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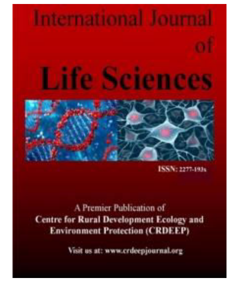

Full Length Research Paper

Effect of Different Packaging Materials on Shelf Life of Banana (*Musa paradisiaca* L.) at Wolaita Sodo, Southern Ethiopia

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ABSTRACT

This study was conducted to evaluate the effect of different packaging materials on shelf life of banana (Musa paradisiaca L.). A laboratory experiment was laid out at Wolaita Sodo University in the period of 2017. The packaging materials were four different packaging materials which are locally available at community level: open air as a control, teff straw, dried banana leaf and plastic bag. The experiment was laid out in Completely Randomized Design with each replicated three times. Fruits were washed to remove adhering dirt and dried in air and kept in packaging materials and storage to be used in the experiment. The highest physiological weight loss (27.83%) and decay percentage (100%) were recorded on the open air treated fruits. On the other hand, the lowest weight loss (20.29%) and decay percentage (13.33%) were observed in bananas which were treated by plastic bag (T3). In relation to shelf life plastic bag and banana leaf packaging materials showed the longest shelf life (12 and 8 days) and the lowest had been recorded on open ground and teff straw treated fruits. In general, banana fruit packed with plastic bag showed better result for moisture content, physiological weight loss, peel to pulp ratio, decay percentage and marketable as compared to fruits packed in other packaging materials. Therefore, it can be concluded that packaging of banana fruit in plastic bags resulted in longer shelf life and maintained the qualities of the banana compared to other packaging materials.

Introduction

Banana (*Musa sapientum* L.) is one of the important tropical fruits and native to south east Africa. It is the most popular fresh fruit all over the world and its name comes from the Arabic word 'banan', which means finger. Banana is a large perennial herb with leaf sheaths that form the trunk like pseudo stem. They vary in height from 1.5-8 m and generally divide in to starchy type called plantation and the desert type known as banana (Hailu *et al*, 2014).

Banana is a very popular fruit due to its low price and high nutritive value. It is consumed both in fresh and cooked form both as ripe and raw fruit, is a rich source of Carbohydrate and is rich in vitamins particularly vitamin B. It is also a good source of potassium, phosphorus, calcium and magnesium. The fruit is easy to digest, free from fat and cholesterol. It helps in reducing the risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, Gastroenteritis and kidney disorders. Processed products, such as chips, banana puree, jam, jelly, juice, wine and halwa can be made from the fruit. Banana can be utilized for the production of edible vaccine against Hepatitis- B virus (HBV). The plant based vaccine for HBV from edible banana seems to be an economical alternative for human healthcare by many scholars.

The total area under banana in the world is 11.13 million ha, producing 97.38 million tons of banana and plantains. India is the largest producer of banana in the world, contributing 24 % to the global production with a total area of 0.565 million ha and production 19.19 million tons reported for the year 2011 (FAO, 2011).

Ethiopia lies in the tropics where vast areas aresuitable for banana growing. Bananaproduction in Ethiopia ranges from homesteadto large commercial plantations. At present, bananas are the leading fruit crops produced inthe country both in terms of area coverage (28,695 ha) and production (1,245,615.60 qyear−1) (Central Statistics Authority, 2004). In Ethiopia there is no proper means ofpostharvest handling of fruits and vegetables atthe retail and wholesale levels, which results inpoor quality of banana at the consumer level.Although the country is experiencing hugepostharvest losses of banana very little or no emphasis is given to postharvest handling of the fruit (Workneh *et al*, 2011).

The spoilage of banana is mainly due toharvesting at improper stage of maturity. Physical damage during transport, consequent fungal infections, and fungal breakdownprimarily leads the fruit to senescence. Packaging of the fruit protects from physicaldamages 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.

In most of the time the traditional packaging method for banana is nested packaging in which dried banana leaf and straw of teff are used but the effectiveness of these packaging materials even has not yet been investigated. Modified atmospheric packaging (MAP) has also been found to increase the shelf life of banana fruit. It is often desirable to generate an atmosphere low in O2 and/or high in CO2 to influence the metabolism of banana being packaged or the activity of decay-causing organisms to increase storability and/or shelf life. Packaging isolates the product from the external environment and helps to ensure conditions (Beaudry, 2000).

The quality of banana is reduced and considerable amount is wasted, from harvesting to final consumption. This loss can be kept at minimum by improving postharvest handling techniques through the use of packaging materials or through improving traditional packaging practices. Therefore, this study was aimed at shelf life extension of banana using an appropriate packaging material. The specific objective of the study was to evaluate the effect of packaging materials on some selected qualities of three banana cultivars.

Materials and methods

Description of the Experimental site

Laboratory experiments were carried out at Wolaita Sodo University, Department of Horticulture laboratory. It is located at southern part of Ethiopia. It is 360 km far from Addis Ababa and geographically $6^0$49'N and $37^0$45' E and lies on an altitude of 1483 meters above sea level. The annual average temperature of the zone is 20^oc and the mean annual rainfall ranges from 1200 to 1300mm. The rainfall has a bi-modal distribution pattern with small rains from March to May and long and heavy rains from June to September. The zone covers an area of 44,721km^2 and found in the altitude range of 1500-2100 masl. (Hailu *et al.,* 2011).

Experimental Materials

Banana fruit harvested at commercial maturity with uniform size, shape, and color were collected from wolaita Sodo farmer site. The fruits transported to the experimental site one day after harvest. The different locally available packaging materials are *teff* straw, dried banana leaf and polyethylene bag.

Treatments and Experimental Design

The experiment were four different packaging materials which are locally available at community level, open Ground (control), *teff* straw, dried banana leaf, plastic bag. The experiment had a total of 12 numbers of observations. The design of experiment was complete random design (CRD) with three replication in each treatment. Each treatment was assigned randomly to the experimental unit within a replication.

Data Collected

Different qualitative and quantitative data were collected for different parameters. Observation and recording of the data were done on the 4^{th} and 8^{th} day during the storage period. On the first storage day data for initial weight was recorded.

Fruit Color Determination

Fruit color analysis was assessed visually by matching the color with standardized color charts that describe the given ripening at eight stages and color score was assigned accordingly: 1=green, 2=green with trace yellow 3=most green, 4=green and yellow,5=most yellow,6=almost yellow,7 =yellow, 8= yellow with brown flex and 9 =black. Banana fruit was considering unripe at stages

Shelf Life (day)

Shelf life of banana fruits as influenced by different packaging material was calculated by counting the days required to ripe fully as to retaining optimum marketing and eating qualities. The shelf life of the fruit was determined by the long lasting of the fruit.

Physiological Weight Loss

Weight loss was determined by using Portable Electronic Scale balance. The weight loss of Banana fruit sample was calculated as the percentage of the initial fruit weight. The following formula used to compute physiological weight loss (Monerzumma *et al.,* 2009).The percentage weight loss was calculated for each sampling interval using the formula given bellow and the cumulative WL is expressed as percentage for the respective treatments.

$$\textbf{Weight loss (\%)} = \frac{\text{Weight of fresh fruit (g) - eight after interval (g)}}{\text{Weight of fresh fruit (g)}} * 100$$

Peel to Pulp Ratio

Banana fruits from each treatment were peeled off and the pulp and peel portion of each finger were weighted separately by electronic sensitive balance. The following formula was used to determine the percentage of peel to pulp.

$$\textbf{Peel to pulp (\%)} = \frac{\text{Pulp weight}}{\text{Peel weight}} * 100$$

Decay Percentage

Decay or rotting was determined by visual observation. Development of spots on the fruit and softening and rotting of the fruits was recorded (Monerzumma *et al.,* 2009).

Determination of pH

Assessment of pH of banana is used primarily to estimate consumption quality and hidden attributes. They could be considered as indicators of fruit maturity or ripeness. The pH value of the filtrate from pulp samples is determined using a pH electrode at a temperature of 20°C (Model Jenway 3320).

Percentage of marketability

The marketable quality of fruits was subjectively assessed according to the procedure of Mohammed *et al.* (1999). These descriptive quality attributes were determined subjectively by observing the level of visible mould growth, decay, shriveling, smoothness, and shininess of fruits. A 1-9 rating with1=unusable, 3= usable, 5=fair, 7=good, 9=excellent was used to evaluate the fruit quality. Fruits receiving a rating 5 and above were considered as marketable. The numbers of marketable fruits were used as a measure to calculate the percentage of marketable fruits during storage.

Statistical Analysis

The collected data were subjected to Analysis of Variance (ANOVA) by using SAS Version9.2 computer software. Fisher's Least Significance Difference (LSD) was used to establish the multiple comparisons of mean values. Mean values were considered at 5% significance level ($p < 0.05$).

Results and Discussion

Effect of packaging materials on physiological weight loss

Weight loss of fresh fruits is primarily due to transpiration and respiration (Tadesse, 1991).On current study weight loss of banana fruit was significant within the storage period. Table 1 showed that there was a significant variation in physiological weight loss between the different treatments. The highest physiological weight loss was recorded on the T4 (control) treated fruits (27.83%) followed by T1 (teff straw) (23.32%) and the lowest physiological weight loss was observed in banana fruits treated by T3 (plastic bag) (20.29%) at the 4th days of storage period. On the 8th and 12 days of storage the highest physiological weight loss was recorded.Treatment T4 and T1 had the highest physiological weight loss (36.93%) and (35.48%) respectively and the lowest physiological weight loss was observed in banana fruits which were treated by T3 (plastic bag). The highest physiological weight loss was observed with fruits treated by T4. This might be due to the packaging material (open air) increases the transpiration and respiration rate as compared to the room temperature storage.. Weight loss of fresh banana is primarily due to transpiration and respiration. Transpiration is a mechanism in which water is lost due to differences in vapor pressure of water in the atmosphere and the transpiring surface (Tasdelen and Bayindirli, 1998). Respiration causes a weight reduction because a carbon atom is lost from the fruit, each time a carbon-dioxide molecule is produced from an absorbed oxygen molecule and evolved into atmosphere (Bhowmik and Pan, 1992). Higher respiration rate also resulted in higher transpiration of water from the fruit surface which led to increase in percentage of weight loss (Sabir *et al.,* 2004).

Table 1: Physiological Weight Loss of bananas stored at different packaging materials for4, 8, and 12days (%)

Treatment combinations	**Physiological Weight loss (%)**		
	Day 4	**Day 8**	**Day 12**
T1	23.32b	35.48ab	43.28b
T2	21.44c	33.31bc	39.71c
T3	20.29c	25.19d	31.19d
T4	27.87a	36.93a	47.13a
LSD (5%)	**3.07**	**3.30**	**6.85**
CV (%)	**7.76**	**6.06**	**4.74**

Means within the same column followed by a common letter are not significantly different at P ≤ 0.05 (LSD test). *Where: T1 teff straw; T2, dried banana leaf; T3, polyethylene bag; and T4, is Control.*

Effect of different packaging materials on moisture content

Table 2 showed there was a significant variation in moisture content observed between the different treatments. The highest moisture content was observed in bananas which were treated by T3 (93.39) andthe lowest moisture content was recorded in bananas which were treated by T4 (77.13) after 4 days of storage. Whereas at the 8th days of storage the highest moisture content was recorded in banana fruits treated by T3 (98.66) and the lowest moisture content were observed in banana fruits which were treated by T4 (84.83).Water comprises about 60 to 86 % of the fresh weight of the banana fruit with the size of the fruit influenced by availability of water to the plant (Babitha and Kiranmayi, 2010). Ripening in fruits is proceeded by softening, with the resultant effect of increased moisture content of the fruit. The moisture content of banana fruit was observed increasing until the 12 ^{to}days of storage. Pulp moisture content was continued to increasing until last days of storage. This reveals fruit moisture has been migrated from peel to pulp. However, the acceleration in pulp moisture content was increased from 8 to12 days of storage. Mohapatra and Sabayasachi (2010) reported that the increased in moisture content of pulp was occurred due to increase in sugar content in the pulp as a result of starch hydrolysis to sugar.

Table 2: Moisture content of bananas stored at different packaging materials for 4, 8, and 12days (%)

Treatment combinations	**Moisture content (%)**		
	Day 4	**Day 8**	**Day 12**
T1	90.13 b	91.83bc	94.13b
T2	90.28b	94.80ab	97.19a
T3	93.39a	96.86a	98.28a
T4	77. 13c	84.83d	77.71c
LSD (5%)	**6.85**	**34.41**	45.55
CV (%)	**4.74**	**2.84**	2.74

Means with same letter within a column are not significantly different *Where: T1 teff straw; T2, dried banana leaf; T3, plastic bag; and T4, is Control.*

Effect of packaging materials on decay percentage and shelf life

In present study it is clearly identified that decay percentage increased with the storage time for fruits stored inside different packaging materials and treated with different post-harvest treatments. However, the decay was early and very massive for control comparing to those fruits treated and stored inside different packaging materials. The main cause for fruit deterioration is fruit ripening and ethylene production. High temperature fastens the rate of fruit ripening, thus fastens the rate of fruit deterioration. The evaporative coolers reduce the inside storage temperature which slows the rate of fruit ripening and ethyleneproduction. These have a direct effect on shellfire extension of the fruit (Esa *et al.,* 2015).The deterioration of banana fruit was recorded mostly during harvesting followed by marketing, transporting, storage, and in some causes through the entire channel. This isbecause fresh produce after harvest continues the process of respiration and transpiration until its reserved food and water are reserved (Sirivatanapa, 2006). This physiological process is influenced by temperature, Composition of surrounding air, and humidity of the environment. Table 3 showed that there was a significant variation in decay percentage among the treatments. The highest decay % was found in bananas stored at ambient on the 4th storage day (100%) and the lowest decay % was observed in bananas which were treated byT1 (10%). On the 8th days of storage on most storages the fruit was 100% deteriorated but storages like T2 and T3 still performs to the best (only15% deterioration).

Table 3: Decay percentage of banana stored under different packaging material for 4 days, 8 days and 12days

Treatment	**Decay percentage (%)**		
	Day 4	**Day 8**	**Day 12**
T1	70.00b	100[a]	100[a]
T2	70.00b	100[a]	100[a]
T3	13.33d	33.33[b]	44.36[b]
T4	100 a	100[a]	100[a]
LSD (5%)	0.0015	0.0018	0.0021
CV (%)	9.58	8.86	12.86

Means with same letter within a column are not significantly different

Shelf life is the period from harvesting up to the last edible stage (Sewed *et al.,* 2006). The Shelf life of a product depends on initial quality of the food products, amount of quality change that can be allowed, prevailing environmental condition, and brakes properties of the packaging materials, and compatibility between food product and packaging (Esa *et al.,* 2015).

Significant variation was obtained among the treatment in relation to shelf life extension of bananas. The banana fruit T3 and T2 showed the longest shelf life (8 days) and the lowest shelf life had been recorded on T4 and T1 (4 days). Similar results were also obtained by the effects of different postharvest treatments used in the investigation were significant in respect of prolonging the shelf life of banana. Control banana fruits showed the lowest shelf life as compared to those treated.

Effect of different packaging materials on pH

When ripening advances an increasing in pH value was observed (Table 4). The same trend was observed for all packaging even though the rate of change was different. This value was related to treatable acidity in which the higher the pH the lower the treatable acidity (Gowen, 1995).

Significant differences ($P \leq 0.05$) in pH value were observed for banana fruits subjected to packaging treatments during the storage period at ambient condition. Fruits kept in plastic packaging exhibited a higher value of pH, while the control fruits showed lower pH value at the beginning of the storage period. Salunkhe and Kadam (1995) also reported that unripe banana subjected to ripening in polyethylene bags at ambient temperature had significantly lower value of higher pH value indicating that the ripening process in these fruits was slowed down.

Table 4: pH of banana stored under different packaging material

Treatment		**pH**	
	Day 0	**Day 4**	**Day 8**
T1	5.43aa	4.98aa	4.97aa
T2	5.25aa	4.53aa	4.63bac
T3	4.12	4.13aa	3.56bac
T4	6.43aa	5.74aa	4.68bac
LSD (5%)	**0.63**	**0.58**	**0.37**
CV (%) 3.56	**3.56**	**6.72**	**4.72**

Effect of different packaging materials on Percentage of marketability

The percentage marketability of banana fruit was significantly ($P \leq 0.05$) affected by the packaging materials. After 8days, all the control fruits became unmarketable whereas fruit packaged in T3 and T2 continued until day 12 (Table 5). Since fruits were exposed directly to the atmosphere, control fruits had lost more weight than banana leaf and *teff*straw. In the present study, the main causes of unmarketability of control fruits was color change and weight loss. Even though fruits packaged in T3 and T2 were found to be better than control fruits in preventing the weight loss, they became unmarketable totally due to weight loss. But fruits packaged in polyethylene bags continued being marketable until date 15.

At the beginning of the storage period the difference between the plastic packaging was insignificant. But, starting from day 8, a significant difference was observed. This may be due to the difference in permeability of plastic films to gases in which banana fruits from the T1 bags had lost more weight than the T2 but not significantly affected the percentage of marketability. At the end of the storage period T2 maintained marketability to 66.7% whereas T3 kept to 77.6%.

Table 5. Effect of packaging materials on the percent of marketability

Treatment	Percent of marketability				
	Day 0	Day 4	Day8	Day 12	Day 15
T1	-1	100a	100a	100a	100a
T2	-	100a	100a	100a	100a
T3	-	100a	93.1b	83.2b	72.6b
T4	-	94.8b	84.9c	68.6c	55.2c
CV	0.00	1.00	1.34	2.07	1.84

Means within the same column followed by a common letter are not significantly different at $P \leq 0.05$ (LSD test).

Conclusion

On the basis of above findings it is concluded that packaging materials has a significant effect on quality and shelf life of banana fruit. Each treatment had its own effect on quality parameters and shelf life of banana.

In this experiment out of four treatments the use of banana with plastic bag was found to be best in extending the shelf life and maintaining the physiochemical quality attributes of banana fruits throughout the storage period followed by other treatment. Therefore, plastic sheet which are very available at the community level were recommended as appropriate packaging material on shelf life and quality of banana fruit and ground is not recommended as storage material due to absence of ability to resist unfavorable environment, pests and physiological activity of banana fruits.

The highest physiological weight loss (27.83%) and decay percentage (100%) were recorded on the open air treated fruits. On the other hand, the lowest weight loss (20.29%) and decay percentage (13.33%) were observed in bananas which were treated by plastic bag (T3). In relation to shelf life plastic bag and banana leaf packaging materials showed the longest shelf life (12 and 8 days) and the lowest had been recorded on open ground and *teff* straw treated fruits. It could be concluded that different packaging materials can extend the shelf life of banana fruits and maintain the postharvest quality of the fruit. Accordingly, banana producers, wholesalers, retailers and consumers are recommended to use this packaging material so as to maintain quality and extend shelf life of their banana fruit. However, all the above conclusions and recommendation were derived from results of studies conducted within one time. Therefore, further testing with different banana varieties and packaging materials on the shelf life of banana should be carried out.

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