

RESPONSE OF EMBUL BANANA (*MUSA* spp.) TO MODIFIED ATMOSPHERE STORAGE

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ABSTRACT

Modified atmosphere (MA) that developed in sealed polyethylene bags (PEB) has been found to delay the onset of climacteric in "cavendish" banana. This study was conducted to observe the response of banana variety "embul" to MA. Although, peel colour remained green throughout the storage period (over 15 days), firmness of the fruits rapidly declined 12 days after storage, indicating that MA was no longer effective in preventing climacteric respiration. Since fruits kept open ripened after 5 days of storage, this technique could be used to store "embul" banana up to 12 days at ambient temperature. Time taken for ripening was shortened with increasing storage period compared to control. Visual quality rating (VQR) of fruits remained unaffected throughout the storage period. Taste and flavour of the fruits were unaffected up to 12 days of storage.

KEY WORDS : Banana (*Musa* spp), Modified atmosphere, Storage

INTRODUCTION

In Sri Lanka banana is harvested mature green and transported over long distances without refrigeration. However, during transit some fruits start to ripen while others may ripen unevenly leading to losses. Although, refrigerated transport is the best way of transporting banana over long distances, this facility is expensive and is not available in Sri Lanka.

Increase of green life by modified atmosphere (MA) in sealed polyethylene bags (PEB) has been successfully demonstrated in "cavendish" banana (Scott *et al.*, 1971). This is a low cost technique which could assist banana producers to transport their fruits for an appreciable duration without the need of costly refrigeration.

However, reported maximum storage life under such conditions was 14 days without affecting the quality of ripened fruits (Scott, 1974). Softening of the fruits beyond that period with an accompanying green peel colour was a common problem that limit MA under ambient temperature. This "green soft" condition was associated with rise in concentration of ethylene in the bags (Scott *et al.*, 1971).

Several studies carried out to determine the response of "cavendish" (Kevin *et al.*, 1983) and "Saba" (Lizada *et al.*, 1987) bananas to MA, revealed that green life could be extended up to 2 weeks. Hence, this study was carried out using the popular 'embul' banana with a view to determine the storage time period under MA conditions, the variation in quality of stored banana with time and occurrence of green soft disorder.

MATERIALS AND METHODS

Freshly harvested, three quarters full, mature green bunch of 'embul' banana bought from a banana collection point at Katugastota (Kandy) was brought to the Horticulture Division, Getambe. Fingers were separated excluding first and last hand, and undamaged fingers were dipped in 500 ppm Benlate and allowed to dry.

To study peel colour development and sensory firmness of the fruits during storage, observations were made for a period of 15 days. Three fingers were enclosed in 15×22cm polyethylene bags (0.05mm, high density) and sealed. Another 3 fingers were kept in perforated polyethylene bags while a further 3 were kept open.

In order to evaluate ripening characteristics and quality of stored banana with time sealed bags were perforated at 5, 10 and 12 days of storage to enhance ripening. Time taken to colour break at each stage of perforation was recorded. Quality of the ripened fruits was evaluated by a taste panel.

All treatments were replicated 4 times. The experiments were carried out at ambient temperature ($26 \pm 3^{\circ}\text{C}$).

Peel colour development was evaluated daily, using the following numerical colour index developed by the United Fruits Sales Corporation (U. K.): 1 = mature green, 2 = light green, 3 = more green than yellow, 4 = more yellow than green, 5 = yellow with green tip, 6 = full yellow and 7 = yellow with brown flecks. Flesh colour, taste, flavour and overall acceptability were recorded using numerical indexes, where 1 = poor, 2 = acceptable and 3 = very good. Sensory firmness of the fruits was also measured using a numerical scale, where 1 = soft, 2 = slightly soft and

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3 = firm. External appearance of the fruits or visual quality rating (VQR) was measured using a numerical scale, 0 = very poor, 2 = acceptable, 3 = good and 4 = excellent.

RESULTS AND DISCUSSION

Peel colour development during storage is given in Table 1. No colour development was observed even after 15 days of storage in sealed PEB while fingers in perforated PEB and the bags kept open showed maximum peel colour development on the 9th day. Oxygen in sealed PEB is utilized for respiration by the green fruits and carbon dioxide is evolved. The MA developed in sealed PEB seems to prevent peel colour development in "embul" banana. Similar result has been obtained with several banana cultivars by other workers (Liu, 1970; Scott *et al.*, 1971; Kevin *et al.*, 1983).

Sensory firmness of the fruits during storage is given in Table 2. Fruits kept open showed decline in firmness within 3 days. Fruit kept in the open and in perforated bags were very soft at 7 days of storage, whereas no reduction in firmness was recorded in fruits stored in sealed PEB until after 12 days of storage. Reduction in firmness was associated with peel colour development on fruits kept in perforated PEB and in the open. No colour development was noted in fruits stored in sealed PEB even when fruits were very soft.

Ethylene is synthesized by the fruit tissues during ripening. Methionine, 1-aminocyclopropane-1-carboxylic acid (ACC) and ethylene are the precursor, intermediate and the product respectively during ethylene biosynthesis (Yang and Hoffman, 1984). Conversion of ACC to ethylene is strongly an oxygen dependent reaction. Furthermore, carbon dioxide is a competitive inhibitor of ethylene (Burg and Burg, 1967). Therefore, low oxygen and high carbon dioxide that develop in MA reduce ethylene biosynthesis and action of ethylene. This may be the reason for the delayed ripening of fruits stored in sealed PEB. However, softening of pulp with peel remaining green, at the later stage of storage (12 days after) could not be explained with this concept. This may be due to the different response of peel and pulp to ethylene (Hirofumi *et al.*, 1974). Decreased oxygen and increased carbon dioxide probably cause a delay in the time of onset of

climacteric; but once the climacteric was induced those levels of gases may not have had any effect on the rate of respiration of banana (Yang *et al.*, 1962) which could be the case in this study.

Time taken to colour break was shortened with increasing storage period (Table. 3). Fruits kept open took 5 days to colour break. Results show that MA reduced the time taken to colour break even though it prolonged the storage life. Under stress conditions plant tissues tend to produce ethylene (Yang and Hoffman, 1984). High carbon dioxide and low oxygen concentration developed in the sealed PEB cause physiological stress to the fruits, enhancing production of ACC (McGlasson and Wills, 1972). When bags were perforated, high oxygen facilitates rapid conversion of ACC to ethylene which causes early colour break.

There was no significant difference in visual quality rating (VQR) up to 12 days of storage (Table 4). High relative humidity that develop in PEB keep the external appearance better and there was no carbon dioxide injury. Results showed that MA does not affect external appearance of the fruits.

All the quality parameters throughout the storage period remained unaffected (Table 5). Absence of astringent fruits showed that MA did not accelerate anaerobic respiration. It is necessary to measure oxygen and carbon dioxide levels to provide a clear explanation regarding astringency.

However, at 12 days of storage softening of fruits was observed regardless of MA. This indicates that MA developed in PEB was no longer effective in preventing fruits to attain climacteric respiration. Softening of the fruits beyond that period with an accompanying green peel colour was a common problem that limit MA storage under ambient temperature. This "green soft" condition has been reported by many workers (Scott *et al.*, 1974; Kevin *et al.*, 1983).

CONCLUSIONS

Response of "embul" banana to MA seems similar to that of "cavendish" banana. Since refrigerated storage is costly, this technique could be easily utilized to store "embul" banana up to 12 days at ambient temperature.

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Table 1. Peel colour development of banana during storage

Time in days	Colour index		
	Open	Perforated	Sealed
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1.9	1.9	1
6	4	4.4	1
7	5.2	5.5	1
8	6.3	6.3	1
9	7	7	1
10	-	-	1
11	-	-	1
12	-	-	1
13	-	-	1
14	-	-	1
15	-	-	1

1 = green; 2 = light green; 3 = more green than yellow; 4 = more yellow than green; 5 = yellow with green tip; 6 = full yellow; 7 = yellow with brown flecks

Table 2. Sensory firmness of the fruits during storage

Time in days	Sensory firmness		
	Open	Perforated	Sealed
1	3	3	3
2	3	3	3
3	2.8	3	3
4	2.6	2.8	3
5	2.3	2.1	3
6	1.3	1.2	3
7	1	1	3
8	1	1	3
9	1	1	3
10	-	-	3
11	-	-	3
12	-	-	2.8
13	-	-	2.1
14	-	-	1.2
15	-	-	1

1 = soft; 2 = slightly soft; 3 = firm

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Table 3. Time taken to colour break after perforation of sealed PEB

<i>Storage period before perforation (days)*</i>	<i>Time taken to colour break (days)</i>
Control (open)	5
5	3
10	2
12	2

* Storage in sealed PEB

Table 4. Visual quality rating (VQR) of banana after opening of PEB followed by ripening at ambient temperature

<i>Storage period before perforation (days)</i>	<i>Days after perforation</i>					
	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
Control (open)	4	4	4	4	4	4
5	4	4	4	4	4	4
10	4	4	4	4	4	4
12	4	4	4	4	4	4

0 = very poor; 1 = poor; 2 = acceptable; 3 = good; 4 = excellent;

Table 5. Quality parameters of ripened fruits after making perforations as assessed by tasting panel

<i>Storage period before perforation (days)</i>	<i>Flesh colour</i>	<i>Flavour</i>	<i>Astringency</i>	<i>Taste</i>	<i>Overall acceptability</i>
Control (open)	3	3	no	3	3
5	2.5	2.5	no	2.6	2.5
10	2.5	2.5	no	2.5	2.5
12	2.5	2.5	no	2.3	2.3

1 = poor; 2 = acceptable; 3 = very good