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Post-harvest treatment of wild mango (*Irvingia gabonensis*) for improved shelf life

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The effectiveness of hot water, chemicals, wax and film packaging in extending the post-harvest life of wild mango under tropical ambient conditions was investigated. Dipping wild mangoes in hot (55°C) water or hot 0·1% benomyl, 0·5% sodium dehydroacetate or 0·5% $Na_2S_2O_5$, followed by waxing or packaging in boxes overwrapped with stretch PVC film, delayed ripening, controlled decay, minimised weight loss and extended the shelf life of the fruits when held at 22–35°C and 70–95% relative humidity without adverse effects on visual and chemical qualities. The best results were obtained when PVC film packaging was preceded by a sulphite dip.

INTRODUCTION

In several developing tropical countries, there are many little known indigenous crops that play vital roles in the nutrition of the rural populace. Some of these less known indigenous crops are available at certain critical periods of the year when the more common sources are very scarce or completely unavailable (Okigbo, 1977). One such crop, of horticultural and nutritional importance, that has received little research attention, is wild mango (*Irvingia gabonensis* Aubry Lecomte ex O'Rorke-Baill).

Wild mango, a member of the family Simarubaceae, is botanically unrelated to cultivated mango (*Mangifera indica* L.). It produces fruit between June and October, when cultivated mango is out of season. Two varieties of the fruits, 'gabonensis' and 'excelsa', have been distinguished (Okafor, 1975). 'Gabonensis' with a sweet edible scantily fibrous pulp, deep-yellow to orange when ripe, is consumed in the fresh form, as a fruit, while the oil-rich cotyledons of 'excelsa', that have a bitter and very fibrous inedible pulp, are used as a flavouring ingredient and to impart desired consistency to soups.

In a study of the post-harvest physiology of wild mango, variety 'gabonensis', it was found that the fruits, like cultivated mango, had a high rate of respiration under tropical ambient conditions, with a pronounced climacteric which coincided with the onset of ripening (Joseph, 1990). The physico-chemical changes that occur during ripening of wild mango are typical of tropical fruits and include softening, degradation of starch, formation of sugars and increases in total carotenoids (Aina, 1990). The high rate of respiration, moisture loss and susceptibility to microbial attack, especially when ripe, limit the shelf life of wild mango to less than 10 days under tropical ambient conditions (Joseph, 1990). This short shelf life aggravates post-harvest losses and does not allow for efficient distribution and marketing.

Attempts at extending the shelf life of wild mango by refrigeration were unsuccessful. The fruits exhibited marked chilling sensitivity with severe injury symptoms including pitting and black spots in mature green fruits, and brownish discoloration, pitting, surface scald, excessive softening and decay in ripe fruits held at 12–15°C (Joseph, 1990). Simple and relatively inexpensive treatments such as post-harvest fungicidal dips, coating with wax and other surface agents, such as Pro-long, and product-generated modified atmosphere packaging have proved beneficial in extending the shelf life of many tropical and sub-tropical fruits in developing tropical countries, where more complex treatments are, at the moment, impracticable (Passam & Blunden, 1982; Olorunda & Aworh, 1984; Aworh & Ubebe, 1988; Aworh *et al.*, 1991).

This study investigates the effectiveness of hot water, chemical, wax and film packaging in extending the post-harvest life of wild mango under tropical ambient conditions. The effects of these treatments on visual and chemical qualities of the fruits were also studied.

MATERIALS AND METHODS

Materials

Selected, freshly hand-harvested, uniformly sized, pre-climacteric mature-green wild mango fruits were obtained from Iware village via Fiditi in Oyo State in southwestern Nigeria. All fruits were free of physical injury and other blemishes. Shield Brite AP 40 wax was obtained from Shield Brite Corporation, Kirkland, WA, USA. Polyvinyl chloride film (Auto RMF–B) was obtained by courtesy of Borden (UK) Ltd, Southampton, UK. Benomyl, trade name 'Benlate' (methyl 1-(butyl-carbamoyl)-2-benzimidazole carbamate), is a product of Du Pont/National Oil and Chemical Marketing Co. Ltd, Lagos, Nigeria. Sodium dehydroacetate (DHA–S) and sodium metabisulphite were supplied by Sigma Chemical Co., St Louis, MO, USA. All other chemicals used were of analytical grade.

Treatment and storage

A series of pilot experiments was conducted to determine the effects of dipping wild mango fruits, in hot water and in different concentrations of benomyl, DHA–S and $Na_2S_2O_5$ at different temperatures, on the shelf life and quality of wild mango fruits. Based on the results of the pilot experiments, nine treatments were selected and three replicates of batches each consisting of 8–10 wild mangoes, were given one of the following treatments after washing and draining:

(1) Waxing by spraying the fruits uniformly with a thin film of Shield Brite AP 40 wax, after dipping in hot 0·1% benomyl at 55°C for 5 min and drying.
(2) Waxing after dipping in hot 0·5% $Na_2S_2O_5$ at 55°C for 5 min and drying.
(3) Packaging in heat-sealed low-density polyethylene bags, 0·04 mm thick.
(4) Packaging in wooden boxes overwrapped with stretch polyvinyl chloride film (PVC).
(5) Dipping in hot water (55°C) for 5 min followed by PVC packaging.
(6) Dipping in hot 0·1% benomyl (55°C) followed by PVC packaging.
(7) Dipping in hot 0·5% DHA–S (55°C) followed by PVC packaging.
(8) Dipping in hot 0·5% $Na_2S_2O_5$ (55°C) followed by PVC packaging.
(9) Dipping on hot 0·5% $Na_2S_2O_5$ followed by PVC packaging with the inclusion of 100 g of sawdust moistened with saturated $KMnO_4$ solution, as ethylene absorbent.

Waxed fruits and untreated fruits (controls) were packed in ventilated polypropylene stack/nest containers (WCB Containers Ltd, Cheshire, UK). All fruits were stored under tropical ambient conditions at 22–35°C (mean daily minimum and maximum temperatures) and a mean daily relative humidity of 70–95%. Relative humidity was determined daily at 7 a.m., 10 a.m., 4 p.m. and 6 p.m. from wet and dry bulb temperature readings.

Assessment of shelf life and quality

For each treatment, individual fruits were assessed for ripening during storage on the basis of change in skin colour from green to yellow and softness, using an arbitrary scale of 1–6 (unripe to fully ripe) where 1 = mature green, firm; 4 = 30–60% yellow, slightly soft; and 6 = full yellow, moderately soft. Beyond stage 6, the fruit turns brownish black and becomes unmarketable.

Weight loss was determined by weighing the fruits in each treatment at intervals during the storage period and was expressed as a percentage of the initial weight. Decay was assessed by visual inspection on a daily basis. At the fully ripe stage, the weight of fruits with signs of decay was determined and expressed as a percentage of the initial weight.

Reduced ascorbic acid content of wild mangoes was determined by the indophenol method (Ruck, 1969). Ascorbic acid in 50 g samples of fruits was extracted with 0·4% oxalic acid and the extract titrated with standardised sodium 2:6-dichlorophenolindophenol. Soluble solids were measured on a drop of undiluted juice with a Bausch and Lomb Abbe desk refractometer. pH was measured directly on a Metrohm Herisau (Metrohm Ltd., Herisau, Switzerland) pH meter (model E-250). Total acidity was determined by titration with standard 0·1 N NaOH to an end point of pH 8·1 and was expressed as % citric acid (Ruck, 1969). All chemical analyses were run in duplicate.

RESULTS

Untreated mature green wild mangoes ripened quickly under tropical ambient conditions. By day 8, untreated fruits had become fully ripe (stage 6) with the skin turning completely yellow and the flesh deep-yellow to orange (Table 1). By day 12, untreated fruits had turned brownish black and had become unmarketable. In contrast, wild mangoes dipped in hot 0·1% benomyl or 0·5% $Na_2S_2O_5$ followed by waxing had an attractive yellow coloration and lustre, and did not show any signs of quality impairment until day 14. Ripening was inhibited in film-packaged fruits relative to those packed in ventilated containers (Table 1). Wild mangoes packed in sealed polyethylene bags or in wooden boxes overwrapped with stretch PVC film did not become fully ripe until after 16–20 days at 22–35°C and 70–95% RH, depending on the pre-packaging treatment applied. The best results were obtained for fruits dipped in hot 0·5% $Na_2S_2O_5$ prior to packaging in PVC (Table 1). The

Table 1. Effect of hot water, wax, chemicals and film packaging on shelf life of wild mango held at 22–35°C and 70–95% RH

Treatment	Mean number of days to ripening score of:[a]		Decay[b] (%)	Weight loss[c] (%)
	4	6		
Untreated (control)	6	8	17	21·8
Dipping in 0·1% benomyl (55°C) + waxing	6	12	0	15·8
Dipping in 0·5% $Na_2S_2O_5$ (55°C) + waxing	6	12	0	16·1
Packaging in sealed polyethylene bags	10	16	25	4·3
Packaging in boxes overwrapped with PVC	10	16	17	4·3
Dipping in hot water (55°C) + PVC packaging	10	16	0	4·2
Dipping in 0·1% benomyl (55°C) + PVC packaging	12	18	0	4·2
Dipping in 0·5% DHA–S (55°C) + PVC packaging	12	18	0	4·2
Dipping in 0·5% $Na_2S_2O_5$ (55°C) + PVC packaging	12	20	0	4·3
Dipping in 0·5% $Na_2S_2O_5$ (55°C) + C_2H_4 absorbent + PVC packaging	12	20	0	4·3

[a] Ripening score of: 4 = ripe, 6 = fully ripe.
[b] Per cent of diseased to wholesome fruits at fully ripe stage.
[c] At fully ripe stage, expressed as percentage of initial weight.

use of ethylene absorbent in combination with PVC packaging did not result in additional benefits in terms of delayed ripening in fruits stored under tropical ambient conditions.

A high incidence of decay was observed in untreated wild mangoes during the course of ripening at 22–35°C and 70–95% RH. Packaging in sealed polyethylene bags aggravated decay, with 25% of the fruits showing decay symptoms on ripening (Table 1). Dipping wild mangoes in hot water or hot chemical (0·1% benomyl, 0·5% DHA–S or 0·5% $Na_2S_2O_5$) completely suppressed decay during the course of ripening.

Waxing minimised weight loss in wild mangoes during storage under tropical ambient conditions. By day 8 at 22–35°C and 70–95% RH, untreated fruits had lost 22% of their initial weight, whereas waxed fruits lost 16% after 12 days (Table 1). By far the best results, in terms of controlling weight loss, were obtained in fruits packed in sealed polyethylene bags or in wooden boxes overwrapped with PVC film, where less than 5% of the initial fruit weight was lost on ripening (Table 1).

Changes in chemical composition occurred during ripening of wild mangoes. pH increased from 2·9 in mature green fruits to 5·2 in fully ripe fruits whilst total acidity decreased from 0·81% in mature green fruits to 0·10% in fully ripe fruits. Soluble solids increased from 2·8% in mature green fruits to 14·8% in fully ripe fruits, whilst reduced ascorbic acid decreased from 72·6 mg/100 g in mature green fruits to 54·5 mg/100 g in fully ripe fruits. Waxing, hot water, chemical treatment and film packaging had no significant effect on changes in these chemical components during ripening.

DISCUSSION

The short shelf life of wild mango under tropical ambient conditions is due to its high rate of respiration, susceptibility to microbial attack, especially when ripe, and moisture loss resulting in shrivelling (Joseph, 1990). Dipping wild mangoes in hot water, hot 0·1% benomyl, 0·5% DHA–S or 0·5% $Na_2S_2O_5$ followed by waxing suppressed decay and extended the shelf life of the fruits. These results are consistent with previous work with other fruits including cultivated mango. The beneficial effects of hot water and benomyl in reducing the incidence of anthracnose and extending the shelf life of cultivated mangoes have been reported (Subramanyam *et al.*, 1972; Lakshminarayana *et al.*, 1974; Passam, 1982; Aworh & Ubebe, 1988). Sulphites, which are commonly used in the food industry, are very effective in controlling oxidative changes that result in colour impairment in fruits (Atkinson & Strachan, 1962). DHA–S has been reported to be effective in controlling storage decay in strawberries caused by *Rhizopus*, *Alternaria* and *Botrytis* species (Thompson, 1958; Watada, 1971). Waxing, apart from enhancing fruit appearance, minimises weight loss and extends storage life of fruits by inhibiting moisture loss from fruit surfaces, without adversely interfering with respiratory gas exchange (Mathur & Subramanyam, 1956; Paredes-Lopez *et al.*, 1974; Passam, 1982; Aworh *et al.*, 1991).

Film packaging retarded ripening and extended shelf life of wild mangoes presumably be creating a beneficial modified atmosphere, with reduced oxygen and/or elevated carbon dioxide tension, around the fruits. Such beneficial modified atmosphere packaging systems have been reported for a wide range of fruits and vegetables (Daun & Gilbert, 1974; Geeson *et al.*, 1985; Smith *et al.*, 1987; Aworh & Ubebe, 1988). By inhibiting respiratory and transpiratory water vapour losses, film packaging substantially reduced weight loss in wild mangoes during storage (Table 1). The higher incidence of decay in fruits packed in sealed polyethylene bags is presumably attributable to very high humidity around the fruits arising from the low permeability of polyethylene to water vapour (Bussel & Kenigsberger, 1975). Similar results have been reported for cultivated

mango, plantain and banana packed in sealed polyethylene bags (Olorunda, 1976; Shillingford, 1978; Passam, 1982; Aworh & Ubebe, 1988).

The trend in chemical changes observed in this study during ripening of wild mangoes is, in general, consistent with the findings of Aina (1990). However, whilst we observed a decline of ascorbic acid during ripening under tropical ambient conditions, Aina (1990) reported much lower values for ascorbic acid in green preclimacteric wild mangoes relative to ripe fruits. In an earlier study, a decrease in ascorbic acid was observed during ripening of cultivated mango, variety 'Ogbomoso', under tropical ambient conditions (Aworh & Ubebe, 1988). Similarly, Thomas (1975) reported that Alphonoso mangoes stored at tropical room temperature (29 ± 3°C) retained about 32% of the original ascorbic acid content when ripe while those held at low temperatures and subsequently ripened at room temperature retained 67–90%. The reduction in ascorbic acid at high temperatures is presumably due to oxidative destruction (Thomas & Oke, 1980). There were also differences in actual values recorded for soluble solids, pH and total acidity in this study in comparison with Aina's work (Aina, 1990). These differences might be due to variety, agronomic conditions, stage of maturity at harvest and storage conditions.

In conclusion, dipping wild mangoes in hot (55°C) water or chemicals (0·1% benomyl, 0·5% DHA–S or 0·5% $Na_2S_2O_5$) followed by waxing or packaging in boxes overwrapped with stretch PVC film, delayed ripening, controlled decay, minimised weight loss and extended the shelf life of the fruits under tropical ambient conditions, without adverse effects on visual and chemical qualities. The best results were obtained when PVC film packaging was preceded by a sulphite dip. It should be possible to integrate these treatments into the postharvest handling practices for wild mangoes and other indigenous fruits in Nigeria through the activities of the Directorate of Food, Roads and Rural Infrastructures (DFRRI) established by the Nigerian Federal Military Government in 1986 to promote integrated rural development.

Future studies will focus on the effects of the treatments on consumer acceptability of wild mangoes.

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