit pulp increased during storage owing to decrease in acidity of the fruits in all the treatments. The continuous increase in pH till the end of shelf life of the fruits could be attributed to the continuous fall in the acidity as reported by the Lodhe *et al.* (1963) [9] in orange fruit.

Table 1: Effect of different types of packaging materials on fruit weight (g), Physiological Weight Loss % & Fruit firmness (Kg/cm^2) of Banana (*Musa paradisica* L.)

Treatments	Fruit weight (g)				Physiological Weight Loss %				Fruit firmness (Kg/cm^2)			
	0 days	5 days	10 days	15 Days	0 days	5 days	10 days	15 Days	0 days	5 days	10 days	15 Days
T_0	170.84	164.43	158.40	*	0.00	3.75	7.28	*	3.35	1.31	0.97	*
T_1	170.93	166.98	164.98	160.54	0.00	2.31	3.48	6.08	3.30	3.06	2.62	2.39
T_2	170.91	167.51	165.32	160.96	0.00	1.99	3.27	5.82	3.42	3.21	2.79	2.57
T_3	170.99	165.88	164.25	159.57	0.00	2.99	3.94	6.68	3.36	2.73	2.25	1.97
T_4	171.14	166.40	164.65	160.05	0.00	2.77	3.79	6.48	3.38	2.84	2.38	2.10
T_5	171.05	166.71	164.84	160.60	0.00	2.54	3.63	6.11	3.39	2.95	2.50	2.25
T_6	170.66	167.09	164.96	160.57	0.00	2.09	3.34	5.91	3.40	3.16	2.74	2.52
T_7	171.12	165.25	163.83	158.94	0.00	3.43	4.26	7.12	3.34	2.50	2.01	1.64
T_8	171.04	165.55	164.06	159.17	0.00	3.21	4.08	6.94	3.41	2.62	2.11	1.80
F-Test	NS	**	**	**	-	**	**	**	NS	**	**	**
CV	0.16	0.04	0.09	0.07	-	4.31	1.70	1.41	1.48	1.85	2.65	3.25
S.E. (m) (±)	0.16	0.04	0.09	0.06	-	0.07	0.04	0.05	0.03	0.03	0.03	0.04
CD (5%)	NS	0.12	0.26	0.19	-	0.21	0.12	0.16	NS	0.09	0.10	0.12
CD (1%)	NS	0.16	0.35	0.26	-	0.28	0.16	0.21	NS	0.12	0.14	0.17

[Note: (*) means the fruit became unconsumable]

T_0: Control, T_1: LDEP (40 micron) Polythene bag,T_2: LDEP (40 micron) Polythene bag + Silica gel sachet (2 gm),T_3: Gunny Bag,T_4: Gunny Bag + Silica gel sachet (2 gm),T_5: Aluminum Foil,T_6: Aluminum Foil + Silica gel sachet (2 gm),T_7: Plastic box&T_8: Plastic box +Silica gel sachet (2 gm).

Table 2: Effect of different types of packaging materials on Pulp to Peel ratio, Days to colour break, Spoilage % & Shelf life (days) of Banana (*Musa paradisica* L.)

Treatments	Pulp to Peel ratio				Days to colour break	Spoilage %				Shelf life (days)
	0 days	5 days	10 days	15 days		0 days	5 days	10 days	15 days	
T_0	1.30	2.11	3.02	*	3.03	0.00	25.00 (0.52)	50.00 (0.79)	100.00 (1.57)	9.89
T_1	1.32	1.46	2.12	2.23	7.85	0.00	0.00 (0.00)	8.33 (0.29)	25.00 (0.52)	16.64
T_2	1.31	1.38	2.06	2.11	8.65	0.00	0.00 (0.00)	2.78 (0.10)	16.67 (0.41)	17.51
T_3	1.30	1.67	2.27	2.47	6.24	0.00	8.33 (0.29)	22.22 (0.49)	52.78 (0.81)	14.57
T_4	1.30	1.59	2.21	2.39	6.8	0.00	5.55 (0.20)	19.44 (0.45)	41.67 (0.70)	15.27
T_5	1.32	1.53	2.17	2.31	7.32	0.00	2.78 (0.10)	11.11 (0.34)	30.56 (0.58)	15.96
T_6	1.30	1.40	2.08	2.15	8.39	0.00	0.00 (0.00)	5.56 (0.20)	19.44 (0.45)	17.32
T_7	1.31	1.81	2.38	2.62	5.02	0.00	13.89 (0.38)	36.11 (0.64)	63.89 (0.93)	13.11
T_8	1.32	1.74	2.32	2.54	5.66	0.00	11.11 (0.34)	30.56 (0.58)	58.33 (0.87)	13.82
F-Test	NS	**	**	**	**	-	**	**	**	**
CV	1.53	1.84	0.87	1.70	4.27	-	45.93	22.14	10.38	2.35
S.E. (m) (±)	0.01	0.02	0.01	0.02	0.16	-	0.05	0.06	0.05	0.20
CD (5%)	NS	0.05	0.03	0.07	0.48	-	0.16	0.16	0.14	0.60
CD (1%)	NS	0.07	0.05	0.10	0.66	-	0.22	0.22	0.19	0.82

[Note: The data in the parenthesis for spoilage % contain re-transformed value & (*) means the fruit became unconsumable]

T_0: Control, T_1: LDEP (40 micron) Polythene bag, T_2: LDEP (40 micron) Polythene bag + Silica gel sachet (2 gm),T_3: Gunny Bag,T_4: Gunny Bag + Silica gel sachet (2 gm),T_5: Aluminum Foil,T_6: Aluminum Foil + Silica gel sachet (2 gm),T_7: Plastic box&T_8: Plastic box + Silica gel sachet (2 gm).

Table 3: Effect of different types of packaging materials on Total Soluble Solids (ºBrix) & Ascorbic Acid (mg/100 g of pulp) of Banana (*Musa paradisica* L.)

Treatments	Total Soluble Solids (ºBrix)				Ascorbic Acid (mg/100 g of pulp)			
	0 days	5 days	10 days	15 days	0 days	5 days	10 days	15 days
T_0	3.92	14.55	20.21	*	13.94	8.82	7.43	*
T_1	3.89	8.85	13.57	18.05	13.93	12.57	11.54	10.88
T_2	3.71	7.93	12.91	17.09	13.94	12.90	12.05	11.53
T_3	3.67	9	14.85	20.24	13.95	11.89	10.36	9.47
T_4	3.65	8.79	14.42	19.48	13.91	12.12	10.75	9.94
T_5	3.75	8.57	13.98	18.77	13.92	12.35	11.15	10.39
T_6	3.82	8.02	13.09	17.34	13.89	12.79	11.91	11.37
T_7	3.8	9.49	15.79	21.87	13.88	11.44	9.55	8.53
T_8	3.86	9.24	15.28	20.99	13.91	11.68	9.94	9.01
F-Test	NS	**	**	**	NS	**	**	**
CV	3.17	1.28	1.34	1.82	0.22	0.84	1.90	2.56
S.E. (m) (±)	0.07	0.07	0.12	0.20	0.02	0.06	0.12	0.15
CD (5%)	NS	0.21	0.34	0.61	NS	0.17	0.34	0.45
CD (1%)	NS	0.28	0.47	0.83	NS	0.24	0.47	0.62

[Note: (*) means the fruit became unconsumable]

T_0: Control, T_1: LDEP (40 micron) Polythene bag, T_2: LDEP (40 micron) Polythene bag + Silica gel sachet (2 gm), T_3: Gunny Bag,T_4: Gunny Bag + Silica gel sachet (2 gm),T_5: Aluminum Foil,T_6: Aluminum Foil + Silica gel sachet (2 gm),T_7: Plastic box&T_8: Plastic box +Silica gel sachet (2 gm).

Table 4: Effect of different types of packaging materials on pH & Acidity (%) of Banana (*Musa paradisica* L.)

Treatments	pH				Acidity (%)			
	0 days	5 days	10 days	15 days	0 days	5 days	10 days	15 days
T_0	2.95	5.04	6.89	*	1.07	0.53	0.39	*
T_1	2.97	4.88	5.42	6.29	1.09	0.91	0.68	0.59
T_2	2.96	4.78	5.24	6.1	1.08	0.95	0.72	0.63
T_3	2.95	5.19	5.89	6.73	1.07	0.8	0.57	0.49
T_4	2.95	5.08	5.73	6.58	1.07	0.84	0.6	0.53
T_5	2.97	4.97	5.58	6.43	1.09	0.88	0.64	0.56
T_6	2.95	4.8	5.28	6.16	1.07	0.94	0.71	0.62
T_7	2.96	5.38	6.16	7.02	1.08	0.73	0.5	0.42
T_8	2.97	5.3	6.02	6.89	1.09	0.77	0.53	0.46
F-Test	NS	**	**	**	NS	**	**	**
CV	1.69	0.79	1.21	0.92	1.85	1.22	1.69	1.86
S.E. (m) (±)	0.03	0.02	0.04	0.03	0.01	0.01	0.01	0.01
CD (5%)	NS	0.07	0.12	0.10	NS	0.02	0.02	0.02
CD (1%)	NS	0.10	0.16	0.14	NS	0.02	0.02	0.02

[Note: (*) means the fruit became unconsumable]

T_0: Control, T_1: LDEP (40 micron) Polythene bag, T_2: LDEP (40 micron) Polythene bag + Silica gel sachet (2 gm), T_3: Gunny Bag,T_4: Gunny Bag + Silica gel sachet (2 gm),T_5: Aluminum Foil,T_6: Aluminum Foil + Silica gel sachet (2 gm),T_7: Plastic box&T_8: Plastic box + Silica gel sachet (2 gm).

Table 5: Effect of different types of packaging materials on Reducing Sugars (%), non- Reducing Sugars (%)&Total Sugars (%)of Banana (*Musa paradisica* L.)

Treatments	Reducing Sugars (%)				non-Reducing Sugars (%)				Total Sugars (%)			
	0 days	5 days	10 days	15 days	0 days	5 Days	10 days	15 days	0 days	5 Days	10 days	15 Days
T_0	3.10	6.41	8.82	*	1.43	8.67	8.81	*	4.61	15.54	18.09	*
T_1	3.05	3.6	3.84	7.58	1.47	3.52	6.56	7.36	4.60	7.31	10.74	15.33
T_2	3.17	3.38	3.56	7.34	1.37	3.09	6.45	6.75	4.61	6.63	10.35	14.45
T_3	3.11	4.04	4.38	8.07	1.43	4.37	6.85	8.45	4.62	8.64	11.59	16.96
T_4	3.13	3.89	4.18	7.9	1.38	4.08	6.75	8.09	4.58	8.18	11.28	16.42
T_5	3.14	3.74	4	7.74	1.38	3.80	6.65	7.72	4.59	7.74	11.00	15.87
T_6	3.15	3.45	3.66	7.42	1.34	3.27	6.46	7.02	4.56	6.89	10.46	14.81
T_7	3.09	4.37	4.75	8.39	1.39	5.04	7.13	9.20	4.55	9.68	12.25	18.07
T_8	3.16	4.21	4.56	8.23	1.35	4.67	6.98	8.84	4.58	9.13	11.91	17.54
F-Test	NS	**	**	**	**	**	**	**	NS	**	**	**
CV	1.60	1.70	1.94	1.02	1.36	2.95	0.55	2.40	1.53	2.37	1.09	1.73
S.E. (m) (±)	0.03	0.04	0.05	0.05	0.01	0.08	0.02	0.11	0.04	0.12	0.08	0.16
CD (5%)	NS	0.12	0.15	0.14	0.03	0.23	0.07	0.33	NS	0.36	0.22	0.48
CD (1%)	NS	0.16	0.21	0.19	0.04	0.31	0.09	0.45	NS	0.49	0.31	0.67

[Note: (*) means the fruit became unconsumable]

T_0: Control, T_1: LDEP (40 micron) Polythene bag, T_2: LDEP (40 micron) Polythene bag + Silica gel sachet (2 gm),T_3: Gunny Bag,T_4: Gunny Bag + Silica gel sachet (2 gm),T_5: Aluminum Foil,T_6: Aluminum Foil + Silica gel sachet (2 gm),T_7: Plastic box&T_8: Plastic box + Silica gel sachet (2 gm).

Conclusion

From the present investigation it may be concluded that effect of Treatment T_2 [LDPE (40 micron) polythene bag + Silica gel sachet (2 g)] was found to be best. It is best in terms of physical attributes i.e., Fruit weight (g), Fruit firmness (Kg/cm^2), Physiological loss in weight (PLW) (%), Pulp to Peel ratio, Days to colour change, Spoilage (%) and Shelf life (days).

It was also found significantly best in terms of quality attributes i.e., Total Soluble Solids (TSS ºBrix), Acidity (%), Total sugars (%), Reducing Sugar (%), Non-reducing Sugar (%), Ascorbic Acid (mg/100 g) and ph.

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