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RESEARCH PAPER

Control of physiological changes in the elakki banana (*Musa paradisiaca*) fruits using modified atmospheric packaging

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SUMMARY : Banana is one of the most appreciated fruit all over the world because of its multipurpose use as food. Lack of suitable post harvest treatment practices may lead to a huge economic loss for the banana producing regions. Different postharvest management practices are in use to enhance its shelf life by delaying the ripening, reducing respiration rate and reduces the storage losses. Respiration rate of Elakki banana was studied (*Musa paradisiaca*) at two different maturity levels (matured fruit and one day after maturity), placed at two different temperatures (Ambient and 15°C). A typical climacteric peak of 94.6 mg CO_2 $kg^{-1}hr^{-1}$ was noticed in fruits harvested at matured stage at ambient condition. At 15°C, fruits harvested at maturity showed the respiration peak of 74.5 mg CO_2 $kg^{-1}hr^{-1}$. The physiological loss in weight (PLW) of the Elakki banana fruits was continuous in the banana fruits stored both in ambient and low temperature storage conditions. This is attributed to the general loss of water (*i.e.*, partial desiccation of the fruit) during storage. Among the different (Ambient and 15°C) storage temperatures, fruits stored at room temperatures recorded significantly higher PLW up to 9.46 per cent compared to lower (15°C) temperature (5.43%) on 38th day of storage. The principle of extending the storage life by altering the storage atmosphere around the commodity and slowing down the metabolic ripening processes without affecting the quality of the commodity. Recently long term storage of vegetables has been achieved by using silicon membrane systems.

Key Words : Elakki banana, Respiration rate, Low temperature, Maturity, Shelf life

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Bananas are affordable, and delicious fruit that offer not only the taste and great value but also offers many excellent health benefits including being a great source of potassium, which helps to control blood pressure (and of course to prevent painful muscle spasms) and a natural antacid which helps to protection from ulcers in the stomach. In fact, the only downside to them is that they have relatively short life expectancy - it is not easy to keep fresh bananas.

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Banana (*Musa paradisiaca*), "Queen" of tropical fruits is cultivated by man from prehistoric times. Banana provides nourishment and well-balanced diet to million of people around the globe and contributes to livelihood through crop production, processing and marketing (Singh, 2002). It grows well in humid tropical lowlands and is predominantly distributed between 30°N and 30°S of equator.

Sunderaraju (1998) reported that the 'green-life' of fully matured Karpurvalli var. of banana could be stretched to 25 days when stored at 13°C with $KMnO_4$ impregnated vermiculite as against 4 days at room temperature (33°C). He also reported that the storage of green mature fruits under refrigeration (8-10°C) result in severe chilling injury after 24 hours in dessert varieties whereas plantain group are much less affected even after 5 days of storage . Fully mature Pachandan fruits stored at 10°C developed chilling injury symptoms characterized by pitting and black spots after 15 days of storage while at 15°C

no chilling injury symptoms were noticed till 15 days (Anonymous, 2001). Temperature conditioning gradually to 8°C extended the storage life of Elakki banana to 4 weeks as compared to 3 weeks and 18 days when continuously stored at 13°C and 8°C, respectively (Anonymous, 2002). The safe storage temperature with 15°C giving the longest delay in ripening. Storage at lower temperatures gave rise to symptoms of chilling injury (Wills *et al.,* 1984).

Respiration rate of Annona was very high at ambient temperature (25°C) and decreased with decrease in storage temperature (Vishnu Prasanna *et al.,* 2000). The results of respiration rates showed the fruits stored at ambient (25-27°C) and 15°C had a clear climacteric peak 94.6 mg CO_2 $kg^{-1}hr^{-1}$ and 74.5 mg CO_2 $kg^{-1}hr^{-1}$, respectively on 38th day of storage.

The mature climacteric fruit when detached from tree, can maintain an independent existence for days or even weeks. During this period, the fruit undergoes a series of metabolic processes which eventually lead the fruit toward ripening. During these metabolic processes, the tissues continue to respire and transpire and lose a significant quantity of their moisture and other chemical ingredients, which ultimately results in the loss of weight (Eskin and Sommar, 1967 and Biale, 1975).

Muthuswamy *et al*. (1971) observed that 11.85 per cent loss in weight of banana fruits stored at room temperature (29-32°C) with in 7 days. Sen and Choudhary (1976) reported that the weight loss in fresh fruit was rapid at room temperature (28-30°C) than the cold storage (5°C). The results of physiological loss in weight showed the fruits stored at ambient (25-27°C) and 15°C had a loss of 9.46 per cent and 5.43per cent, respectively on 38th day of harvest.

The principle involved in the storage techniques like controlled atmosphere storage and modified atmosphere packaging is, manipulation of respiration rate of the stored produce. However, since respiration rate is dependent on factors like storage temperature and composition of storage atmosphere. The objective of the study was the use of silicon membrane and diffusion channel at ambient and low temperature conditions to reduce the respiration rate and weight loss of the produce and it leads to increase in the shelf life and fetches the remarkable profit to the banana producers.

EXPERIMENTAL METHODS

The present study was carried out with a view, to know the effect of the different packages and temperatures on the shelf life extension of Elakki banana fruits. For that, study on respiration was necessary in order to determine the dimensions of the packaging material. The fruits were procured from the Amruth halli, near Yalahanka, Bangalore-92. The banana fruits were washed with water to remove the adhesive material. The washed banana fruits at different maturity levels were kept in PET jar for determination of respiration rate. The experiments were conducted in the laboratories of AICRP on Post Harvest Technology, UAS, GKVK, Bangalore, during the year 2007-2008.

Treatment details

Treatments	Packaging materials	
	Silicon membrane window area	
Control		
T_1	2 X 2 cm^2	
T_2	3 X 3 cm^2	
T_3	4 X 4 cm^2	
	Diffusion channel dimensions	
	L	D
T_4	10	3
T_5	15	3
T_6	20	3

Note: L = Length of the diffusion channel, cm
D = Diameter of the diffusion channel, mm

Determination of respiration rate:

The respiration rates of the fruits were measured at two different temperatures (Ambient and 15°C). Fruits were enclosed in PET jars of 2250 ml capacity and scaled airtight for 2 hours after which gas composition *i.e.*, O_2 and CO_2 concentration inside the package was measured using PBI Dansensor O_2 – CO_2 (Make : Denmark) analyzer and then the fruits were removed from the jars and kept in respective storage environments. Respiration rate of the produce was recorded for the fruits stored under ambient condition daily till the fruits were fully ripe, while for the fruits stored at other temperature level the same parameters were recorded, on alternate days till the fruits were ripe. The respiration rate of the fruits was calculated by using the following formula:

$$r = \frac{2 \times (\%\ CO_2) \times V}{m_s \times t}$$

where,
r = Respiration rate, (mg O_2 mg/ kg/h)
V = Free volume of the chamber (cc)
ms = Mass of the stored product (kg)
t = Time (h)
CO_2 = O_2 concentration inside the chamber, (mg/l)

Physiological loss in weight (PLW):

The weight of the fruits with the PET jars and silica gel was weighed before kept for storage. It was recorded as initial weight. On the subsequent dates of observation during storages, the PET jars were weighed and was recorded as final weight on each date of the observation. It was expressed in terms of per cent loss and it was given by

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight-weight on the date of observation}}{\text{Initial weight}} \times 100$$

EXPERIMENTAL FINDINGS AND ANALYSIS

The results of the present study as well as relevant discussions have been presented under following sub heads:

Respiration rate of fruits at ambient (25-27°C) condition:

The fruits stored under ambient conditions showed an upsurge the rate of respiration on second day of storage. The pronounced increase in respiration coinciding with ripening, termed as climacteric peak, was a natural phenomenon in the climacteric fruits. The respiration rate of Elakki banana fruits stored at ambient conditions (25-27°C) has been graphically shown in Fig 1. From the graph it is confirmed that the respiration rate of fruits which were harvested at different maturity levels (matured, 1 day after maturity) ranged between 61.6 to 96.4 mg CO_2 /kg/hr, and 37 to 83.1 mgCO_2/kg/hr during 38 days of storage, respectively. A typically climacteric peak of (96.4 mgCO_2/kg/hr) was noticed in fruits harvested at matured stage.

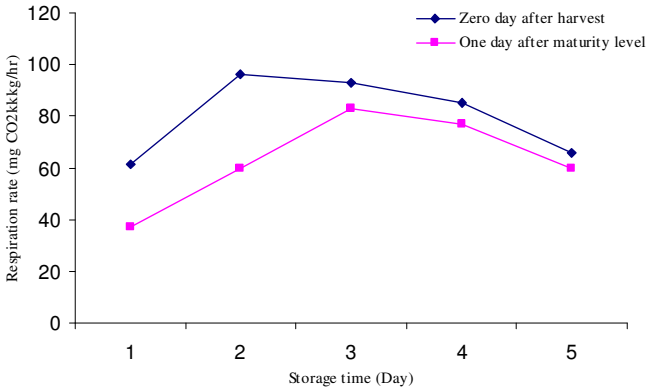

Fig. 1 : Respiration rate of Elakki banana fruits stored at ambient (25-27°C) condition

Any change in the temperature affected the rate of respiration and the equilibrium conditions with in the package unless the rate of diffusion of gases through the package was changed by temperature to exactly the same extent of respiration (Kader, *et al.,* 1989). The results obtained regarding gas composition inside modified atmospheric packages were in accordance with the other workers (Lazen *et al*., 1990; Gonzalez *et al*., 1990; Yantarasri *et al*., 1995).

Respiration rate of fruits at refrigeration (15°C) temperature:

The respiration rate of Elakki banana fruits stored at 15°C is shown in Fig. 2. The results showed that the respiration rate

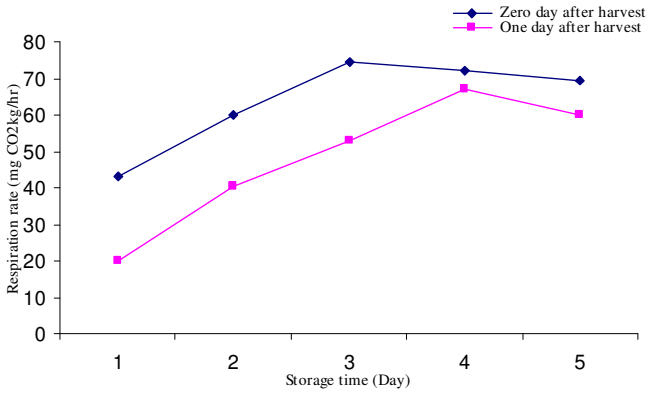

Fig. 2 : Respiration rate of banana fruits at stored refrigeration (15°C) condition

of fruits harvested at different maturity levels (matured and 1 day after maturity) ranged between 43.2 to 74.5 mg CO_2/kg/hr, and 20 to 67.2 mg CO_2/kg/hr during 38 days of storage period. A typical climacteric peak of 74.5 mg CO_2/kg/hr was noticed.

Storage of fruits at low temperature resulted in very low respiration rate through out storage period. The rate of respiration of a fresh produce is a temperature dependent process and is regulated by many enzymes. The low storage temperature results in the reduced enzyme activity, thus lowering the rate of respiration. The results are in acquiescence with Lam (1990) and Vishnuprasanna *et al*. (2000).

Effect of silicon membrane system with different window area on physiological loss in weight (%) banana fruits stored ambient condition:

The physiological loss in weight of the Elakki banana fruits in the PET jars stored under ambient condition is shown in Fig. 3. In case of control storage, the weight loss was occurred up to 9.46 per cent. Treatment T_1 had a slightly higher weight loss compared to T_2 and T_3 treatments. The silicon membrane

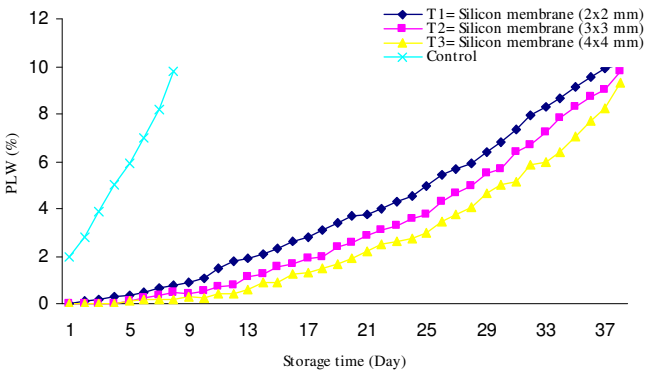

Fig. 3 : Effect of silicon membrane system on physiological loss in weight of Elakki banana fruits stored in ambient condition

system was found to be suitable for long term modified atmosphere storage of many vegetables grown in Canada (Gairepy *et al.,* 1988). Gairepy *et al.* (1986) found that the Pascal celery was stored for 29 days under regular atmosphere with 80 per cent RH compared to 120 days under 2 per cent CO_2 + 12.6 per cent O_2.

Effect of silicon membrane system with different window area on physiological loss in weight (%) of Elakki banana fruits stored at refrigeration condition:

The weight loss occurred in the Elakki banana fruits stored in silicon membrane under refrigeration condition is shown in Fig: 4. The results showed that, the fruits stored in treatment T_3 had lowest PLW (3.98%) which was closely followed by treatmentsT_2 and T_1 (4.21% and 4.96%, respectively) after 38 days of storage with modified atmospheric packaging (MAP) followed by 7 days storage period under ambient condition and it was in the tune of 4.45%. The safe range of storage temperature was between 15°C and 25°C with 20°C being the optimum for the development of eating quality but with 15° C giving the longest delay in ripening. Storage at lower temperatures gave rise to symptoms of chilling injury (Wills *et al.*, 1984).

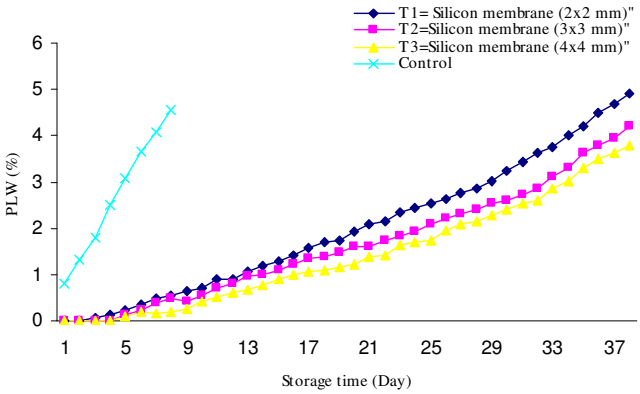

Fig. 4 : Effect of silicon membrane system on physiological loss in weight of Elakki banana fruits stored in refrigeration condition

Effect of diffusion channel system with different lengths and diameters on physiological loss in weight (%) of banana fruits stored in ambient condition:

The effect of diffusion channel system on physiological loss in weight of the Elakki banana fruits stored under ambient condition is shown in Fig. 5. The results reveals that fruits stored in T_6 exhibited the minimum weight loss (6.59%) compared T_5 (7.27%) and T_4 (9.46%) after 38th day of storage period under modified atmospheric packaging followed by control (8.27%) after 7 days of storage. Stewart *et al.,* (2005) have reported that the smallest area of 50.29 cm^2 silicon

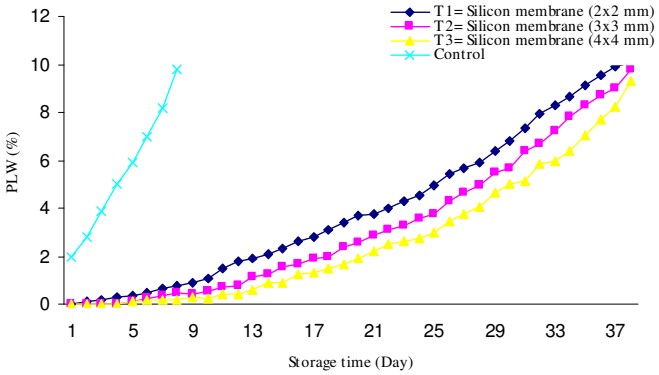

Fig. 5 : Effect of diffusion channel system on physiological loss in weight of Elakki banana fruits stored in ambient condition

membrane achieved gas levels of 3.5% CO_2, 3% O_2 in about 10 days while the shortest diffusion channel length of 4 cm achieved 5% CO_2 3% O_2 in 12-16 days. Banana fruits in these atmospheres remained unripe for 42 days with minimum mould and excellent marketability compared to control and fruit stored in different gas compositions.

Effect of diffusion channel system with different lengths and diameters on physiological loss in weight (%) of banana fruits in refrigeration condition:

The influence of diffusion channel system on physiological loss in weight of banana fruits under refrigeration condition is shown in Fig: 6. The results indicated that the treatment T_4 showed the highest PLW (7.2%) followed by and T_5 (6.4%) and T_6 (5.43%) after 38 days of storage under modified atmospheric packaging. The PLW in control treatment was 4.56per cent after7 days of storage.

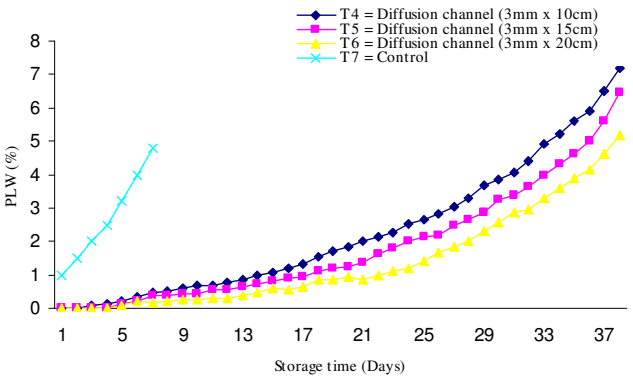

Fig. 6 : Effect of diffusion channel system on physiological loss in weight of elakki banana fruits stored in refrigeration condition

The fruits placed under refrigeration condition had a minimum weight loss. Vishnuprasanna *et al.* (2000) reported that the safe range of storage temperature was found to be between 15^{0}C and 20^{0}C, with maximum shelf life at 15^{0}C.

Ranganna *et al.* (2003) studied the modified atmospheric packaging of guava fruits using diffusion channel system and reported that diffusion channel of 5 cm length and a diameter of 7 mm were found to maintain the desired level of O_2 and CO_2 concentration inside the chamber and there by extending the shelf-life of guava fruits up to 10 days of storage.

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