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Effect of Vacuum and Shrink Packaging on Shelf Life of Banana (Musa Paradisica)

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Abstract - *Banana (Musa paradisica) is an edible fruit valued worldwide for its flavour, nutritional value, and availability throughout the year. Huge post-harvest losses and loss during distribution are major problems banana encounters. To reduce these losses, use of suitable packaging methods for the fruit is found to be a solution. It works on the principle that if CO2 in the atmosphere is augmented, the respiration rate and storage life can be extended. Various samples of Nendran bananas were vacuum and shrink packaged and stored in ambient conditions to study their effect on shelf life extension. Various physico chemical parameters were analysed. Change in peel colour with time, progressive decrease in fruit firmness and toughness, and increase in total sugars and TSS were observed. Evaluations of organoleptic properties were performed by sensory analysis. Of these, the best results and a maximum shelf life of twenty eight days were obtained for shrink packaged samples.*

***Key Words*: vacuum packaging, shrink packaging, shelf life extension, banana, storage**

1. INTRODUCTION

Fruits are nature's most important gift to mankind as they are important supplements to the human diet. Fruits account for substantial fraction of world's agricultural output and are of extensive cultural importance. Banana (*Musa paradisica*) is an edible fruit produced by several kinds of large herbaceous flowering plants in the genus *Musa.* It is referred as "Kalpatharu" (Plant of Virtue) due to its multifaceted uses [1]. It is grown in the tropics and is widely consumed in those regions. It is valued worldwide for its flavour, nutritional value, and availability throughout the year.

Bananas have become a key source of revenue earner for farmers as they are traded not only within the region but also exported to other countries including Europe earning lot of foreign exchange for the Country [2]. Banana stands in the third position among the top 25 healthy fruits [3]. India holds the first position in the world in banana production. It accounts for 13% of the total area and 33% of the production of fruits.

Important banana varieties cultivated in Kerala are Nendran, Njalipoovan, Palayankodan (Poovan), Rasthali, Monthan, Red Banana and Robusta. Nendran. Bananas are a variety of banana popular in Kerala. Processed products, such as chips, banana puree, jam, jelly, juice, wine and halwa can be made from the fruit. The fruit is easy to digest, is free from fat and cholesterol and hence banana powder is commonly used as the first baby food. It also helps in reducing risk of heart diseases [4].

Bananas are harvested green and begin ripening as soon as the banana stem is cut from the plant. This results in huge post-harvest losses. Ripening of fruits can be delayed if the fruits are kept in an anaerobic atmosphere which can be achieved by special packaging methods.

Loss during distribution is major problem banana encounters. Inorder to reduce this wastage, use of polyethylene film bags for wrapping whole bunches for transport is found to be most suitable. Food packaging is a system by which a fresh produce or processed product will reach from the production centre to the ultimate consumer in safe and sound condition at an affordable price. It works on the principle that if CO2 in the atmosphere is augmented, the respiration rate and storage life can be extended [5]. The major benefits of banana packaging includes reduced damage during distribution, reduction in space requirement during transportation, reduced shrink at supermarket level convenience and reduction in customer-induced fruit abuse.

Banana can be protected and its shelf life increased by packing using vacuum. Vacuuming removes air from the containers which in turn retards spoilage. This principle is employed in case of vacuum packaging. Containers are usually bags made of polyethylene, aluminium, PET etc [6]. This method can delay ripening upto 3 weeks and further ripening is completed within one week after opening the package. It made possible to present to consumers fresh and hygienic products and to export fresh products throughout the world. Vacuum packing lengthens the edibility quotient of food in all its varieties. Produce can be delivered to homes and export markets with guaranteed freshness and minimum waste and spoilage. Food is protected from air and moisture, as vacuum-packing locks in freshness and prevents freezer burn. Food remains fresh for three to five times longer.

Shrink packaging is the process in which sheets of transparent plastic film are wrapped around a product to form a solid, weather-resistant packaging layer. Plastic film are preheated, stretched and cooled prior to use. Shrink wrapping is now becoming one of the newest trends in

packaging because it offers a versatile, cost effective packaging. It is also considered as an ideal aid for general marketing purposes. The technology delays physiological deterioration of fruits and also prevents condensation of droplets within the package. Individual shrink-wrapping of the produce provides optimum gas and humidity for maintaining quality of the produce during the transit and storage. As a result, it doubles or sometimes triples storage life of the fruits under proper storage conditions. Such unit packs also provide protection against abrasion and maintain attractive appearance of the product. It is easy, user-friendly, can be very well adopted by marginal farmers and/or entrepreneurs [7].Market promotion is needed for better adaptability of the technology. In India, banana crop after harvest are traded by middlemen without adapting any preservation technique, causing wastage of large quantities. Size of the bunch and external fruit appearance determine the market price. Efforts are needed for better storage facility with assured marketing and trading. Research efforts are needed in developing better packaging and transportation techniques to avoid the losses and to fetch better price to farmers (Anon, 2011).

This study is helpful to banana farmers to increase their profits by prolonging the storage time of banana and also in creating new business enterprises and jobs, and thus provide sustainability of farm families and communities that depend on banana cultivation. The main objectives of the study were:

1) To study different packing methods for long term storage of banana (*Musa paradisica*)
2) To analyse the physical and bio chemical changes during storage of banana

2. MATERIALS AND METHODS

2.1 Banana sample collection:

Matured green banana belonging to Nendran variety was purchased from the local market. The collected samples taken in clusters were washed with clear tap water to remove the extraneous matter and then wiped off with clean cloth to remove the external water. The fruits with external infections, deformities and damages were discarded.

2.2 Packaging materials:

For vacuum packaging, LDPE films (150 and 350 gauges) which were found suitable from previous vacuum packaging studies was adopted. In order to shrink pack the bananas 90 micron polyethylene films were used.

2.3 Vacuum packaging:

For vacuum packing the test sample were taken in suitable packing covers and sealed in vacuum packaging machine. The packaging operation includes removal of air in the packets loaded with the product. Air exclusion is attained and maintained by using vacuum pump and heat sealing. Sealing may take around 20-30secs.

2.4 Shrink packaging

In order to shrink pack the bananas, the cluster selected has to be sealed in a desirable heat-shrinkable film with the help of an impulse sealer. The produce is then then passed through a heated tunnel in the machine (Sevana DSTV) maintained at 120°C . A fan is then activated which circulates hot air around the produce, and the film shrinks tightly around the produce. Shrink-wrapped produce is immediately removed from the machine. The conveyor speed can be adjusted as per requirement of the product in the machine itself.

The following were the test conditions:

1. Bananas kept under normal atmospheric conditions without any package (Control, C)
2. Bananas vacuum packed using LDPE 150 gauge film and stored in normal conditions (T1)
3. Bananas shrink packed with 90 micron polyethylene film and stored in normal conditions (T2)

Eight samples containing two bananas each were packed under the above test conditions. One of the samples stored under each test condition was opened in a periodic interval of 4 days and was left for further ripening. The various physico-chemical characteristics were determined on the day corresponding to unsealing.

2.5 Physico-chemical characteristics:

2.5.1Physiological loss in weight:

Fruits were weighed during storage daily with the help of an electronic balance. Percentage physiological loss in weight was calculated by the formulae given below.

$$PLW\ (\%) = \frac{\text{Loss of fresh weight}}{\text{Initial weight}} \times 100$$

Loss of fresh weight = Initial weight-Final weight

2.5.2 Total soluble solids:

Total soluble solid (TSS) was measured using a hand refractometer. Bananas were smashed well and filtered using muslin cloth. One or two drops of the clear sample was placed on the hand refractometer for TSS measurement. It was expressed in degree Brix.

2.5.3 External appearance:

Colour was inspected visually as an index to the quality of banana. The percentage of fruits spoilage due to

fungal pathogens in different packaging methods of storage was calculated using the formulae, Microbial spoilage (%) = (Area affected by fungal pathogens / Total surface area)*100

2.5.4 Total sugar:

Total sugarwas determined using Fehlings method (fssai, 2012).

Reducing sugars (%) = (Dilution x Factor of Fehling (gm)/ Weight of sample x titre value)*100

2.5.5 Textural attributes:

This important quality parameter which affects the consumer acceptability of banana was determined using Texture Analyser (Stable Micro Systems, UK). The sample was kept on the flat platform of the instrument and was subjected to double compression by a cylindrical probe with 5 mm diameter. The test was conducted at a speed of 10 mm/s using 50 N load cell. The sample was allowed for a double compression of 40% with trigger force of 0.5 kg during which various textural parameters were determined. From the force deformation curve, the firmness or hardness (peak force), and toughness (area under the curve) were determined.

2.5.6 Sensory evaluation

Fruits were removed from storage after complete ripening and sensory evaluation was conducted on the corresponding day. Descriptive sensory quality of ripe fruit viz., colour and appearance, texture (finger feel), taste flavour and overall quality were assessed by a panel of 7 judges. Judges were asked to access based on the 5 point scale. The scores marked by panellists were collected and an average was calculated for each parameter. These calculated averages were presented in the form of tables.

3. RESULT AND DISCUSSION

Bananas are highly perishable and ripen within 4-5 days under the ambient conditions in Kerala. The effect of vacuum and shrink packaging in extending the shelf life of green banana were studied under ambient conditions (35 ^{0}C and 80% RH). In general, bananas were found to show extended shelf life when both vacuum and shrink packed.

3.1. External appearance:

The external appearance is a major indicator of the ripening process. The change in colour and fungal infestation are the major changes in external appearance noted for banana. All the samples were inspected each day for any such change.

The ripening of banana kept as control was indicated by change in colour from green to yellow by the 3rdday, and complete ripening was confirmed at the end of fourth day by the presence of black speckles over the bright yellowish peel. Vacuum packed banana retained the green colour even up to the 12th day after which they turned black. But the same was rejected due to fungal growth seen after 9th day. So, the packing was unsealed after the 9th day and ripening could be extended up to the12th day indicated by the yellow peels.

Shrink packed bananas shown prolonged freshness. They were more acceptable in terms of external appearance. There was no visible fungal growth throughout the period of study. The intensity of greenness in the peel was retained up to the 18th day and gradual change to greenish yellow was observed on the 19th day. Ripening was completed on 23rd day confirmed by the yellow peel with scattered black spots.

The samples kept as control under ambient conditions did not last longer than 6days and vacuum packaged not more than 15 days whereas that which was shrink wrapped showed a greater shelf life of 28 days (Table 1).

Table 1. Result of microbial spoilage on samples (%)

Storage days	C[1]	T1[2]	T2[3]
0	0	0	0
4	0	0	0
8	7.6	0	0
13	36.5	2.1	0
18	100	39.8	0
23	-	85.2	0
28	-	-	11.2

[1]C- Control

[2]T1- Vacuum packed sample

[3]T2- Shrink packed sample

3.2. Physiological loss in weight:

Data on loss in weight due to transpiration and respiration processes indicated that banana fruits kept in open condition (without packaging) lost weight up to 7.5% on the 4th day of storage. Vacuum packaged and shrink packaged fruits showed an increase in PLW ranging from 5-6% and 7-9% respectively (Table 2).

Table 2. Physiological loss of sample weights

Storage days	0th	4th	8th	13th	18th	23rd
C[1]	0	7.5				
T1[2]	0	2.7	5			
T2[3]	0	0.66	1.3	5.8	6.7	7

[1]C- Control

[2]T1- Vacuum packed sample

[3]T2- Shrink packed sample

The higher weight loss (7.5%) in C after 4 days of storage at ambient conditions can be attributed to faster rate of respiration. Whereas shrink wrapped samples registered the lowest mean PLW (7%) even after 23 days of storage at ambient conditions.

3.3 Total soluble solids:

The result exhibited that TSS content developed in continuous stream with the expansion of storage period. High significant variation as observed in TSS content between two different packages at different days after storage. The TSS of different samples for different storage period is shown in Table 3.

Table 3. TSS of samples (°Brix)

Mode of pack	0th	4th	5th	12th	18th	23rd	28th
C[1]	5.5	13.6					
T1[2]	5.4	6.05	6.95	18.5			
T2[3]	5	5.3	5.5	7.3	24.6	25.2	19

[1]C- Control

[2]T1- Vacuum packed sample

[3]T2- Shrink packed sample

From the initial to 4th day the TSS increased only to 16% for control. But in case of vacuum packaged samples there was a gradual increase up to 25% on the 12th day whereas tremendous increase in TSS up to 35% from the 0th to 23rd day was observed for shrink packaged samples. Different days of storage results showed that TSS accumulation increase with the increase of storage duration. It also explored that TSS content was hastily grown up from control to shrink. It revealed that TSS accumulation is strongly related to ripening and it caused falling off owing to decaying.

TSS content was found to increase during advancing stages of ripening and storage for shrink packaged banana was possibly due to extended period of time obtained for hydrolysis of starch into sugar. However due to utilization of sugars in respiration and degradation of total soluble substances because of prolonged storage are possible reasons for the decrease in TSS.

3.4. Textural attributes:

Firmness and toughness showed a gradual decline with the increase in storage intervals. The softening of flesh during storage could be due to the degradation of soluble pectin as a result of various enzymatic activities in the sample.

In case of control, rapid decline in toughness and firmness (shear force) values were recorded up to 4.82 Kg Sec and 2.29 Kg respectively in 4 days. Vacuum packaged samples showed an increased value of both toughness and firmness by 8th day which gradually decreased to 6.58Kg sec and 4.45 Kg on the 12th day after unsealing the package. Gradual decrease was observed in case of shrink packaged samples as 2.74 Kg Sec and 1.12 Kg respectively for toughness and firmness. It was thus observed that softening of flesh occurs along with ripening of fruits(Table 4).

Table 4. Result of textural analysis on samples

Mode of packaging	Day	Toughness (Kg Sec)	Firmness (N)
C[1]	1	13.59	49.58
	2	11.24	47.82
	3	6.54	33.81
	4	4.82	22.44
T1[2]	4	17.35	53.8
	8	18.36	63.48
	12	6.58	43.61
T2[3]	4	15.15	45.18
	8	11.36	43.8
	12	7.88	31.46
	18	5.45	35.77
	23	3.94	21.46
	28	2.74	10.97

[1]C- Control

[2]T1- Vacuum packed sample

[3]T2- Shrink packed sample

3.5. Total sugar:

Shrink wrapped bananas showed the highest percentage of reducing sugars (5.1%) when compared to the control and vacuum packed samples (Figure 1). The increase in reducing sugars could be due to increased hydrolysis of starch into sugar with extended period during ripening.

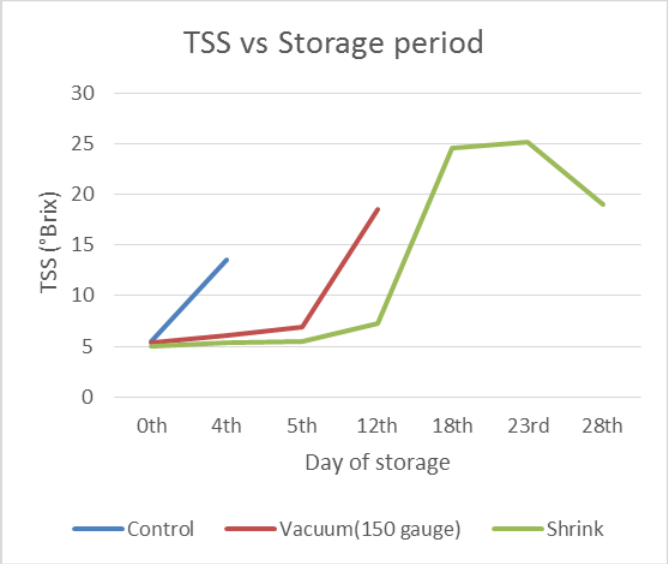

Figure (1) TSS of samples

3.6. Sensory evaluation:

Sensory evaluation indicated that bananas in normal air ripened normally without any significant difference in eating quality. The result of organoleptic evaluation shows that the sample T2 is the best with total score of 18.1(Table5).

Table 5. Result of sensory analysis on samples

	Flavour and taste	Texture	Colour and Appearance	Overall quality	Total
C[1]	3.8	3.9	4.3	4.2	16.2
T1[2]	2.4	2.3	2.8	2.3	9.8
T2[3]	4.2	4.9	4.5	4.5	**18.1**

[1]C- Control

[2]T1- Vacuum packed sample

[3]T2- Shrink packed sample

Observing the results of various analysis conducted, it was concluded that the sample T2 (shrink packaged) proved to be the best in terms of PLW, microbial activity, TSS, total sugars, colour, texture and organoleptic characteristics. Owing to the physical injuries during harvesting and transportation, the shelf life extension was limited to one month.

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