

**TECHNOLOGY FOR "EMBUL" BANANA EXPORT**

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Peradeniya***ABSTRACT**

Green and firm fruit of good external appearance and absence of crown rot are the major pre-requisites for banana export. Both field and laboratory simulated studies showed good quality "Embul" banana for export can be produced by bagging after flowering and harvesting them at 11 weeks after flowering. Ripening process of the fruits can be delayed by storing them at 14°C immediately after packaging under modified atmosphere storage using 150 gauge low-density polyethylene bags. Evacuation of bags before sealing showed better extension of storage life at low temperature. If bananas are harvested at 75 days after flowering and packed under vacuum packaging condition, green life can be maintained for more than 21 days with very good external appearance. After the storage period, bananas undergo natural ripening process with similar physico-chemical parameters to that of naturally ripened freshly harvested bananas. If fruits are to be air-freighted, the stage of maturity for harvesting was 80 days after flowering. Good quality harvested bananas must be packed using perforated, 100 gauge low-density polyethylene liner and stored at 14°C immediately after packaging. Low temperature must be continued at least up to the airport, if the air travel duration is one day. If the travel duration exceeds two days or more, bananas must be transported in low temperature containers until they reach their destination. Results of both commercial shipments of air-freight and sea-freight "Embul" bananas to Japan are also included. An additional precaution to control crown-rot during sea-freight has to be taken to control the crown-rot.

**KEYWORDS:** Air-freight, Crown-rot, Modified atmosphere, Sea-freight, Vacuum packing.

**INTRODUCTION**

"Embul" banana production in Sri Lanka has come to a saturated level. Further expansion results in price reduction causing a low income to farmers. If bananas are exported, a vacuum in the local market can be created resulting in a reasonable price paid for farmers. Banana export industry in the world is well commercialized with 'Cavendish' group of bananas (Scott *et al.*, 1968). However, in Sri Lanka only limited experimental information is available on export of "Embul" bananas (Sarananda and Wijerathnam, 1994 and Sarananda *et al.*, 1996). No commercial export is practiced yet due to risk involved in quality maintenance. Blemish free bananas having a reasonably long green life until they reach the importing country are major requirements during banana export. In addition, control of fungal rot developed at the cut crown surface is another requirement (Sarananda and Wijerathnam, 1994). Technology to produce high quality fruits, delayed ripening and control of crown rot for Cavendish group of bananas has been developed. Ripening process of fruit can be delayed by reducing the respiration rate which can be achieved by storing at 13.5°C.

Respiration rate can further be lowered down by enclosing in modified atmosphere generated passively using low-density polyethylene bags (Sarananda, 1989a). The maximum storage life, however, can be obtained through vacuum packing. Experimental evidence for the above key areas has been reported for "Embul" banana (Sarananda *et al.*, 1996). However, no commercial scale data are available because the technology has not been used during export. Therefore, this paper describes the results of commercial shipment of "Embul" banana.

## MATERIALS AND METHODS

### Commercial sea shipment

"Embul" bananas grown in Embilipitiya under irrigation were used for the study. Farmer organization at Mauara was selected and fields with satisfactory banana cultivation were selected for collection of banana. Farmers were made aware about the quality and harvest maturity for export. Polysack bags with 40-60 (1 cm) perforations were used for bagging on tree of newly emerged bunches after removal of inflorescence. Bagging was done to improve the peel quality without blemishes. After bagging, plants were tagged to monitor the harvest maturity. Bunches were harvested at 75 days after bunch emergence. Preliminary studies showed that harvesting bananas at 75 days of maturity delayed the ripening process compared to those harvested at 80-85 days for the local market. Harvested bunches were wrapped individually in foam sheets and bunches were placed vertically as a single layer in a ventilated lorry and transported to the pack house at Mirijjawila.

Bunches were then deheaded using very sharp curved deheading knife, floral remnants were removed and immediately put into water for washing. Hands were separated into clusters for easy packing. Twisted fingers in hands or clusters were removed using a sharp curved knife. Plastic basins were used for washing. Wash after in the basin was regularly changed to reduce infection at the cut crown surface. Dirt present on fingers was removed during washing and then hands transferred into 1% Alum (Potassium aluminum sulphate) solution to coagulate latex. Alum washed bananas were then taken out and weighed for required quantity of 8 kg per carton. Five ply cartons were used and the carton was lined with 150-gauge low-density polyethylene (LDPE) bag. Banana hands or clusters were then packed inside placing distal end of fingers to the bottom of the box. During the packing rows were separated using a sheet of foam to prevent bruising. Once the box was packed with bananas a low vacuum horse was inserted into the bag and then the bag was evacuated. Bag was then sealed using a rubber band. Packed boxes were immediately transferred into a cold room maintained at  $14^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Packed boxes were stacked as 5 layers on a standard size pallet and pallets loaded in a 20 foot container, which was also

maintained at  $14^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Fruits were exported to Japan. The time of shipment was 26 days. Similarly 10 boxes of bananas harvested at 80 days after bunch emergence were also included for the shipment. Except the maturity difference, the rest of the procedure adopted was similar to that followed for 75 days mature bananas harvested for the sea shipment study.

### Commercial air shipment

For air-shipment, bananas from the same field were used. Bagging and tagging were done similar to the previous experiment. Bunches were harvested at 80 days maturity and brought to the packing shed located in the field itself. Bunches were deheaded, floral remnants were removed and washed with water. Bananas were then separated into clusters and washed with 1% alum and fruit weight of 8 kg was weighed and packed in boxes similar to the sea-shipment trial. The bags were lined with perforated polyethylene bags to facilitate air exchange. Boxes were then closed without sealing the bags. Packed boxes were immediately transferred into the refrigerated cargo van, which was maintained at  $14^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Sixty-five banana boxes were packed in the refrigerated container and transported to the airport. Bananas were then exported to Japan by air-cargo without temperature control.

Fruits were assessed for ripening using colour index 1 = green, 2 = colour break, 3 = more green than yellow, 4 = more yellow than green, 5 = yellow with green tip, 6 = full yellow, and 7 = over ripe. Crown rot was also measured using standard crown rot index 0-4. Overall fruit quality together with colour index and crown rot index have been assessed by the Japanese importing company.

## RESULTS AND DISCUSSION

Bananas harvested at 75 days after emergence were firm and green when they reached Japan, 26 days after storage at  $14^{\circ} \pm 2^{\circ}\text{C}$  (Table 1). Modified atmosphere generated using low density polyethylene bags has proven to extend the storage life of "Embulo" banana even at ambient temperature (Sarananda, 1989b). Low temperature used in this shipment would have further attributed to reduce the respiration rate resulting in long green life. When "Embulo" bananas were stored at  $13, 5^{\circ}\text{C}$  under MA conditions, the gas composition developed was 5-7%  $\text{O}_2$  and 3-5%  $\text{CO}_2$  (Hewage, 1995). Similar gas composition at the same temperature has increased the storage life of Cavendish bananas (Truter and Combrink, 1990). On the other hand, bananas harvested at 80 days after emergence was less firm and yellow colour development has been initiated. The difference in responses of 'Embulo' banana harvested from the same field may be due to difference in maturity.

Since banana belongs to the climacteric group of fruits, at 80 days after flowering, fruits must have reached the pre-climacteric minimum level. When fruits are harvested, washed and enclosed in sealed polyethylene bags, fruits are exposed to high CO<sub>2</sub> and low O<sub>2</sub> stress. Since mature fruits are sensitive for ethylene production, it would have initiated the ripening process of bananas. Peel colour development up to CI 2.6 is an indication that autocatalytic ethylene production has been initiated. With the ethylene biosynthesis, pectic substances are dehydrated, starch is hydrolyzed to sugars resulting in softening of fruits. Fruits harvested at 75 days after flowering might not have reached the climacteric minimum hence the stress caused due to enclosing in modified atmosphere is not sufficient to initiate auto catalytic ethylene production. Maturity at harvest therefore plays a vital role in extending storage life of "Embul" banana. The mechanism of delaying ripening is mainly due to initiation of ethylene biosynthesis under MA at low temperature (Mapson and Robinson, 1966; Sarananda *et al.*, 1996)

**Table 1. Quality parameters of sea freighted 'Embul' banana, assessed in Japan upon arrival.**

Stage of maturity	Firmness	Colour index	Crown rot index
75 days after emergence	Firm	1	0
80 days after emergence	Less firm	2.6	0

Colour index: - 1- green, 2-colour break, 3- more green than yellow, 4-more yellow than green, 5- yellow with green tip, 6-fully ripe and 7- over ripe

Crown-rot index: - 0 = no rot, 1 = 1-10% crown is rot, 2 = 11-20% crown is rot, 3 = 21-30% crown is rot, 4 = over 30% of the crown is rot.

Crown rot is caused by a combination of fungi *Colletotrichum musae*, *Fusarium moniliforme*, *Botryodiplodia theobromae* and *Verticillium theobromae* (Sarananda and Wijerathnam, 1994). Crown rot development normally takes place with the onset of ripening. However, no crown-rot incidence was reported in this consignment. The causes for the cut crown surface infection could be the dehanding knife and wash water. Regular disinfected dehanding knife and regular removal of wash water may have reduced the number of inoculation, which result in no rot development. In addition low oxygen in modified atmosphere would have suppressed the growth of fungi (Follstad, 1996).

Since the ripening process of 80 days mature bananas had been initiated, only 75 days mature bananas were used for ripening with exposure to ethylene gas at low temperature. The results showed that peel colour development was very good giving bright yellow colour. However, the external appearances of the fruits were of poor quality. The reasons for poor quality have been reported as blemishes on the skin due to mechanical injuries, brown dots due to freckle disease and size variation of fruits in a box.

Cavendish group banana requires ethylene exposure at 16-20°C for proper chlorophyll degradation. However, chlorophyll degradation in 'Embul' banana does not require those specific conditions described for Cavendish (Sarananda and Wijerathnam, 1994).

Table 2. Peel colour and quality of "Embul" banana after ripening.

<i>Stage of maturity</i>	<i>Peel colour</i>	<i>Visual quality rating</i>
75 days after flowering	CI-6	6.5

Colour index: - 1- Green, 2-Colour break, 3- More green than yellow, 4-More yellow than green, 5- Yellow with green tip, 6-Fully ripe and 7- Over ripe

Visual Quality Index: - 9 - Excellent, 7 - Slight defects, 5 - Moderate defects, 3 - High defects, not saleable and 1 - Not edible

However, 'Embul' bananas did respond for commercial ripening treatment. Very high extent of mechanical injuries on the skin of banana may be due to careless packing. Skin of "Embul" banana seems to be much more sensitive than that of 'Cavendish'. Thin peel with less resistance to mechanical injuries is a varietal character of "Embul" banana. However, careful handling during preparation and packing could reduce the extent of wounds. Very high susceptibility to freckle disease caused by *Phylosticia musarum* is also an inherent disease of "Embul" banana if control measures are not adopted. This problem, however, can be overcome by maintaining the cleanliness in the plantation and bagging bunches soon after emerging of the bunches.

Non-uniformity of size of fruits is an inherent character of "Embul" banana. Fruit size variation from the first to the last hand is gradually reducing in "Embul" bananas. In certain bunches a number of last hands have to be rejected due to under size. One way of overcoming this problem is packing bananas of uniform size in separate boxes. The other alternative is to select varieties, which have greater proportion of hands with uniform size.

The duration to transport banana from Sri Lanka to Japan was approximately 2 days. Although more mature bananas were used for airfreight than those used for sea-freight, ripening process was not initiated (Table 3). This may be due to temperature control immediately after packing and maintaining the same temperature until reaching the airport. Simulated trials, however, showed if refrigerated temperature was not used, ripening process was initiated even 2 days after harvesting. Although bananas are harvested at pre-climacteric minimum stage, low temperature storage alone is sufficient to delay fruits entering the climacteric rise.

**Table 3. Quality parameters of airfreighted "Embul" banana assessed in Japan .**

<i>Physical stage</i>	<i>Firmness</i>	<i>Colour index</i>	<i>Crown rot index</i>
Upon arrival (green)	Firm	1	0
After ripening	Soft	6	0

Colour index: - 1- green, 2-colour break, 3- more green than yellow, 4-more yellow than green, 5- yellow with green tips, 6-fully ripe, 7- over ripe

Crown-rot index:- 0 = no rot, 1 = 1-10% crown is rot, 2 = 11-20% crown is rot, 3 = 21-30% crown is rot, 4 = over 30% of the crown is rot.

No incidence of crown rot had been observed upon arrival of fruit. The same results were recorded in ripe bananas when they were ripen by exposing to ethylene gas at 18°C. Sanitation followed during dehanding and washing reduced the number of inoculum deposit on cut surface of the crown. This may be the reason for no crown rot development. In addition, very short (2 days) transit time may not be sufficient to initiate the crown rot.

### CONCLUSIONS

Based on the results, 'Embul' banana could successfully be sea-freighted when fruits were harvested at 75 days of maturity and packed in cartons under vacuum packing and without causing mechanical injuries. By storing bananas at 14°C from the pack house until they reach their destination, ripening process can be delayed for up to 30 days allowing export to any country in the world. Similarly 'Embul' bananas can be air freighted using more mature fruits (80 days) if they are packed in cartons as a single layer and transported from the pack house to the airport at 14°C.

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### REFERENCES

- Follstad, M.N. 1996. Mycelial growth rate and sporulation of *Alternaria tenuis*, *Botrytis cinerea*, *Cladosporium herbarum* and *Rhizopus stolonifer* in low oxygen atmosphere. *Phytopathology* 56: 1098-1099.
- Hewage, K.S. 1995. Factors influencing postharvest longevity of 'Embul' bananas. PhD Thesis. Wye College, University of London.
- Mapson, L.W. and J.E. Robinson. 1966. Relation between oxygen tension, biosynthesis of ethylene, respiration and ripening changes in banana fruit. *Food Technology* 1: 215-225.

- Sarananda, K.H. 1989a. Response of 'Embul' bananas to modified atmosphere storage. *Tropical Agriculturist* 145: 104-113.
- Sarananda, K.H. 1989b. Response of 'Embul banana (*Musa* spp.) to modified atmosphere storage. *Tropical Agriculturist* 145: 113-119.
- Sarananda, K.H. and R.S.W. Wijerathnam. 1994. Controlled atmosphere storage of 'Embul' bananas. *Tropical Agricultural Research* 6: 17-22.
- Sarananda, K.H., H. Wainwright and R. Wijerathnam. 1996. Inhibition of ethylene biosynthesis in modified atmosphere stored bananas. *Tropical Agricultural Research* 8: 306-314.
- Scott, K.J., Me W.B. Glasson and E.A. Robberts. 1968. Ethylene absorbent increases storage life of bananas packed in polyethylene bags. *Agriculture Gazette, New South Wales*, Pp 79-82.
- Truter, A.B. and J.C. Combrink. 1990. Controlled and modified atmosphere storage of bananas. *Acta Horticulturae* 275: 631-637.