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Original Research Article

Packaging Materials and Their Effect on Shelf Life and Quality of Banana in Kailali District of Nepal

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Abstract: The research was held in Kailali District of Nepal to assess the effect of different packaging materials on shelf life and quality of banana fruit. The experimental set up was done in Completely Randomized Design (CRD) with five treatments of different packaging, each replicated four times. There were five different treatments used for the study and they were allotted as follows: T1: No packaging/open (control) T2: Banana leaf, T3: Straw, T4: Polythene bag, T5: Cardboard box. A digital hygrometer for measuring relative humidity and thermometer for measuring temperature were used. RH was recorded every 3rd day. Similarly, temperature was also recorded during those days. R-Studio 4.2.2 version was used for data analysis. TSS was found highest in polythene bag followed by cardboard box and lowest was control followed by straw. TSS (16.02^0 Brix) was found in polythene bag at 13th day and lowest TSS (5.25^0 Brix) in at 1st day. At 16th day, maximum TSS was found in polythene bag (15.32^0 Brix) and minimum in control (12.72^0 Brix). Titrable Acidity (TA) tends to increase at initial stage but later decreases with increase in storage time. The highest TA (0.32%) was found in polythene bag and lowest (0.24%) was found in control at day 16th. Physiological Loss in Weigh t(PLW) tends to increases with increase in storage time. The highest PLW (27.68 gm) was found in Control and lowest loss (21.61 gm) was found in polythene bag at day 16th. The firmness was decreased with the advancement in storage time in all treatments. The highest firmness (9.385kgcm^{-2}) was found in polythene bag at 1st day and lowest (9.12 kgcm^{-2}) was found in control at 1st day. At the end of the day i.e., at day 16th, maximum firmness was observed in Polythene bag (3.34 kgcm^{-2}), and minimum was observed in control (2.07 kgcm^{-2}) and pulp thickness tends to increase with increase in storage time. At day 16th, the highest pulp thickness (3.34 cm) was found on banana leaf and lowest (2.07 cm) on straw. Based on these findings, it is evident that packaging bananas in polythene bags resulted in significant improvements in weight loss, TA, firmness, TSS, pulp thickness, and peel thickness. This suggests that using polythene bags as packaging material provides better quality and extends the shelf life of bananas compared to the other materials tested in the study.

Keywords: TSS, Titrable Acidity, Brix Percentage, Banana, Packaging Materials.

1. INTRODUCTION

Banana (Musa paradisiaca, family Musaceae) is a important fruit crop of the tropical and subtropical regions of the world which is cultivated on about 8.8 million hectares (Mohapatra *et al.*, 2010). It is the world's oldest grown plants (Kumar *et al.*, 2012). The fruit is grown in more than 100 countries throughout the tropics and sub tropics, with an annual production of about 98 million ton. (Frison and Sharrock, 1999). It is early maturing, fast growing herbaceous and perennial herb of about 2-to-9-meter height. Banana is a climateric fruit which shows an increase in respiration resulting in color, flavor, aroma and texture change (Sogo-Temi, Idowu and Idowu, 2014).

The principal countries in terms of production are Brazil, India and Philippines (Maduwanthi and Marapana, 2019). Since history banana has been a staple human food. It is recorded as the fourth largest food crop of the world after rice, wheat, and maize (Hailu *et al*., 2013). It is usually eaten raw when ripe and is a major starchy food common in Sub-Sahara Africa and Asia, providing more than 25% of carbohydrate (Adeniji *et al*., 2007). Banana is unique due to its high calorie and nutritive value and plays significant role in human diet by supplying vitamins, minerals and dietary fibre

(Khader *et al*., 1990). It contains nearly all the essential nutrients including minerals and vitamins and has several medicinal properties (Bose, 1990). In addition to health benefit most people enjoy eating banana. It can be eaten alone or in combination with fruit salad, added to jelly or made into milkshake or smoothie. Banana is one of the most affordable fruit in the market place with year availability in almost all parts of the world Bananas are broadly classified into dessert and cooking types (Nayar, 2010).

Dessert types are eaten raw when ripe, while cooking (starchy) bananas are boiled, fried, brewed, powdered, or roasted before consumption (Nayar, 2010). It has amount of importance in different field like in medicines, cosmetics and agro based industries for processing. Raw, ripen and processed bananas are used for various items. Not only fruit but other also parts of banana have variety of uses like its leaves are used in religious ceremony as well as can be used a packaging material. Its stems and leaves can be used as livestock feed. Banana fibers are used to make clothes, tissue paper, cardboard, paper etc.

The B/C ratio of banana was 2.35, which was better as examine to different staple crops. In Indian geophysical situation, it can be grown from plains to 1500m altitude of mid hills, where frost does not occur usually. The most common variety cultivated in Indiar are robusta, dwarf Cavendish, poovan, alpan, nendran. Banana ripening is the result of transcriptional regulation (Yan *et al*., 2019), associated with an increase in the respiration rate and autocatalytic synthesis of ethylene (Johnson *et al*., 1997; Gamage & Rehman, 1999).

The action of ethylene results in softening of the fruit, acceleration of deterioration and shortening of postharvest shelf-life (Saltveit, 1999).The climacteric peak triggers various physiological and physicochemical changes: conversion of starch to sugars (Hill &Ress, 1995), enzymatic degradation of the structural carbohydrates (Kojima *et al*., 1994) and degradation of the chlorophyll (Thomas & Janave, 1992) which changes the color by uncovering the carotenoids in fruit peel and by regulating the pigment change. In the ripening period, the propensity of decreasing unsaturated fatty acids and the small upsurge of saturated fatty acids concentration was perceived (Palmer, 1971).

These changes affect the organoleptic attributes of the fruit as well as commercial value, and need to be controlled to minimize losses (Liu *et al*., 2013). In the nature, banana ripens easily showing changes in skin color, flavor and texture of the flesh during ripening (Botondi *et al*., 2014). But natural ripening may result in softening with non- uniform, dull, pale yellow and unattractive color (Eduardo, 2012). Besides, due to slow ripening natural process leads to high weight loss, splitting fruit's peel (Subbaiah *et al*., 2013). To overcome these disputes small- and large- scale farmeruse ripening agents. Being climacteric fruit, it is usually harvested at the pre climacteric stage and for commercial purposes it is artificially ripened by using different ripening agent.

The spoilage of banana is mainly due to harvesting at improper stage of maturity. Physical damage during transport, consequent fungal infections, and fungal breakdown primarily leads the fruit to senescence. Packaging of the fruit protects from physical damages and contaminations at retail level. As, extract of different spices and herbs have an antifungal characteristic they suppress development of fungus on the surface of the fruits. Hot water dip also suppresses growth of some fungi and inactivates enzymatic activities which fasten ripening of the fruit. The quality of the fresh and processed fruit depends upon the postharvest handling during harvesting, transportation, and storage and should be monitored effectively to keep the best quality of fruit at harvest. Because of rainfed farming system, lack of storage facilities, limited access to transportation, and risk of high losses growers in India are often forced to dispose of their produce over a short period of time which causes an economic loss of horticultural crops in general and fruits in particulars (Pokhrel, 2011).

Overall, there is no proper means of postharvest handling of fruits and vegetables at the retail and wholesale levels, which results in poor quality of banana at the consumer level. Although the country is experiencing huge postharvest losses of banana very little or no emphasis is given to postharvest handling of fruits. For the fresh bananas to reach the consumer in the right condition, it must be marketed properly, bearing in mind the application of most suitable temperature and humidity as well as appropriate packaging and handling methods. Good handling during harvesting can minimize mechanical damage and reduce subsequent waste due to microbial attacks. Low temperature handling and storage are the important physical method of postharvest management. The traditional method of packaging for banana is nested packaging in which dried banana leaf and straw are used but the effectiveness of this packaging materials has not yet been investigated and reported (Hailu *et al*., 2013).

Packaging isolates the product from the external environment and helps to ensure conditions that, if not sterile, at least reduce exposer to pathogens and contaminants their extent the shelf life of the produce (Mangaraj & Goswami, 2009). Overall, there is no proper means of postharvest handling of fruits and vegetables at the retail and wholesale levels, which results in poor quality of banana at the consumer level. Although the country is experiencing huge postharvest losses of banana very little or no emphasis is given to postharvest handling of the fruit (Tadesse 1991; Workneh *et al*., 2011a and b).

The loss of banana can be kept minimum by improving postharvest handling techniques through the use of different locally available packaging materials. Therefore, this study was aimed at the investigation of the effectiveness of different packaging materials in extending the shelf life of banana. The specific objective of the study was to evaluate the effect of packaging materials on physical quality of three banana cultivars.

2. METHODOLOGY

2.1 Experimental Material

The harvested green banana were brought from the farmer's farm for the research.

2.2 Preparation of Experiment Samples

For the study, the fruit grown on a field of farmer in Kailali was carefully selected. Harvesting takes place at the physiological maturity phase, with manual techniques employed to prevent any mechanical damage. The harvested fruits are then sorted based on size and color, discarding any that exhibit defects. Subsequently, the unblemished and uniform fruits undergo a washing process using tap water. This step serves multiple purposes, including removing field heat, reducing the microbial population, and eliminating soil particles present on the surface of the fruits. To establish the various treatments, different packaging materials are employed as per the experimental design.

2.3 Experimental Design

The experimental set up was done in Completely Randomized Design (CRD) with five treatments of different packaging, each replicated four times.

Table 1: Layout of experimental design

T3	T4	T5	T2
T1	T3	T1	T4
T3	T4	T2	T1
T5	T1	T3	T2
T4	T5	T2	T3

TREATMENTS DETAILS

There were five different treatments used for the study and they were allotted as follows:
T1: No packaging/open (control)
T2: Banana leaf
T3: Straw
T4: Polythene bag
T5: Cardboard box

3.4 Observation Table

Storage Condition

A digital hygrometer for measuring relative humidity and thermometer for measuring temperature were used. RH was recorded every 3rdday. Similarly, temperature was also recorded during those days.

Post Harvest Qualities

Pulp Firmness

The pulp firmness was measure with the help of penetrometer every third day throughout our experimental period.

Total Soluble Solid (Tss ^{0} Brix)

The total soluble solid was measured with the help of Refractometer. A drop of banana juice was squeezed from the sample on the prism of refractometer and TSS content was recorded.

Physiological weight loss

It was calculated as the percentage weight loss of the initial weight. Initial weight of each sample per replication was taken before packing. The weight of the sample was taken on a three days interval after setting of the experiment. It can be calculated by:

Weight loss = initial weight-final weight/initial weight

TITRABLE ACIDITY (TA)

The titration method was used in order to determine the titrable acidity (TA) with 0.1% NaOH and 2-3 drops of phenolphthalein indicator. It can be calculated as:

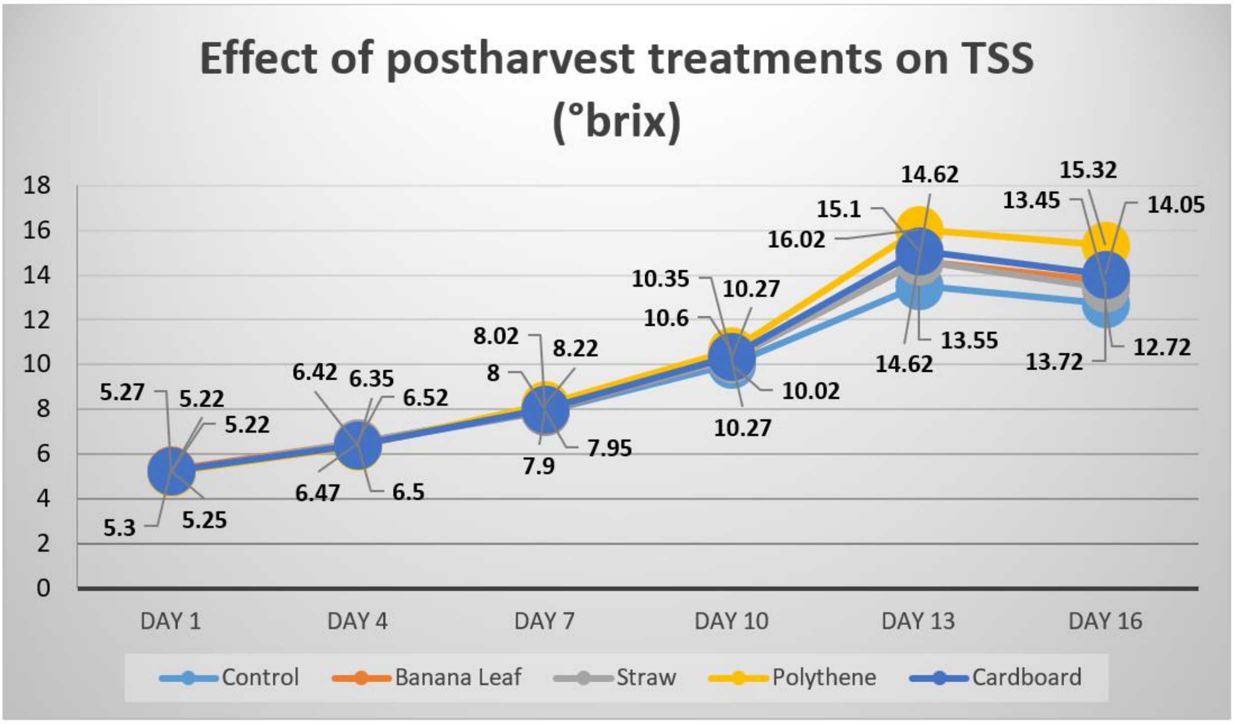
A%=Volume of Sample * Normality* Eqv. Wt. / volume of sample * 1000

3.5 Data Analysis
R-Studio 4.2.2 version was used for data analysis.

4 RESULT AND DISCUSSION
4.1 Total Soluble Solid (^{0} Brix)
TSS is consider as the one of the major indicators to judge the quality of the banana fruits. From the table 1, we can see that TSS was found highest in polythene bag followed by cardboard box and lowest was control followed by straw. There was rise in TSS of banana fruits accordance the storage period. The highest TSS (16.02^0 Brix) was found in polythene bag at 13th day and lowest TSS (5.25^0 Brix) in at 1st day. At 16th day, maximum TSS was found in polythene bag (15.32^0 Brix) and minimum in control (12.72^0 Brix) Similar result was found on A. Mahmud *et al*., 2015, the maximum value of TSS (27.11^0 Brix) was observed at the 6th day of storage in controlled condition. The degree of increase in TSS value for different postharvest treatments might be due to the modified internal atmosphere and physiological aspects of banana fruits, suppressed respiration and metabolic processes, which involve in increasing TSS at different magnitudes.

Table 1 : Effect of postharvest treatments on TSS (° Brix) of Banana (Musa paradisiaca L.) at different days

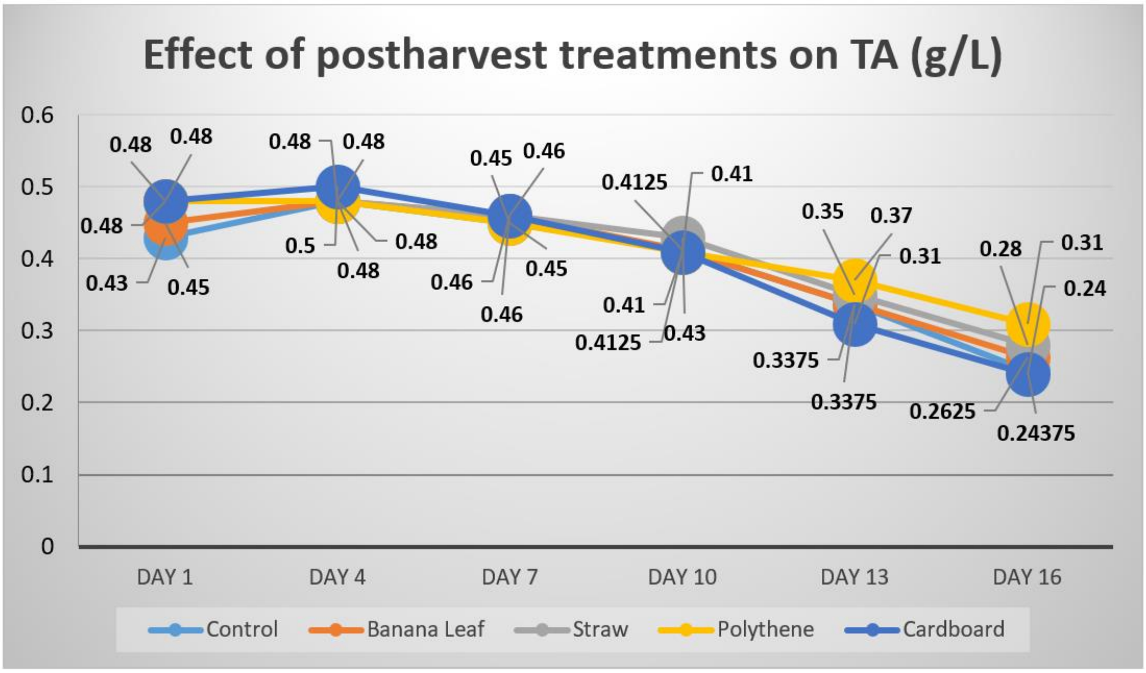
Treatments	Day1	Day4	Day7	Day10	Day13	Day16
Control	5.25 ^{a}	6.47 ^{ab}	**7.90 ^{c}**	**10.02 ^{c}**	**13.55 ^{c}**	**12.72 ^{a}**
Banana Leaf	5.30 ^{a}	6.50 ^{a}	7.95 ^{bc}	10.27 ^{bc}	14.62 ^{b}	13.72 ^{b}
Straw	5.22 ^{a}	6.52 ^{a}	8.00 ^{bc}	10.27 ^{bc}	14.62 ^{b}	13.45 ^{bc}
Polythene	5.22 ^{a}	6.35 ^{b}	**8.22 ^{a}**	**10.60 ^{a}**	**16.02 ^{b}**	**15.32 ^{c}**
Carboard	5.27 ^{a}	6.42 ^{ab}	8.05 ^{b}	10.35 ^{ab}	15.10 ^{b}	14.05 ^{d}
F test	NS	NS	**	**	***	***
LSD	0.15	0.13	0.13	0.26	0.51	0.50
CV%	1.91	1.34	1.14	1.68	2.31	2.41
Sem±	0.05	0.04	0.04	0.08	0.17	0.16
Grand Mean	5.255	6.455	8.02	10.3	14.7	13.85



4.2 Titrable Acidity (TA)
From the table no.2, it showed that the TA tends to increase at initial stage but later decreases with increase in storage time. The highest TA (0.32%) was found in polythene bag and lowest (0.24%) was found in control at day 16th. This result was in agreement with (Mahmud A.A. *et al*., 2015). Which reported that as time increases until it reaches full ripening stage gradually the acidity decreases. The acidity content of the banana fruit increases initially from 0-3 days after harvest. This could be due to synthesis of organic acids from carbohydrates. After that it decreases due to utilization of organic acids as a substrate and by conversion of acids into sugars. This finding is in line with (Mahmud A.A. *et al*., 2015).

Table 2: Effect of postharvest treatments on TA (g/L) of Banana (Musa paradisiaca L.) at different days

Treatments	Day1	Day4	Day7	Day10	Day13	Day16
Control	0.43 ^{a}	0.48 ^{a}	0.45 ^{a}	0.41250^{a}	0.33750^{a}	**0.24375^{b}**
Banana Leaf	0.45 ^{a}	0.48 ^{a}	0.46 ^{a}	0.41250^{a}	0.33750^{a}	0.26250^{ab}
Straw	0.48 ^{a}	0.48 ^{a}	0.46 ^{a}	0.43 ^{a}	0.35 ^{a}	0.28 ^{ab}
Polythene	0.48 ^{a}	0.48 ^{a}	0.45 ^{a}	0.41 ^{a}	0.37 ^{a}	**0.31 ^{a}**
Cardboard	0.48^{a}	0.50 ^{a}	0.46 ^{a}	0.41 ^{a}	0.31 ^{a}	**0.24 ^{b}**
F-test	NS	NS	NS	NS	NS	NS
LSD	0.06	0.06	0.06	0.06	0.07	0.05
CV%	9.90	8.5	8.65	10.13	15.37	14.34
Sem±	0.02	0.02	0.02	0.02	0.02	0.01
Grand Mean	0.46	0.49	0.46	0.41	3+60.34	0.27

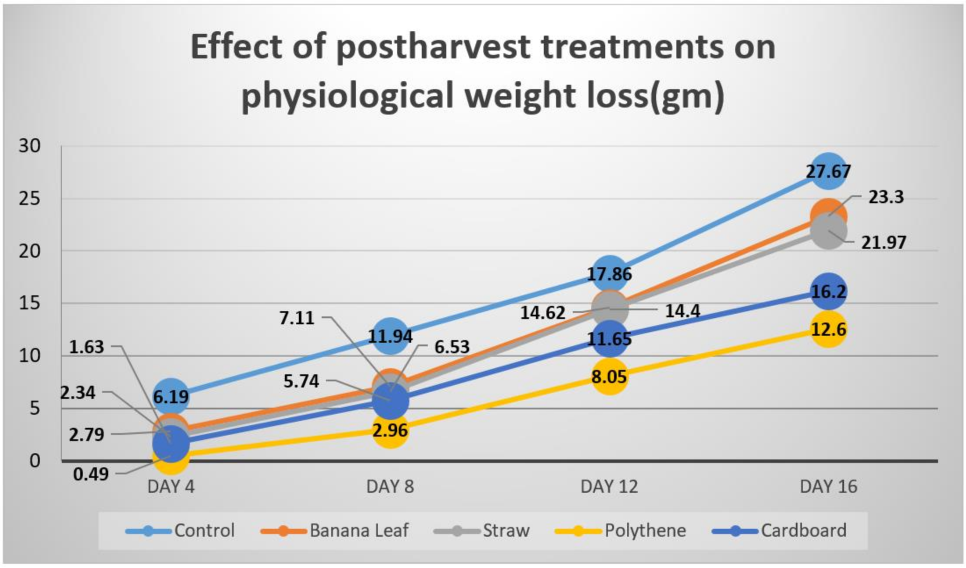


4.3 Physiological Loss in Weight (PLW)

From the table no.3, it showed that the PLW tends to increases with increase in storage time. The highest PLW (27.68 gm) was found in Control and lowest loss (21.61 gm) was found in polythene bag at day 16th. Loss of weight progressively increased with storage time. Weight loss of fresh banana is primarily due to transpiration and respiration. The minimum weight loss is in polythene bag might be due to high relative humidity, low temperature and low respiration rate inside the polythene bag. Heterat (2020), Blakely (2011) and Kirmani *et al*., (2013) reports also agree with these results.

Table 3: Effect of postharvest treatments on Physiological Weight loss (gm) of Banana (Musa paradisiaca L.) at different days

Treatments	Day4	Day8	Day12	Day16
Control	**6.19 ^{a}**	**11.94 ^{a}**	**17.86 ^{a}**	**27.67 ^{a}**
Banana Leaf	2.79 ^{b}	7.11 ^{b}	14.62 ^{b}	23.30 ^{b}
Straw	2.34 ^{c}	6.53 ^{c}	14.40 ^{b}	21.97 ^{c}
Polythene	**0.49 ^{e}**	**2.96 ^{e}**	**8.05 ^{d}**	**12.60 ^{e}**
Carboard	1.63 ^{d}	5.74 ^{d}	11.65 ^{c}	16.20 ^{d}
F test	***	***	***	***
LSD Value	0.2414441	0.5760601	0.9303397	1.279281
CV%	5.955308	5.572866	4.634574	4.170398
Sem±	0.0801	0.1911	0.3086	0.4244
Grand Mean	2.69	6.8585	13.319	20.353

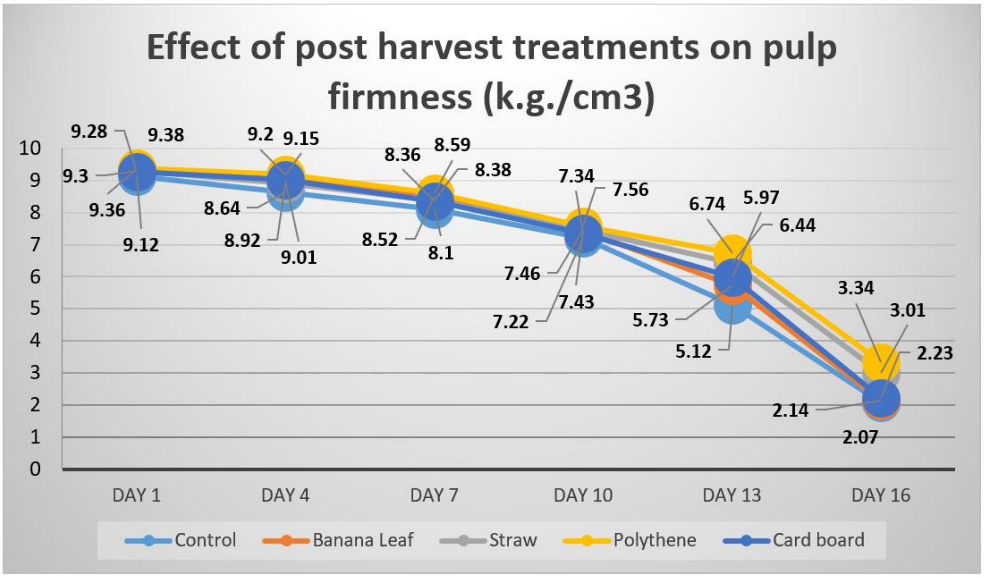


4.4 Firmness (kg/cm^2)

From the table no.4, it showed that the firmness was decreased with the advancement in storage time in all treatments. The highest firmness (9.385kgcm^{-2}) was found in polythene bag at 1st day and lowest (9.12 kgcm^{-2}) was found in control at 1st day. At the end of the day i.e., at day 16th, maximum firmness was observed in Polythene bag (3.34 kgcm^{-2}), and minimum was observed in control (2.07 kgcm^{-2}). This could be due to the reduced weight loss resulting from reduced respiration or lower enzymatic activity in polythene bag whereas this phenomenon is opposite in case of control treatment. This result also similar found in Hailu *et al.*, (2014).

Table 4: Effect of postharvest treatments on Pulp firmness (Kg/cm3) of Banana (Musa paradisiaca L.) at different days

Treatments	Day1	Day4	Day7	Day10	Day13	Day16
Control	9.12 ^{a}	**8.64 ^{b}**	8.10 ^{b}	7.22 ^{a}	**5.12 ^{c}**	**2.07 ^{c}**
Banana Leaf	9.36 ^{a}	9.15 ^{a}	8.52 ^{a}	7.43 ^{a}	5.73 ^{b}	2.14 ^{c}
Straw	9.30 ^{a}	8.92 ^{ab}	8.38 ^{ab}	7.46 ^{a}	6.44 ^{a}	3.01 ^{b}
Polythene	9.38 ^{a}	**9.20 ^{a}**	8.59 ^{a}	7.56 ^{a}	**6.74 ^{a}**	**3.34 ^{a}**
Carboard	9.28 ^{a}	9.01 ^{ab}	8.36 ^{ab}	7.34 ^{a}	5.97 ^{a}	2.23 ^{c}
F test	NA	*	NA	NA	***	***
LSD	0.2595355	0.3691076	0.3563757	0.3470076	0.3694342	0.2561807
CV%	1.853621	2.724437	2.81611	3.109657	4.083275	6.640965
Sem±	0.0816	0.1225	0.1182	0.1151	0.1226	0.085
Grand Mean	9.29	8.9891	8.3965	7.404	6.003	2.5595

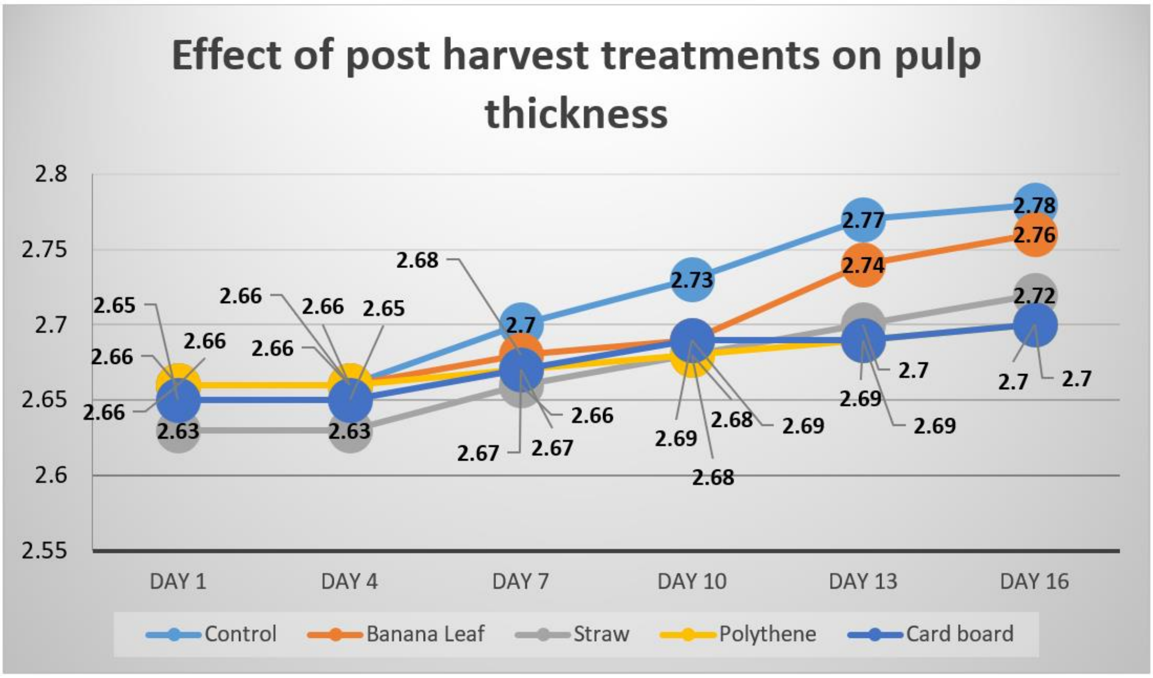


4.5 Pulp Thickness

From the table no.5, it showed that the pulp thickness tends to increase with increase in storage time. At day 16th, the highest pulp thickness (3.34 cm) was found on banana leaf and lowest (2.07 cm) on straw.

Table 5: Effect of postharvest treatments on Pulp thickness (cm) of Banana (Musa paradisiaca L.) at different days

Treatments	Day1	Day4	Day7	Day10	Day13	Day16
Control	2.66 ^{a}	2.66 ^{a}	2.70 ^{a}	2.73 ^{a}	2.77 ^{a}	**2.78 ^{a}**
Banana Leaf	2.66 ^{a}	2.66 ^{a}	2.68 ^{a}	2.69 ^{a}	2.74 ^{a}	2.76 ^{a}
Straw	2.63 ^{a}	2.63 ^{a}	2.66 ^{a}	2.68 ^{a}	2.70 ^{a}	2.72^{a}
Polythene	2.66 ^{a}	2.66 ^{a}	2.67 ^{a}	2.68 ^{a}	2.69^{a}	**2.70 ^{a}**
Carboard	2.65 ^{a}	2.65 ^{a}	2.67 ^{a}	2.69 ^{a}	2.69^{a}	2.70 ^{a}
F-test	NS	NS	NS	NS	NS	NS
LSD	0.21	0.21095	0.19316	0.19028	0.19161	0.19005
CV%	5.47	5.418199	4.78055	4.67953	4.674085	4.611151
Sem±	0.0727	0.072	0.0641	0.0631	0.0636	0.0631
Grand Mean	2.655	2.6585	2.681	2.698	2.72	2.7345

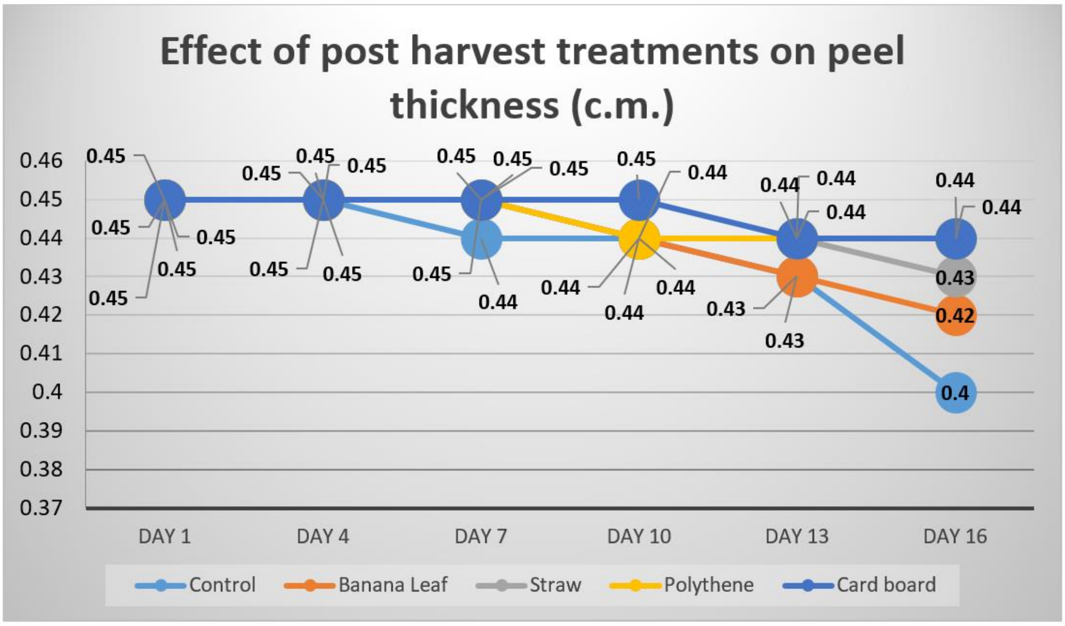


4.6 Peel Thickness

From the table no.6, it showed that the firmness tends to increase at initial stage but later decreases with increase in storage time. Straw has peel thickness highest (0.28 cm) than others at day 16. Polythene bag (0.32 cm) has lowest thickness at last day.

Table 6: Effect of postharvest treatments on Peel thickness (cm) of Banana (Musa paradisiaca L.) at different days

Treatments	Day1	Day4	Day7	Day10	Day13	Day16
Control	0.45 ^{a}	0.45 ^{a}	0.44 ^{a}	0.44 ^{a}	0.43 ^{a}	**0.40 ^{b}**
Banana Leaf	0.45 ^{a}	0.45 ^{a}	0.45 ^{a}	0.44 ^{a}	0.43 ^{a}	0.42 ^{ab}
Straw	0.45 ^{a}	0.45 ^{a}	0.45 ^{a}	0.44 ^{a}	0.44 ^{a}	0.43 ^{ab}
Polythene	0.45 ^{a}	0.45 ^{a}	0.45 ^{a}	0.44 ^{a}	0.44 ^{a}	**0.44 ^{a}**
Carboard	0.45 ^{a}	0.45 ^{a}	0.45 ^{a}	0.45 ^{a}	0.44 ^{a}	0.44 ^{a}
F-Test	NS	NS	NS	NS	NS	NS
LSD	0.033134	0.033693	0.33461	0.033868	0.036074	0.031000
CV(%)	4.831834	4.930165	4.92005	5.021556	5.422594	4.75199
SEm(±)	0.011	0.0112	0.0111	0.0112	0.012	0.0103
Grand Mean	0.455	0.45345	0.45125	0.4475	0.4414	0.433285



5. SUMMARY AND CONCLUSION

The study employed a Complete Randomized Design (CRD) with 5 treatments: T1 (control), T2 (banana leaf), T3 (straw), T4 (polythene bag), and T5 (cardboard box), with each treatment replicated 4 times. The data collected included weight loss, titratable acidity (TA), firmness, total soluble solids (TSS), pulp thickness, and peel thickness.

Comparing the weight loss, it was observed that the control group had the highest weight loss (27.6775), while the polythene bag treatment had the lowest weight loss (12.6075). This indicates that packaging bananas in polythene bags helped reduce weight loss during storage.

When considering the titratable acidity (TA), the polythene bag treatment showed the highest value (0.31875), surpassing the control group (0.24375). A higher TA suggests better fruit freshness and flavor.

In terms of firmness, the polythene bag treatment demonstrated the highest value (3.3400), whereas the control group had a lower firmness value (2.0700). This indicates that using polythene bags helped maintain the firmness of the bananas.

Examining the total soluble solids (TSS), the polythene bag treatment exhibited the highest value (15.325), surpassing the control group (12.725). A higher TSS implies better taste and sweetness in the fruit.

Analyzing the pulp thickness, the control group showed the highest increase (2.7825), while the polythene bag treatment had the least increase (2.7025). This indicates that the control group experienced more pulp thickening during storage compared to the bananas in polythene bags.

Regarding peel thickness, the control group had the highest decrease (0.40875), while the polythene bag and cardboard box treatments had the least decrease (0.44375). This suggests that the peel thickness was better preserved in the bananas packed in polythene bags and cardboard boxes.

Based on these findings, it is evident that packaging bananas in polythene bags resulted in significant improvements in weight loss, TA, firmness, TSS, pulp thickness, and peel thickness. This suggests that using polythene bags as packaging material provides better quality and extends the shelf life of bananas compared to the other materials tested in the study.

6. RECOMMENDATION

Based on the study's findings, here are some recommendations to improve the quality and shelf life of bananas:

1. **Use Polythene Bags for Packaging**: The research showed that packing bananas in polythene bags resulted in better preservation of their quality. It is recommended to promote the use of polythene bags as the preferred packaging material for bananas.

2. **Focus on Post-Harvest Practices**: Proper handling techniques during harvesting, careful sorting to remove damaged fruits, and washing the bananas with tap water can help maintain their quality and extend their shelf life.
3. **Educate Farmers and Stakeholders**: Providing training and information to farmers and those involved in the banana industry about the importance of using suitable packaging materials and implementing good post-harvest practices can significantly enhance the overall quality of bananas.
4. **Further Research**: More studies can be conducted to explore the specific factors that contribute to the effectiveness of polythene bags. Investigating factors such as gas exchange, moisture control, and temperature regulation within the packaging could provide valuable insights to improve banana storage and preservation.

By following these recommendations, we can expect to see improvements in the quality and availability of bananas, leading to better incomes for farmers, increased access to nutritious food, and overall benefits for the local economy.

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