Effect of Waxing and of a Number of Waxes on Weight Loss, Shelf-life and Fruit Quality of Mangoes after Four Weeks of Cool-storage

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ABSTRACT

Tommy Atkins, Kent and Sensation mangoes were respectively washed (1 % Bi-Prox solution), rinsed, hydro-heated at 50°C for 5 minutes, dipped in prochloraz (180 ml Omega per 100 l H2O) for 20 seconds and waxed. The standard concentration of Shellac, Carnauba, Citrishine-green, Citrishine-orange, TAG or Self Cote (anti-transpirant) was evaluated as a skin coating. Evaluation took place after four weeks of cool-storage at 12.5°C. Waxing reduced weight loss and shrivel, and increased shelf-life. In Keitt, Shellac and TAG were most effective in extending shelf-life. Shellac depressed ground skin colouration in Sensation. Waxing generally increased ground skin colouration in Kent and Keitt. Disease was generally enhanced, and total soluble solids content generally depressed by wax treatment of the Sensation fruits, which were relatively immature at harvest. In Keitt, a reduction in TSS was apparent following treatment with TAG. In Sensation, taste was poor following treatment with Shellac, and in Kent, taste was poor following treatment with Shellac or Citrishine-green. When all of the quality parameters quantified were collectively considered, treatment with Citrishine-orange or TAG was generally associated with the highest percentages of good quality fruit present on ripening. The results did not clearly indicate a difference in effect between the non-polyethylene waxes used (Shellac and Carnauba).

INTRODUCTION

In Australia, packline treatment of mangoes does not include waxing. Mangoes grown in South Africa are waxed prior to their export by sea to Europe. The holding and transit period prior to the arrival of fruit in Europe varies from between 21 to 32 days. TAG or Citrishine green are generally used. The effect on fruit quality of waxing, and of a number of alternative waxes, including natural waxes, has not been properly assessed.

The aim of the present study was to determine the importance of waxing of mangoes destined for sea export from South Africa to Europe, and to evaluate the effect of a number of waxes on fruit quality after extended cool-storage.

MATERIALS AND METHODS

Three identical but separate experiments were performed. In each, a different cultivar was used.

Tommy Atkins, Kent and Sensation mangoes were harvested from trees in the region surrounding Tzaneen during the 1996/97 harvest season. All of the fruits showed signs of pulp colouration at harvest. The maturation stage, ascertained in terms of the degree of pulp colouration, was least advanced in Sensation.

After harvest, the fruits were respectively washed (1% Bi-Prox solution), rinsed, hydro-heated at 50°C for 5 minutes, dipped in prochloraz (180 ml Omega per 100 l H2O) for 20 seconds and waxed. Waxing was done by hand with a soft cloth. Treatment and placement in cool-storage occurred within 48 hours of harvest.

The waxes used were (standard concentration applied; one anti-transpirant included):
1. Carnauba or Natural Wax (non-polyethylene wax)
2. Shellac (non-polyethylene wax)
3. Citrishine-green (polyethylene wax)
4. Citrishine-orange (polyethylene wax)
5. TAG (polyethylene wax)
6. Self Cote (anti-transpirant)

Some fruits were not waxed (Treatment “0” - controls). All of the fruits were stored at 12.5°C (± 0.5°C) for 28 days in a commercial cold-room. After cool-storage, the fruits were placed in a well ventilated laboratory maintained at 20°C (± 1°C). On removal of the fruits from cool-storage, the following was carried out:

The degree of softening of each fruit was monitored daily with a densimeter (Heinrich Bareiss, Oberdischingen, Germany). Each fruit was evaluated for quality when it was firm-ripe (densimeter reading of less than 60 and greater than 40 from a non-diseased portion of the fruit). The time taken for the firm-ripe stage to be attained was taken to indicated shelf-life after cool-storage. Quality evaluation was performed as follows:

Skin colour in each fruit was rated. A rating of “0” was given when signs of skin colouration were absent, a rating of “1” if a transition to a lighter green was apparent, a rating of “2” if regions of the skin had become yellow but the total area which was yellow was less than the total area which was green, a rating of “3” if regions of the skin had become
yellow and the total area which was yellow exceeded the total area which was green, or a rating of "4" if the skin was completely yellow. The skin area covered with red-blush was not considered.

Disease manifestation (besides bacterial black spot) in each fruit was rated according its severeness. A rating of "0" was given if a fruit was disease free, a rating of "1" if symptoms were present but were localized to a small portion of the fruit’s surface, a rating of "2" if approximately 1/3 of the fruit’s surface showed symptoms, a rating of "3" if 2/3 of the fruit’s surface was affected, or a rating of "4" if the entire fruit’s surface was visibly diseased. The diseases occurring were also identified.

Blotch (green patchiness of skin), lenticel damage, or shrivel was rated by approximating the percentage of the skin surface over which symptoms could be seen. The percentages designated were either 0, 25, 50, 75 or 100. (Shrivel was only rated in Keitt).

To assess internal quality, each fruit was first cut through twice; 'longitudinally' along the flattened margins of the seed. In each fruit, juice from the 'cheeks' thus obtained was evaluated by measuring its pH (Mettler Toledo 120 pH meter) and total soluble solids content (Euromex RF 0232 hand-held refractometer), and by assessing its taste. Taste was rated. A rating of "1" was given if taste was deemed appealing, a rating of "0" if taste was deemed satisfactory but not appealing, or a rating of "-1" if taste was deemed unsatisfactory.

Physiological disorder manifestation in each fruit was rated as was disease manifestation, except that the degree to which the mesocarp as opposed to the exocarp (skin) was affected, was taken into account. The disorders occurring were also identified.

To assess fruit weight loss, each fruit was weighed immediately prior to cool-storage, immediately after cool-storage, and at the time of evaluation.

In each experiment, there were 15 single-fruit replicates of seven treatments. The treatments were allocated randomly to the fruits in accordance with the randomized complete blocks design. The fruits were placed in 4 kg cartons in the order in which the treatments were allocated. The fruits remained in their positions during and after cool-storage. The data were subjected to analysis of variance incorporating multiple range testing (LSD 5%).

RESULTS

Weight Loss during cool-storage

Fruit weight loss during cool-storage and at the time of ripening is shown in Figs. 1 and 2 respectively (the Kent fruits were generally firm-ripe on removal from cool-storage).

In each cultivar, weight loss was greatest in the unwaxed fruits. Of the treated fruits, weight loss was apparently greatest in the fruits treated with Self Cote. In considering the remaining treatments, differences between them were not consistent. In Keitt, weight loss was markedly reduced following treatment with Shellac.

Shrivel (Keitt)

Shrivel was greatest in the unwaxed fruits (Fig. 3). In the treated fruits, differences relating to treatment were not apparent.

Shelf-life

Shelf-life was shortest in the unwaxed fruits (Fig. 4). Differences between the remaining treatments were not consistent. In Keitt, Shellac and TAG were most effective in increasing shelf-life.

Ground skin colouration

Shellac depressed ground skin colouration in Sensation. Waxing generally enhanced ground skin colouration in Kent and Keitt, which are typically green mangoes.

Blotch

Blotch was not apparent in Keitt. In Sensation, the fruits treated with Shellac showed the lowest incidence of blotch (Fig. 6). This may have been due to the reduction in skin colouration observed in Sensation following Shellac treatment. In Kent, blotch was increased following treatment with Citrishine-green or SelF Cote.

Lenticel damage

In Sensation, lenticel damage was least evident following Shellac treatment (Fig. 7). This may have been due to the effect of this wax on ground skin colouration in this cultivar. Differences relating to treatment were not apparent in Kent or Keitt.

Disease severity

In Sensation, disease severity was generally increased by wax treatment (Fig. 8). Differences relating to treatment were not apparent in Kent or Keitt.

Total soluble solids content (TSS), pH and taste

A depression in TSS due to waxing was generally apparent in Sensation (Fig. 9). In Keitt, a reduction in TSS was apparent following treatment with TAG. Differences in TSS relating to treatment were not apparent in Kent. In general, differences in pH relating to treatment were not apparent (Fig. 10). In Sensation taste was poor following treatment with Shellac (Fig. 11). In Kent, taste was poor following treatment with Shellac and Citrishine-green. Differences in taste relating to treatment were not apparent in Keitt.

Physiological disorder severity

In Kent, physiological disorders were not found. In Sensation or Keitt, differences in physiological disorder severity relating to treatment were not apparent (Fig. 12).
Weight Loss during Cold-storage

Sensation Kent Keitt

- 0: No wax
- 1: Nat. wax
- 2: Shellac
- 3: Citri-G
- 4: Citri-O
- 5: TAG
- 6: Self Cote

Weight Loss at Ripening

Sensation Kent Keitt

- 0: No wax
- 1: Nat. wax
- 2: Shellac
- 3: Citri-G
- 4: Citri-O
- 5: TAG
- 6: Self Cote

Shrivel %

Keitt

- 0: No wax
- 1: Nat. wax
- 2: Shellac
- 3: Citri-G
- 4: Citri-O
- 5: TAG
- 6: Self Cote

Ground Skin Colouration

Sensation Kent Keitt

- 0: No wax
- 1: Nat. wax
- 2: Shellac
- 3: Citri-G
- 4: Citri-O
- 5: TAG
- 6: Self Cote

Blotching

Sensation Kent

- 0: No wax
- 1: Nat. wax
- 2: Shellac
- 3: Citri-G
- 4: Citri-O
- 5: TAG
- 6: Self Cote

Fig. 1 Average fruit weight-loss during cool-storage. Legend: "0" - unwaxed fruits; "1" - fruits coated with Carnuuba; "2" - fruits coated with Shellac; "3" - fruits coated with Citrishine-green; "4" - fruits coated with Citrishine-orange; "5" - fruits coated with TAG; "6" - fruits coated with Self Cote (an anti-transpirant). In each cultivar, bars headed by different letters differed significantly according to LSD (5%).

Fig. 2 Average fruit weight-loss at the time of ripening after cool-storage (the Kent fruits were generally firm-ripe when removed from cool-storage). Refer to Fig. 1 for legend.

Fig. 3 Average percentage of the skin surface which was shriveled on fruit ripening (shriveled was only quantified in Keitt). Refer to Fig. 1 for legnd.

Fig. 4 Average shelf-life after after four weeks of cool-storage. Refer to Fig. 1 for legend.

Fig. 5 Average degree of ground skin colouration on fruit ripening. Refer to Fig. 1 for legend.

Fig. 6 Average percentage of skin showing blotch on fruit ripening. Refer to Fig. 1 for legend.
Percent Lenticel Damage

Fig. 7 Average percentage of the skin showing damaged lenticels on fruit ripening. Refer to Fig. 1 for legend.

Disease Severity

Fig. 8 Average degree of decay on fruit ripening. Refer to Fig. 1 for legend.

Total Soluble Solids Content

Fig. 9 Average TSS on fruit ripening. Refer to Fig. 1 for legend.

pH

Fig. 10 Average pH on fruit ripening. Refer to Fig. 1 for legend.

Taste

Fig. 11 Average taste index on fruit ripening. Refer to Fig. 1 for legend.

Physiological Disorder Severity

Fig. 12 Physiological disorder severity (average index) on fruit ripening (physiological disorders were absent in the Kent fruits). Refer to Fig. 1 for legend.
Fruits of good quality were defined as those which showed no disease, blotch, scald, and physiological disorders, those which showed at least 25% ground skin colouration, those whose taste was satisfactory or appealing, and those which showed at least 25% ground skin colouration. Good quality fruits were defined as those which showed no disease, blotch, scald, and physiological disorders, those whose taste was satisfactory or appealing, and those which showed at least 25% ground skin colouration. The results did not clearly indicate a difference in effect between the non-polyethylene waxes used.

**DISCUSSION AND CONCLUSIONS**

The present study shows that waxing of mangoes exported by sea to Europe is important to limit weight loss (moisture loss and shrivelling), and to enhance shelf-life. In taking all of the quality parameters considered into account, the polyethylene waxes, TAG and Citrishine-orange, generally gave most favourable results. The natural waxes, Carinauba and Shellac, were effective in limiting weight loss and increasing shelf-life. However, their overall effect was generally inferior to that of TAG or Citrishine-orange.

Studies showing increases in shelf-life and reductions in weight loss in mango as a result of waxing are numerous. Brown (1986) found that application of Peerless citrus wax dipped to springy (pre-ripened) mangoes extended shelf-life from 11 days to 14 days. Fruit quality was not adversely affected by waxing. Patel and Goswami (1984) showed that the storage-life of mango fruits was extended by wax coating and cool-storage. Passam (1982) noted that treatment of mango fruits with Stafresh wax increased storage-life. Roy et al. (1980) found that wax treatment was highly effective in increasing storage-life. Weight loss was greatest in the unwaxed fruit (14-15%), it having been reduced to 4.2-7.3% by waxing. Sheikh et al. (1977) found that spoilage due to mold development and skin de-greening was higher in unwaxed than in waxed mangoes. Shelf-life of the waxed mangoes was increased by more than 50%. Musa and Mirghani (1974) observed that liquid paraffin wax increased chilling injury and resulted in fruit spotting. Such effects were absent in fruits treated with Stafresh wax. Garg and Ram (1973) found that waxing reduced weight loss. Ripening retardation as a result of waxing was made evident by slower increases in TSS and sugar content, greater retention of ascorbic acid, and a reduced respiratory rate. Doel and Bhullar (1972) noted that waxing markedly reduced weight loss in mango. Moreover, fruit loss due to disease and physiological disorders was reduced when wax containing fungicide was used. Jacobs et al. (1973) found that waxing of mango fruits immediately after hydro-heating prevented shrivelling and maintained fruit finish. Yuniarti and Subardi (1992) observed that wax treatment of harvested mangoes had a marked effect in retarding ripening (by 11 days), in delaying the onset of the over-ripe stage (by 9 days), and in reducing weight loss. Wax treatment also reduced soluble solids content (14.8% vs 18.8%). Castrillo and Bermudez (1992) noted that waxing reduced the rate of fresh weight loss of mangoes during ripening. Chlorophyll degradation in the exocarp and the increase in mesocarp pH normally occurring during ripening were retarded when relatively high wax concentrations were used. Waxing was not found to have an effect on mesocarp colouration, or sugar or starch content. Ilanganikelle and Salokhe (1989) observed that fruit quality after cool-storage was best in fruits which respectively were hydro-cooled to 15°C, dipped in wax and stored at 13°C at 60 or 100 mm of mercury. Shivarama et al. (1989) found that coating of mango fruits with wax reduced weight loss and, in the presence of fungicide (thiabendazole, benomyl or carbendazim), reduced the amount of spoilage. Ilanganikelle et al. (1989) found that fruits treated with wax retained skin chlorophyll for up to 20 days. High wax concentrations injured the skin. Mangoes precooled to 15°C and treated with wax at a low concentration could be kept for up to 30 days in cool-storage without there being a loss in quality after post-storage ripening.

In the present study, Shellac reduced ground skin colouration in Sensation. Moreover, waxing generally reduced total soluble solids content in this cultivar. In Kent, blotch was increased following treatment with Citrishine-green or Self Cote. TAG reduced total soluble solids content in Keitt. It would appear, in considering the results of the present study and those of the other researchers, that the effect of waxing on fruit quality, whether it be beneficial or detrimental, is determined by the type of wax used, the concentration of the wax emulsion applied, the mango cultivar treated and, possibly, the stage of harvest maturation. It might be considered that lower concentrations of the natural waxes, Shellac or Carinauba, be evaluated in future studies in view of increasing consumer resistance to polyethylene waxes.

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**LITERATURE CITED**


