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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 ripening [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⁻², 150 μm thickness, low density polyethylene (LDPE) bags. Bags were randomly allocated among treatments. Some fruits were sealed in LDPE bags containing KMnO₄ (5 mL saturated KMnO₄ absorbed onto 5 g vermiculite held in an 8 x 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 CO₂ 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\textsuperscript{[1]}. 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\textsuperscript{[2]}. 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 15, 60/80) operating at 70°C using helium as the carrier gas (26 mL min\textsuperscript{−1} flow rate). A gas sample (8 mL) was collected and held in a vactuminer (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\textsuperscript{[3]}. 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\textsuperscript{[4,5]}. 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\textsuperscript{[3]}. 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.\textsuperscript{[6]}. 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 concentration 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\textsubscript{2} inside the polybags in the present study was less than that previously reported. Values around 7% CO\textsubscript{2} are commonly found inside polybags by the third week of storage\textsuperscript{[7,8]}.

<table>
<thead>
<tr>
<th>Feature and temp. (°C)</th>
<th>Not wrapped</th>
<th>Polybag alone</th>
<th>Polybag with scavenger</th>
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<tbody>
<tr>
<td>Peel colour</td>
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<tr>
<td>14</td>
<td>2.60b</td>
<td>2.60b</td>
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<tr>
<td>19-25</td>
<td>5.00b</td>
<td>3.40b</td>
<td>3.00b</td>
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<td>Firmness (skin depression, mm)</td>
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<tr>
<td>14</td>
<td>0.57b</td>
<td>0.41b</td>
<td>0.31b</td>
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<tr>
<td>19-25</td>
<td>3.72a</td>
<td>0.74b</td>
<td>0.59b</td>
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<tr>
<td>Total soluble solids (°Brix)</td>
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<tr>
<td>14</td>
<td>4.10b</td>
<td>2.70cd</td>
<td>2.30d</td>
</tr>
<tr>
<td>19-25</td>
<td>12.60a</td>
<td>4.10b</td>
<td>2.70cd</td>
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<td>Disease severity (% skin affected)</td>
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<tr>
<td>14</td>
<td>0.20b</td>
<td>0.40b</td>
<td>1.20b</td>
</tr>
<tr>
<td>19-25</td>
<td>75.40a</td>
<td>1.40b</td>
<td>1.70b</td>
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\textsuperscript{1} Values followed by the same letter symbol across a row do not differ significantly at the 5% level by Tukey's Post Hoc test.
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. Polybags alone extend storage life of bananas by lowering the rate of respiration through loss of oxygen and accumulation of carbon dioxide.

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.

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REFERENCES