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Maintenance of Fruit Quality in Organically-grown Bananas under Modified Atmosphere Conditions

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Abstract: The effects of modified atmosphere packaging at low storage temperature on the quality of organic bananas (cv. Cavendish) were investigated. Polybags, with or without an ethylene scavenger, significantly reduced ($p<0.05$) the total weight loss of bananas during storage for 25 days and fruit firmness was favoured by packaging. Bags containing a scavenger prevented the peel colour changing beyond the classification 'greener than yellow' over 25 days and total soluble solids were lower than in unwrapped fruit. The fruit was not treated with fungicide yet disease levels were relatively low at 25 days. Shelf life extension to 62 days was possible in polybags containing potassium permanganate when held at 14°C. When the scavenger was omitted, storage life was 55 days, yet acceptable taste and other quality were maintained.

Key words: Banana, modified atmosphere, ethylene, organically grown, temperature

INTRODUCTION

Bananas are highly perishable commodities with post harvest losses estimated at 20-80%[1]. The current postharvest problems for bananas are mainly concerned with storage and marketing. The causes of such losses during storage and marketing include (i) the susceptibility of mature fruit to physical damage (ii) decay of ripe banana fruit due to the attack by pathogenic fungi and (iii) uneven and unpredictable ripening of the fruit[2].

Reducing post harvest losses of bananas is a critical area of research. A variety of physical treatments has been investigated including low temperatures and modified atmospheres[3,4]. The chemical control of the post harvest wastage has become an integral part of the handling and successful marketing of bananas[5].

The present study has been designed to investigate the effects of modified atmosphere packaging combined with low storage temperature on the extension of shelf life of organically-grown bananas.

MATERIALS AND METHODS

Mature green 'Cavendish' bananas were collected from a non-sprayed and organically grown banana plantation at Murray Upper, North Queensland. Damaged and distorted fruits were discarded and the remainder randomly allocated to treatments the day following their arrival in the laboratory.

Experimental design: The experiment was laid out in a Completely Randomised Design (5 replications); each replication consisted of 10 fruits. A two-way analysis of variance (ANOVA), using the SPSS computer package, version 9.0, with two fixed factors, was used to detect differences. Arcsine and logarithm $(x + 1)$ transformations were performed where appropriate[6]. Tukey's Post Hoc test was used for the comparison of treatment means.

Packaging: Bananas were individually sealed in 935 kg m^{-3}, 150 μm thickness, low density polyethylene (LDPE) bags. Bags were randomly allocated among treatments. Some fruits were sealed in LDPE bags containing $KMnO_4$ (5 mL saturated $KMnO_4$ absorbed onto 5 g vermiculite held in an 8 × 6 cm perforated plastic bag). They were stored at room temperature (19-25°C) and at 14°C. Unwrapped fruits were kept as controls.

Parameters studied: The parameters studied included total weight loss, peel colour change, firmness, Total Soluble Solids (TSS), pH and CO_2 concentration. Data on the above parameters, except carbon dioxide levels, were collected every 4 days. Respiration was measured at 8 day intervals.

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A standardized colour chart (Royal Horticultural Society, London) was used in assessment of peel colour. It was established in diffuse light by placing the middle portion of the banana finger under the hole in the colour patch in order to permit matching of the colour. Colour was scored on a numerical scale of 1 to 5, where 1, 2, 3, 4 and 5 represented green, greener than yellow, more yellow than green, yellow and ripened and blackened and over ripened, respectively; compare for mango[7].

Softness of banana was measured using a modified tomato penetrometer (Analogue CSIRO Tomato Firmness Meter), which measured fruit deformation under a 500 g weight applied for 30 sec., over an area of 5 mm diameter[8]. Total Soluble Solids (TSS) were measured by taking fruit pulp (5 g) from the middle portion of banana fruit. After homogenization in a mortar and pestle with 1 mL of distilled water, the TSS contents were measured directly as °Brix by placing a drop of juice on the prism of a Hand Sugar Refractometer (Model WYT-4, Fujian Quanzhou Optical Instrument Factory). Temperature corrections were made as required.

Pulp pH was measured after blending 20 g of flesh from the mid-section of the fruit in 40 mL distilled water. A filtrate was used for pH determination.

Concentration of carbon dioxide in bags was measured at 8 days intervals using a thermal conductivity gas chromatography (GC-8A, Shimadzu CB1751, Japan). The gas chromatograph was fitted with a Unibeads column (6ft×1/8 OD, stainless steel; packing 1S, 60/80) operating at 70°C using helium as the carrier gas (26 mL min^{-1} flow rate). A gas sample (8 mL) was collected and held in a vacutainer (propane tracer added-4 mL). A 100 μL gas sample was injected. The carbon dioxide peak area was calculated knowing that 33 μL propane had been added with each sample.

Shelf life of bananas was calculated by counting the number of days required for ripening fruit that fully retained optimum marketing and eating qualities. Fruit was considered rotten when more than 5% of surface area was decayed, blackened, or rotten[7].

RESULTS AND DISCUSSION

Postharvest quality as influenced by polybag storage: A number of parameters related to quality were investigated.

Weight losses changes were substantial. The unwrapped bananas lost weight in increasing fashion. Fruit in polybags lost less than 1% weight. By contrast, the unwrapped fruits showed weight losses up to 22% at 21 days of storage at room temperature. Reduced weight loss in plastic bags has been noted by others[9,10]. The unwrapped bananas decreased in fruit firmness (increased depression) from day nine of storage. Longer storage led to decreased firmness. This may be attributed to the commencement of ripening. As ripening progressed, the water soluble pectins of banana pulp presumably increased and the insoluble pectins decreased[11]. The inhibiting effects of polybags on fruit softening (Table 1) may be attributed to the delayed ripening due to changes in the gaseous composition of the storage environment. Bags also helped maintain fruit pH constant at 4.5.

Peel colour scores of fruit in polybags containing an ethylene scavenger remained 'more green than yellow' (colour score 2) till 25 days (Table 1), a result consistent with those of Jiang *et al.*[12].

Total soluble solids (TSS) content tended to increase with storage time. Unwrapped fruits had higher TSS levels compared to the fruits kept in polybags (Table 1) at 25 days at room temperature. Fruit held in polybags with or without an ethylene scavenger produced similar TSS (1.8 °Brix) until 17 days.

The carbon dioxide concentrations inside polybags with or without an ethylene scavenger were similar until 25 days (<3%). Eight days later the levels in bags with low levels of ethylene were still less than 2.4%. The accumulation of CO_2 inside the polybags in the present study was less than that previously reported. Values around 7% CO_2 are commonly found inside polybags by the third week of storage[13,14].

Postharvest quality as affected by storage temperature: Total weight loss changed significantly during the storage period, with low temperature (14°C) favouring weight retention in unwrapped fruit (22.1% compared to 8.9% at 21 days at room and 14°C, respectively), a result consistent with other findings[15,16]. Low temperature trends in firmness paralleled those of peel colour which maintained a score of 2.6 at low temperature compared to 5 at room temperature on 25 days (Table 1). Low temperature resulted in lower levels of TSS (4.1 °Brix in

Table 1: Effects of packaging on selected quality parameters at day 25

Feature and temp. (°C)	Not wrapped	Polybag alone	Polybag with scavenger
Peel colour			
14	2.60b†	2.60b	2.00b
19-25	5.00a	3.40b	2.00b
Firmness (skin depression, mm)			
14	0.57b	0.41b	0.31b
19-25	3.72a	0.74b	0.39b
Total soluble solids (°Brix)			
14	4.10bc	2.70cd	2.30d
19-25	12.60a	4.10b	2.70cd
Disease severity (% skin affected)			
14	0.20b	0.40b	1.20b
19-25	75.40a	1.40b	1.70b

† Values followed by the same letter symbol across a row do not differ significantly at the 5% level by Tukey's Post Hoc test

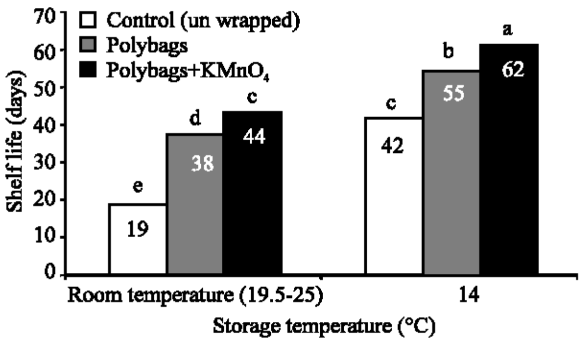

Fig. 1: Combined effects of modified atmosphere packaging and storage temperatures on the shelf life of bananas. The bars having common letter(s) do not differ significantly at the 5% level

unwrapped fruit) compared to that at higher temperature (12.6 °Brix); the TSS level was considerably lower in fruit held in polybags (2.3-2.7 °Brix).

Pulp pH did not change significantly over the time of measuring at low temperature (pH constant at 5.4). At room temperature, however, the unwrapped fruit showed a drop in pH to 4.5.

Shelf life of organic bananas: Modified packaging significantly extended the storage life of organically grown bananas.

Temperature also influenced the storage life of bananas. Packaging treatments were more effective at 14°C temperature in extending the storage life of bananas compared with those at room temperature. The organoleptic features of the fruit were maintained better at this temperature. The longest shelf life was 62 days using polybags containing an ethylene scavenger (Fig. 1). The fruits stored at room temperature displayed shelf lives of 38 days in polybags and 44 days in polybags containing an ethylene scavenger. Storage in polybags occasionally resulted in skin splitting upon ripening at ambient condition after being taken from bags. Storage in bags did not significantly influence the organoleptic features of the stored fruit.

The extended storage life of bananas using polybags containing either ethylene inhibitors (1-methylcyclopropene) or ethylene scavengers ($KMnO_4$) has been noted previously[12,17]. In one study storage was extended, at low temperature, from 24 days, to 30 days using an ethylene scavenger[18]. Present results show that this time can be doubled with organically grown Cavendish bananas when they are stored in polybags at low temperature (14°C). When the scavenger was omitted, storage life was 55 days, yet acceptable taste and other quality were maintained.

The delayed ripening of bananas in our studies, resulting from the use of potassium permanganate in polybags, may be attributed to the combined effects of reduced ethylene production, low oxygen and increased carbon dioxide inside the bags[19]. Polybags alone extend storage life of bananas by lowering the rate of respiration through loss of oxygen and accumulation of carbon dioxide[9,20].

A disadvantage of polybags is that fruit pathogens grow more vigorously. Disease incidence in untreated fruit at low temperature was 24% in polybags and 52% in bags with ethylene scavenger at day 25 compared to 8% in unwrapped fruit. However, the proportion of fruit skin affected was 0.2% for unwrapped fruit and not greater than 1.2% for polybags containing a scavenger at 25 days (Table 1). This result can be acceptable when organically grown fruit is being marketed. The growth of pathogens can be controlled effectively by hot water or fungicide treatments, if desired[21].

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REFERENCES

1. Paull, R.E., 1993. Tropical Fruit Physiology and Storage Potential. In: Proc. Intl. Conf. Postharvest Handling of Tropical Fruits Held at Chiang Mai, Thailand, 19-23 July, 1993 (Eds., Champ, B.R., E. Highley and G.I. Johnson). Aust. Centre Intl. Agril. Res., Proceedings No. 50, Canberra, pp: 198-204.
2. Thompson, A.K. and O.J. Burden, 1995. Harvesting and Fruit Care. In: Bananas and Plantains (Eds., Gowen, W.), Chapman and Hall, London, pp: 403-433.
3. Kader, A.A.,1993. Modified and Controlled Atmosphere Storage of Tropical Fruits. In: Proc. Intl. Conf. Postharvest Handling of Tropical Fruits Held at Chiang Mai, Thailand, 19-23 July, 1993 (Eds., Champ, B.R., E. Highley and G.I. Johnson). Aust. Centre Intl. Agril. Res., Canberra, pp: 239-249.
4. Romphophak, T., J. Siriphanich, S. Promdang and Y. Ueda, 2004. Effect of modified atmosphere storage on shelf life of banana Sucrier. J. Hortic. Sci. Biotechnol., 79: 659-663.

5. Tongthieng, T. and S. Sangchote, 1993. Postharvest Fruit Rot of Banana Caused by *Colletotrichum musae* (Berg. and Curt.) Arx. and its Control. In: Proc. Intl. Conf. Postharvest Handling of Tropical Fruits Held at Chiang Mai, Thailand, 19-23 July, 1993 (Eds., Champ, B.R., E. Highley and G.I. Johnson). Aust. Centre Intl. Agril. Res., Canberra, pp: 462-463.
6. Zar, J.H., 1999. Biostatistical Analysis. (4th Edn)., Prentice Hall International Inc., New Jersey, USA.
7. Upadhyay, I.P., A. Noomhorm and G. Illangantileke, 1993. Effect of Gamma Irradiation and Hot Water Treatment on the Shelf Life and Quality of *Thai mango* Cv. Rad. In: Proc. Intl. Conf. Postharvest Handling of Tropical Fruits Held at Chiang Mai, Thailand, 19-23 July, 1993 (Eds., Champ, B.R., E. Highley and G.I. Johnson). Aust. Centre Intl. Agricl. Res., Canberra, pp: 348-351.
8. Hassan, M.K., 2000. Studies in the postharvest behaviour of bananas. M.App.Sc. Thesis, James Cook University, Townsville, Australia (unpublished).
9. Wills, R.B.H., W.B. McGlasson, D. Graham, T.H. Lee and E.G. Hall, 1989. Postharvest: An Introduction to the Physiology and Handling of Fruits and Vegetables. New South Wales University Press, Kensington, Australia.
10. Sarkar, H.N., M.A. Hasan and P.K. Chattopadhyay, 1997. Influence of polyethylene packing on the postharvest storage behaviour of banana fruits. Hortic. J., 10: 31-39.
11. Robinson, J.C., 1996. Bananas and Plantains. CAB International, Wallingford, UK.
12. Jiang, Y.M., D.C. Joyce, A.J. Macnish and Y.M. Jiang, 1999. Extension of shelf life of banana fruit by 1-methylcyclopropene in combination with polyethylene bags. Postharvest Biol. Technol., 16: 187-193.
13. Elzayat, H.E., 1996. Influence of plastic wrapping on storage and quality of banana. Bull. Fac. Agric., Univ. Cairo, 47: 295-303.
14. Chamara, D., K. Illeperuma and P.T. Galappatty, 2000. Effect of modified atmosphere and ethylene absorbers on extension of storage life of Kolikuttu banana at ambient temperature. Fruits (Paris), 55: 381-388.
15. Kitinoja, L. and A.A. Kader, 1995. Small-scale Postharvest Handling Practices- A Manual for Horticultural Crops. 3rd Edn., University of California, Davis, California.
16. Nagaraju, C.G. and T.V. Reddy, 1995. Deferral of banana fruit ripening by cool chamber storage. Adv. Hortic. Sci., 9: 162-166.
17. Sisler, E.C., T. Alwan, R. Goren, M. Serek and A. Apelbaum, 2003. 1-substituted cyclopropenes: Effective blocking agents for ethylene action in plants. Plant Growth Regul., 40: 223-228.
18. Golding, J.B., D. Shearer, W.B. McGlasson and S.G. Wylie, 1999. Relationship between respiration, ethylene and aroma production in ripening banana. J. Agric. Food Chem., 47: 1646-1651.
19. Patil, S.N. and N.C. Halumani, 1998. Effect of postharvest treatments on physical characters and shelf life of banana fruits. Karnataka J. Agric. Sci., 11: 535-537.
20. Andres, D.S., 1984. Modified atmosphere using plastic bags for storing mangoes. Scient. J., 6: 45.
21. Hassan, M.K., W.A. Shipton, R. Coventry and C. Gardiner, 2004. Extension of banana shelf life. Aust. Plant Pathol., 33: 305-308.