



RESEARCH

Impact of Packaging Materials on Banana Shelf Life and Quality in Subtropical Nepal

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Abstract

Banana is a highly perishable crop susceptible to significant postharvest losses, particularly during handling and transportation throughout the supply chain. This study aimed to evaluate the effects of different packaging materials—polythene bags, cardboard boxes, banana leaves, rice straw, and no packaging (control)—on the shelf life and quality of bananas in subtropical conditions. A completely randomized design (CRD) was employed with five postharvest treatments and four replicates. Major quality parameters assessed over a 16-day storage period included total soluble solids (TSS), pulp firmness, pH, fruit volume, pulp-to-peel ratio, and fruit weight. The results revealed that bananas packaged in polythene bags exhibited the highest fruit volume (81.25 cm³) and the greatest pulp firmness (0.38 kg/cm²), indicating better texture retention. The highest pH value (6.64) was recorded for bananas packed in cardboard, suggesting slower ripening. The control group (no packaging) exhibited the highest TSS, reflecting faster ripening and potential deterioration. Polythene packaging proved most effective in preserving the initial fruit weight and reducing moisture loss during storage. Both polythene and cardboard packaging significantly enhanced the shelf life and maintained the quality attributes of bananas compared to other treatments. The findings suggest that appropriate packaging materials, particularly polythene and cardboard, play a crucial role in minimizing postharvest losses and extending the shelf life of bananas in subtropical environments. Adopting these packaging methods could improve fruit quality during storage and transportation, thereby supporting better market value and reducing economic losses.

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Statement of Sustainability: Using sustainable packaging materials such as biodegradable polyethylene alternatives and recyclable cardboard can help reduce postharvest losses while also decreasing environmental effects. Integrating eco-friendly solutions into banana storage increases shelf life, lowers waste, and promotes sustainable agriculture by encouraging optimal resource usage and lowering carbon footprints throughout the supply chain.

1. Introduction

Banana (*Musa* spp.) is native to southeast Africa and a member of the Musaceae family. Its name derives from the Arabic word "banan," which signifies finger. It is the most popular fresh fruit in the world. The banana plant is a giant perennial herb whose leaf sheath creates a pseudo-stem that forms the trunk. Rice, wheat, and maize are the fourth most stable foods in the world after the Musaceae family, which is also known as the "apple of paradise" and is commonly cultivated in tropical regions (Ghimire et al., 2023). Banana belongs to the Musaceae family and is native to southeastern Africa. Its name derives from the Arabic word 'banan', which is finger-like. It is the most widely consumed fresh fruit worldwide. The banana plant is a major perennial herb whose pseudo-stem-like trunk is formed by sheaths around its leaves (Zerga and Tsegaye, 2020). The banana plant is the eighth most traded fruit in tropical areas and is a major source of fiber and potassium (Maibam et al., 2024a). Generally, plant heights range from 1.5-8 m, and plants are divided into starchy plants and desert plants, known as bananas (Yogi et al., 2023). Statistics demonstrate a large increase in the area of output and productivity every year. Banana is mostly cultivated in the subtropical and tropical regions of Nepal, with a productive area of 21413 ha and a production of 339435 mt, yielding 15.85 mt/ha and contributing 1.54%



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of the agricultural gross domestic product (GDP). Nepal depends upon other countries for the fulfillment of banana demand by an import value of Rs. 1637134000. Nepal imported 66201230 kg of bananas (MoALD, 2022). When the fruit is not ripe, the banana pulp is firm, but as the fruit ages, it becomes softer and can be blended with just a fork. Peel has been utilized for several years to treat a wide range of diseases, such as burns, anemia, diarrhea, ulcers, inflammation, diabetes, cough, snakebite, and excessive menstruation. Peel contains high amounts of carbohydrates and phenolic compounds and has high antioxidants, and antibacterial and antibiotic activities (Mohd Zaini et al., 2022). The pulp, composed of 75% water, is a fresh fruit without oil that contains the highest caloric intake (90 kcal/100 g). Generally, bananas contain K, Mg, Cu, and Mn but supply less vitamin A or vitamin C than other fruits. Bananas are rich in pyridoxine (vitamin B6). The compounds with health benefits potential in banana plants include flavonoids, carotenoids, and polysaccharide compounds, such as starch (Fahrasmane et al., 2014).

The postharvest stage includes activities such as cooling, cleaning, sorting, and packing and starts after crop harvesting. If a crop is sold fresh or as a component of processed foods, this stage is crucial. Like humans, adults are living with the respiratory system. Approximately 20–30% of fresh fruits are lost after harvest, with the chance of reaching 50% under adverse conditions (Raj Bist et al., 2024). Shelf life is the duration of time at which a food product is safe; ensures the proper sensory, chemical, physical, and microbiological characteristics; adheres to any nutritional data declared on the label; and is considered acceptable by the consumer (Phimolsiripol and Suppakul, 2016). Since bananas are climacteric fruits, the quality of fruit usually degrades if well-stored water is not available because it produces ethylene and has a high respiration rate after harvesting, which causes a large postharvest loss. Moreover, weak quality control and technology applications contribute to these losses (Maibam et al., 2024b). When fruits are harvested before the appropriate stage, the quality and responsiveness to physiological disorders decrease, and the shelf life decreases (Etefa et al., 2022). During loading and unloading, when a vehicle vibrates on a damaged road, congested storage space and low air supply result in postharvest loss (Raj Bist et al., 2024). Transportation losses are high due to inadequate ways of shipping in developing countries (Devkota et al., 2014). The losses of various fruits across the Nepal border to various Indian markets vary from 15–36%, depending on the product (Bhattarai, 2018).

Bananas are a perishable fruit. The shelf life of banana plants is affected by a variety of factors, including ambient conditions. Postharvest management during harvesting, shipping, and storage determines the quality of fresh and processed fruit; this quality should be continuously managed to guarantee that the best quality fruit is harvested (Hailu et al., 2014). The shelf life of the banana fruits was determined by counting the days needed for the fruits to reach the last ripe stage before they reached the senescence (unmarketable) stage. Bananas ripen quickly at high temperatures and have a short shelf life. As a result, there is a need to develop low-cost technologies for delaying ripening and increasing shelf life under ambient circumstances while preserving the fruit's eating quality. Its fruits are perishable by nature and cannot be preserved for an extended period. Because of its limited shelf life, it cannot be transported to distant locations, resulting in a surplus on the local market. The shelf life of fruits may be extended by a variety of means, including adequate packing. Paper-based packaging is becoming increasingly common (Krishnakumar and Thirupathi, 2014).

This study aimed to assess how different packing materials affect the shelf life and quality of bananas. The goal of this study was to determine the ideal packing material for extending the shelf life of banana plants and improving their quality. The effects of various packing materials on the postharvest qualitative attributes of bananas were analyzed.

2. Materials and Methods

2.1. Experimental Site

The study was conducted in Dilashaini-5, Baitadi, Nepal, in the horticulture laboratory of Gokuleshwor Agriculture and Animal Science College. The experimental site is located at an elevation of 850 meters above sea level. The latitude and longitude of the research site are 33.03 degrees North and 80.77 degrees East, respectively. The study followed a completely randomized design (CRD) to ensure the reliability and validity of the results, with 5 treatments and 4 replications (Figure 1). Fresh G9 variety bananas were purchased from the farm of Gokuleshwor Agriculture and Animal Science College following all the abovementioned precautions. The study involved a total of 20 plots, with 24 fingers (individual bananas) per plot. For each replicate, 12 nondestructive and 12 destructive bananas were removed from the finger.

2.2. Treatment Groups

The study included five treatment groups to determine how different packing materials affected the shelf life and quality of bananas. The control group (T1) consisted of unpackaged bananas used as a baseline for comparison. The banana leaf treatment (T2) involved wrapping bananas in banana leaves, which is a traditional and biodegradable packaging method. The rice straw treatment (T3) entailed wrapping bananas in rice straw for natural cushioning and ventilation. The polythene bag treatment (T4) created a modified environment to assist prevent moisture loss and postpone ripening. Finally, the cardboard box treatment (T5) housed bananas in cardboard boxes, which provided structural support and modest protection against external environmental variables. These treatments were developed to determine their usefulness in protecting banana quality during storage.

R ₄ T ₂	R ₂ T ₂	R ₂ T ₃	R ₃ T ₂
R ₁ T ₃	R ₄ T ₃	R ₂ T ₄	R ₃ T ₅
R ₄ T ₅	R ₃ T ₄	R ₁ T ₄	R ₃ T ₁
R ₁ T ₅	R ₄ T ₄	R ₄ T ₁	R ₂ T ₅
R ₂ T ₁	R ₁ T ₂	R ₁ T ₁	R ₃ T ₃

Figure 1. One factor CRD experimental layout.

2.3. Observations and Data Collection

The relative humidity and temperature were monitored throughout the storage period to ensure consistency. A digital hygrometer (HTC-1) was used for measuring the temperature and relative humidity. On average, the room temperature ranged from 18–22°C, and the relative humidity ranged from 50–60%. To assess the effect of different packaging materials on the shelf life and quality of the bananas, the following parameters were observed and recorded:

2.3.1. Fruit Weight

Five random bananas were picked for weight evaluation. A digital weighing balance was used to determine the fruit's weight. Fruit weight was obtained from Eq. (1).

$$\text{Average fruit weight} = \frac{\text{total weight of fruits (g)}}{\text{number of fruits}} \tag{1}$$

2.3.2. Pulp pH

The pH of the sample banana juice was measured by using a digital pH meter. The pH meter was calibrated with buffer at pH 4, 7, and 9. Only a 30 g banana sample was mixed with 100 ml of distilled water, and the pH was measured using a pH meter.

2.3.3 Fruit Volume

The volume was measured using the displacement method by submerging the banana in water and measuring the volume of displaced water. The volume of fruit is obtained by using Eq. (2).

$$\text{Volume} = \text{Final water level} - \text{Initial water level} \tag{2}$$

2.3.4. Pulp Firmness

Firmness is important for assessing fruit susceptibility to physical or mechanical damage and postharvest handling. The firmness of the bananas was measured using a penetrometer to (PNR-12) evaluate the texture and structural integrity of the fruit over time. The test tip was inserted into the banana, which was peeled off. The unit of the reading was kg/cm² (Hailu et al., 2014).

2.3.5 Total Soluble Solids (TSS)

The TSS concentration was measured using a refractometer (KERN ORA 10BA) to determine the sugar content and sweetness of the bananas during storage. The mashed pulp was loaded onto the sample plate of the refractometer, and readings were taken. The readings were expressed in °Brix (Pradhan et al., 2023).

2.3.6. Pulp-to-Peel Ratio

The thickness of the banana peel was measured to determine the effects of packaging on the structural characteristics of the fruit, and the thickness of the banana pulp was recorded to evaluate any changes in the fruit's internal quality. The pulp-to-peel ratio was calculated by vernier caliper (Hailu et al., 2014) (Eq. 3):

$$\text{Pulp – to – peel ratio} = \frac{\text{Pulp thickness}}{\text{Peel thickness}} \quad (3)$$

2.4. Data Analysis

The collected data were entered into Excel 2016 for initial organization and basic analysis. Advanced statistical analysis was performed using RStudio (version 4.2.2). ANOVA (analysis of variance) was employed to determine the significance of differences between treatments. Post hoc tests, such as the least significant difference (LSD) test, were also conducted to identify specific differences between treatment means. Descriptive statistics, including the mean and standard deviation, were calculated to summarize the data. The level of significance was 5%. The final result was interpreted.

3. Results and Discussion

3.1. Fruit Weight

ANOVA demonstrated nonsignificant results on days 3 and 12. However, there were significant differences on day 6 ($P \leq 0.05$), day 9, and day 15 ($P \leq 0.01$) after the different postharvest treatments. Fruit weight decreased across the different postharvest treatments on all days. The maximum fruit weight was recorded for polythene (99.87 g), and the lowest was recorded for the control (88.16 g) on day 3. On day 6, the highest fruit weight was observed for polythene (94 g), which was followed by cardboard (83.78 g), while the lowest weight was observed for banana leaves (67.33 g), which was followed by paddy straw (71.25 g) and the control (76.75 g). On day 9, the maximum fruit weight was recorded for polythene (92.16 g), which was followed by paddy straw (76.06 g) and cardboard (76.09 g), while the lowest weight was recorded for the control (60.86 g). The highest fruit weight was recorded for polythene (86.75 g), and the lowest was observed for the control (59.5 g) on day 12. The highest fruit weight was observed for polythene (97.25 g), and the lowest was observed for the control (52.96 g) on day 15 (Figure 2). The weight of fruits decreases with increasing days due to various factors, such as water loss, physiological attributes, and the microenvironment (Sah et al., 2023). Polythene can maintain its microenvironment, reduce moisture loss, and prevent dehydration, whereas different organic postharvest treatments have been used due to their lower effective moisture retention properties than polythene (Mahajan et al., 2014). Similar results were found by Dhakal et al. (2022) on the effect of different packaging materials on pineapple.

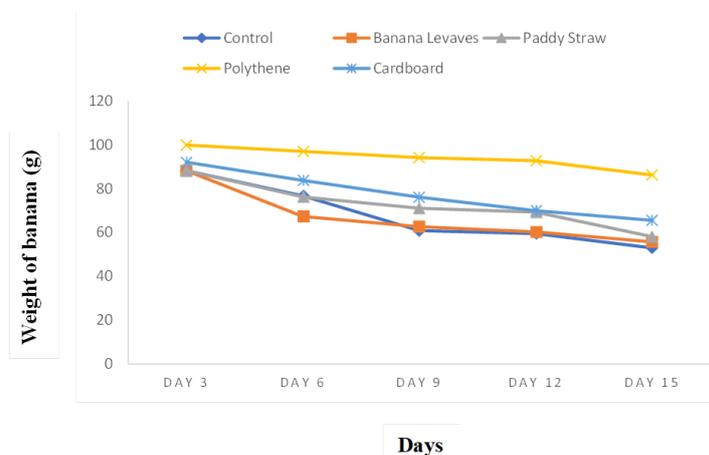


Figure 2. Effect of different packaging materials on fruit weight (g).

3.2 Pulp-to-Peel Ratio

ANOVA demonstrated significant differences among the different postharvest treatments ($P \leq 0.01$) on day 4 and day 8 ($P \leq 0.001$) on day 12 and day 16. The highest pulp-to-peel ratio was recorded for the cardboard treatment (4.76), which was statistically similar to that for the banana leaf treatment (4.51). The lowest pulp-to-peel ratio was observed for the control treatment (2.87), followed by the paddy straw treatment (3.68) and polythene treatment (3.65) on day 4. On day 8, the highest pulp-to-peel ratio was obtained with cardboard (4.36), which was significantly different from that of the banana leaves (5.72) and the control (5.17). The highest pulp-to-peel ratio was observed for banana leaves (6.10), followed by paddy straw (4.56). The lowest pulp-to-peel ratio was obtained with cardboard (2.88), which was significantly similar to that of polyethylene (3.47) and the control (4.04) on day 12. The highest pulp-to-peel ratio was observed on day 16 for cardboard (0.059), followed by polythene (0.043) and paddy straw (0.042). The lowest pulp-to-peel ratio was observed in the control treatment (0.013), followed by that in the banana treatment (0.03) (Table 1). The results demonstrated that the pulp-to-peel ratio increased during the initial days of postharvest treatment and then decreased with increasing duration. Due to the increase in the sugar concentration of pulp tissue and during ripening, moisture is carried out on the pulp from the peel (Abraham et al., 2022). A similar result during banana ripening was found by Hakim K A (2013).

Table 1. Effect of different packaging materials on the pulp-to-peel ratio of banana plants.

Treatment	Day 4	Day 8	Day 12	Day 16
Control	2.877656c	5.171446ab	4.04722bc	0.013156d
Banana Leaves	4.518631ab	5.725193a	6.104433a	0.030673c
Paddy Straw	3.688053bc	4.24692b	4.568901b	0.042805b
Polythene	3.656475bc	2.796863c	3.471228bc	0.043025b
Cardboard	4.768581a	4.363262a	2.882062c	0.059706a
Grand Mean	3.901879	4.460737	4.214769	0.037873
CV	17.5047	19.369	18.7556	12.8189
LSD	1.0294	1.3021	1.1914	0.00731
F Test	**	**	***	***

LSD: least significant difference; CV: coefficient of variation; *** indicates $P \leq 0.001$; ** indicates $P \leq 0.01$; NS indicates nonsignificant difference; means with the same letter indicate that the treatment was not significantly different.

3.3. Volume of Banana Fruits

ANOVA revealed nonsignificant results on days 3, 6, and 12. However, there were significant differences on day 9 ($P \leq 0.05$) and day 15 ($P \leq 0.01$) among the different postharvest treatments. The maximum volume was observed on banana leaves (89.38 cm^3), and the minimum volume was observed on cardboard (77.49 cm^3) on day 3. On day 6, the maximum volume of fruits was polythene (90 cm^3), and the minimum was on banana leaves (69.25 cm^3). The highest volume was observed for polythene (84.25 cm^3), which is significantly on par with paddy straw (73.02 cm^3). However, the lowest volume was observed on cardboard (53.89) on day 9. The maximum volume of fruit was recorded on polythene (82 cm^3), and the minimum volume was observed on the control (60.52 cm^3) on day 12. On day 15, the highest volume was recorded for polythene (81.25 cm^3), followed by banana leaves (63.02 cm^3) and cardboard (52.29 cm^3). The lowest volume was observed in the control treatment (48.67 cm^3), which was significantly lower than that in the paddy straw treatment (50.31 cm^3) (Table 2). The results demonstrated that the volume of fruits decreased with increasing duration. All postharvest treatments outperformed the control treatment. These plants undergo various physiological changes that lead to a decrease in the volume of fruits, which has also been reported (Umeohia and Olapade, 2024). A decrease in the volume of fruits occurs because water loss during storage increases the water loss, and a greater loss of fruit volume is influenced by various environmental factors (Gidado et al., 2024). Similar results were found by Azene et al. (2014) on the effect of different packaging materials on papaya fruits.

3.4. pH of Banana Pulp

Analysis of variance revealed no significant differences among the different postharvest treatments on days 3, 6, 9, and 12. Significant differences were observed on day 15 ($P \leq 0.05$). On day 3, the maximum pH was recorded for the control (6.38). The minimum pH was recorded on the banana leaves (5.82). The maximum pH was recorded for the control (6.29). The minimum pH was recorded for polythene (5.95) on day 6. On day 9, the maximum pH was recorded for the cardboard (6.91). The minimum pH was observed on the banana leaves (6.4). However, on day 12, the maximum

pH was observed in the control treatment (7.02), and the minimum pH was observed in the paddy straw treatment (6). The highest pH was observed for cardboard (6.64), which was statistically at par with that of the control (6.62). The lowest pH was caused by polythene (5.8), which is significantly similar to the pH of paddy straw (5.86) and banana leaves (5.87) (Table 3). Banana pulp was found to have a consistent pH throughout the early days of storage, but as time progressed, the pH was slightly acidic. Because different organic acids are present in banana fruits and are used during respiration, the acid content of fruits will increase as they ripen (Maduwanthi and Marapana, 2019). Amino acids play a significant role in acid formation in banana juice, the pH of which is normally between 6.2 and 6.7 (Albertini et al., 2006). Similar results were found by Zerga and Tsegaye (2020) for different banana packaging materials.

Table 2. Effect of different packaging materials on the volume of banana fruits (cm³).

Treatment	Day 3	Day 6	Day 9	Day 12	Day 15
Control	80.375	71.005	65.605 ^{bc}	60.52	48.675 ^b
Banana Leaves	89.3875	69.25	65.0475 ^{bc}	70.52	63.02 ^b
Paddy Straw	80.455	73.3925	73.0275 ^{ab}	67.0775	50.31 ^b
Polythene	87.5	90	84.25 ^a	82	81.25 ^a
Cardboard	77.4925	71.6725	53.8975 ^c	64.2275	52.29 ^b
Grand Mean	83.042	75.064	68.3655	68.869	59.109
CV	8.4581	14.10053	17.2011	19.3434	18.4568
LSD	10.586	15.95244	17.7237	14.8879	16.4425
F Test	NS	NS	*	NS	**

LSD: least significant difference; CV: coefficient of variation; ** indicates $P \leq 0.01$; * indicates $P \leq 0.05$; NS indicates nonsignificant difference; means with the same letter indicate that the treatment was not significantly different.

Table 3. Effect of different packaging materials on the pH of banana plants.

Treatment	Day 3	Day 6	Day 9	Day 12	Day 15
Control	6.38	6.755	6.6825	7.025	6.62 ^a
Banana Leaves	5.82	6.0325	6.4025	6.24	5.8775 ^b
Paddy Straw	5.96	6.29	6.515	6.0075	5.8625 ^b
Polythene	5.88	5.955	6.735	6.57	5.805 ^b
Cardboard	6.3425	6.2775	6.91	6.83	6.645 ^a
Grand Mean	6.0765	6.262	6.649	6.5345	6.162
CV	7.179	11.2637	6.6449	11.3064	6.5239
LSD	0.6574	1.063	0.6659	1.1135	0.6058
F Test	NS	NS	NS	NS	*

LSD: least significant difference; CV: coefficient of variation; * indicates $P \leq 0.05$; NS indicates nonsignificant difference; means with the same letter indicate that the treatment was not significantly different.

3.5. Pulp Firmness

ANOVA revealed significant differences among the different postharvest treatments on day 6 ($P \leq 0.01$), day 9, day 12 ($P \leq 0.001$), and day 15 ($P \leq 0.01$). Nonsignificant results were exhibited on day 3. The maximum pulp firmness was observed on paddy straw (8.45 kg/cm²), and the minimum pulp firmness was observed on polythene (7.17 kg/cm²) on day 3. On day 6, the highest pulp firmness was caused by paddy straw (6.52 kg/cm²), which was significantly similar to that of the control (5.45 kg/cm²). The lowest pulp firmness was caused by polythene (2.96 kg/cm²), followed by banana leaves (4.75 kg/cm²) and cardboard (5.07 kg/cm²). The highest pulp firmness observed on day 9 was in the cardboard treatment (4.69 kg/cm²), followed by the paddy straw treatment (3.37 kg/cm²) and banana leaf treatment (3.21 kg/cm²). The lowest pulp firmness was caused by polythene (1.37 kg/cm²), followed by the control (2.75 kg/cm²). However, on day 12, the highest pulp firmness was observed for polythene (0.86 kg/cm²), followed by paddy straw (0.54 kg/cm²) and the control (0.53 kg/cm²). The lowest pulp firmness was observed on cardboard (0.28 kg/cm²), which was significantly lower than that on banana leaves (0.37 kg/cm²).

The highest pulp firmness was observed for polythene (0.38 kg/cm²), followed by cardboard (0.26 kg/cm²) and paddy straw (0.25 kg/cm²). The lowest pulp firmness was observed on the banana leaves (0.23 kg/cm²), which was significantly lower than that of the control (0.24 kg/cm²) (Table 4). There was a decrease in pulp firmness throughout the observation days. Due to the increase in ethylene production during storage and microbial activity, the rate of respiration increases, which leads to a decrease in pulp firmness (Mahajan et al., 2014). Another reason for the decrease

in pulp firmness is the various environmental constraints (decreased relative humidity and high temperature), which lead to a decrease in the pulp firmness of fruits (Budhathoki et al., 2022).

Table 4. Effect of different packaging materials on banana pulp firmness (kg/cm²).

Treatment	Day 3	Day 6	Day 9	Day 12	Day 15
Control	7.27	5.45 ^{ab}	2.725 ^b	0.535 ^b	0.24 ^b
Banana Leaves	7.3	4.75 ^b	3.2125 ^b	0.37 ^c	0.2375 ^b
Paddy Straw	8.45	6.525 ^a	3.375 ^b	0.5475 ^b	0.2575 ^b
Polythene	7.175	2.9625 ^c	1.375 ^c	0.865 ^a	0.38725 ^a
Cardboard	7.595	5.075 ^b	4.69625 ^a	0.2875 ^c	0.2625 ^b
Grand Mean	7.558	4.9525	3.07675	0.521	0.27695
CV	12.1267	18.8206	18.9683	20.9054	19.2592
LSD	1.3813	1.4048	0.8795	0.1641	0.08038
F Test	NS	**	***	***	**

LSD: least significant difference; CV: coefficient of variation; *** indicates $P \leq 0.001$; ** indicates $P \leq 0.01$; NS indicates nonsignificant difference; means with the same letter indicate that the treatment was not significantly different.

3.6. Total Soluble Solids (TSS)

ANOVA revealed no significant differences among the different postharvest treatments on days 3, 6, 9, 12, and 15. The TSS concentration increased across the different postharvest treatments on all days. The highest TSS concentration was detected on banana leaves (8.25 °brix), and the lowest TSS concentration was detected on day 3 in response to polythene (5.75 °brix). On day 6, the highest TSS concentration was detected on the banana leaves (17.62 °brix), and the lowest TSS concentration was detected based on the paddy straw (7.75 °brix). The highest TSS concentration was detected in the control treatment (19.55 °brix), and the lowest TSS concentration was detected in the treatment with polythene (14.50 °brix) on day 9. However, on day 12, the highest TSS was observed in the control treatment (25.5 °brix), and the lowest was demonstrated by polythene (17.5 °brix).

The highest TSS concentration was detected in the control treatment (27.45 °brix), and the lowest was detected in the polyethylene treatment (20.25 °brix) (Figure 3). The total soluble solids (TSS) increase with increasing days. Sugars, acids, and other soluble compounds result in the sweetness and flavor profile of fruits (Daniel Valero and María Serrano, 2013). In addition to different physiological changes and particularly ripening processes, the use of breathable packing materials can enhance the ripening process by allowing gas exchange while maintaining moisture content, which is crucial for optimal TSS accumulation (Alina Marc et al., 2024). Similar results were found by Chhetri and Ghimire (2023) for mango fruits.

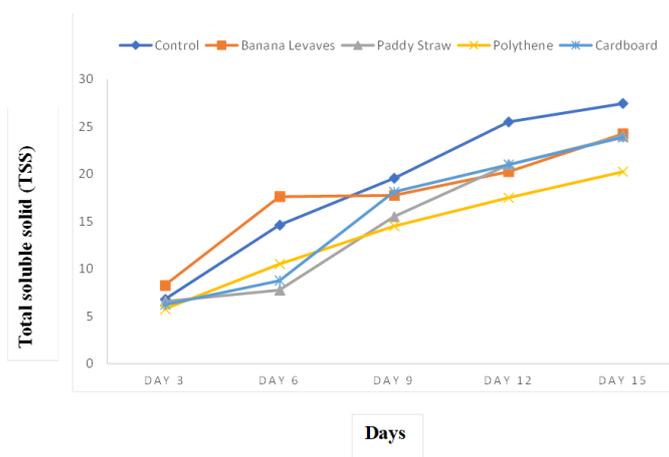


Figure 3. Effect of different packaging materials on the TSS of banana (°brix).

4. Conclusion

Post-harvest activities, such as cooling, cleaning, sorting, and packing, are crucial for fresh or processed foods. Fresh fruit post-harvest losses can reach as high as 50% due to adverse conditions. Poor storage, poor quality control, and

transportation losses. Therefore, it is necessary to evaluate the different packaging materials available to extend the shelf life of bananas. Therefore, an experimental study was carried out to evaluate the effect of different packaging materials on the shelf life and quality of banana fruits. The highest fruit weight was found for polythene (97.25 g). Polythene is capable of creating a microenvironment that protects plants from water loss through evaporation, as is the case for organic postharvest treatments, for which the moisture retention capacity is relatively low. The maximum pulp-to-peel ratios were observed for cardboard (0.059) and polythene (0.043). Because of the increase in sugar concentration in the pulp tissue and the moisture transfer during ripening, moisture was removed from the peel. The highest volume was recorded for polythene (81.25 cm³). This is because the volume of fruits decreases as a result of water loss during storage, and this is determined by factors such as climate. The highest pH was observed for cardboard (6.64). As bananas ripen, their acid content increases because the organic acids used in respiration accumulate. The highest pulp firmness was observed on polythene (0.38 kg/cm²) and cardboard (0.26 kg/cm²). Moreover, ethylene production during storage and microbial activity increase fruit respiration rates, leading to softening of the pulp. The highest TSS concentration was detected in the control group (27.45 °brix).

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Data Availability/Sharing: Data will be made available on request to the corresponding author.

Supplementary Information Availability: Not applicable.

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