Effect of Packline Hydro-heating Treatments on Heidi Fruit Quality after four weeks of Cold-storage

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ABSTRACT

Hydro-heating treatments, aimed at reducing the sensitivity to chilling injury of the skin of hard-mature Heidi mangoes, were applied to fruit on the day of harvest. Prior to treatment, the fruit were washed in water containing 1% Teepol and were rinsed. After treatment, the fruit were respectively dipped in Omega (180 ml/ 100 H_2O) for 20 seconds, waxed with TAG, stored at 11°C for 28 days, and ripened at 20°C. The following treatments were applied: hydro-heating at 50°C for 5 or 7 minutes; hydro-heating at 55°C for 5 or 7 minutes. In each instance, non-scald diphenylamine (DPA) was added to or excluded from the hydro-heating bath.

Severe heat scald and peripheral browning occurred following treatment at 55°C. DPA had little or no apparent effect here in reducing heat scald or surface scald (cold temperature skin injury). The incidence of surface scald or lenticel damage was reduced (in relation to the untreated fruit) by hydro-heating at 50°C for 5 or 7 minutes when DPA was excluded. The incidence of peripheral browning [browning of mesocarp (pulp) tissue adjacent to the skin] increased with the increase in time or temperature treatment. Internal browning increased with the increase in water temperature, and was enhanced by DPA. The incidence of internal breakdown (jelly seed or soft nose) was low, and was apparently unaffected by the treatments. The fruit treated for 5 or 7 minutes at 50°C were of the best taste. After treatment for 5 minutes, skin colouration increased with the increase in bath temperature, whereas skin colouration decreased with the increase in bath temperature following treatment for 7 minutes. DPA enhanced skin colouration when added to the water at 55°C, but reduced skin colouration when added to the water at 50°C.

The percentage of good quality fruit present on ripening was greatest following treatment for 5 or 7 minutes at 50°C. It is recommended that hydro-heating at 50°C for 5 minutes be adopted commercially. Furthermore, an air temperature of 11°C should be maintained throughout the transit period. It is considered very important that Heidi fruit never be exposed to temperatures of less that 11°C during or after their shipment to markets abroad.

INTRODUCTION

Heidi fruit develop surface scald (Fig. 1) during prolonged refrigerated storage (21 to 28 days) at air temperatures ranging from 11 to 13°C. Delivery air temperatures exceeding 11°C may permit softening to occur to a unacceptable degree during extended cold-storage. It was previously found that hydro-heating (50°C for 5 minutes), applied as a pre-storage treatment, reduced the incidence of surface scald to an acceptable level in Heidi following refrigerated storage at 11°C (Oosthuyse *et al.*,1995). Hydro-heating in this way has however been associated with an increase in the incidence of internal browning following extended cold-storage (Leclercq, pers. comm., Westfalia, Duivelskloof).

Diphenylamine (DPA), applied prior to cold-storage, has been found to reduce the incidence of superficial scald in Granny Smith apple (Lotz *et al.*, 1993).

In view of the benefit of hydro-heating found previously, the aim of the present study was to assess the effect of various pre-storage hydro-heating treatments on Heidi fruit quality after four weeks of cold-storage at 11°C. The effect on quality of DPA (added to the heated water) was also assessed.

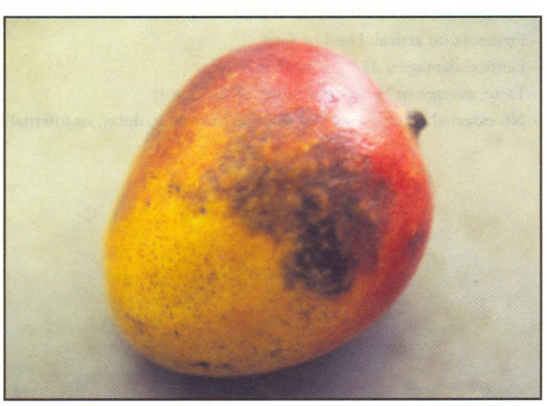

Fig. 1 *Surface scald in Heidi, which is caused by low temperature storage.*

MATERIALS AND METHODS

Ninety 4 kg cartons of Heidi mangoes (counts 8 to 10) were harvested on Feb. 9 1996 from trees on the farm Goedgelegen (Hans Merensky Holdings) at Mooketsi. Eighteen randomly selected fruit were cut to determine the stage of fruit maturation at harvest (as assessed by the extent of mesocarp colouration). The cartons were then transported to Merensky Technological Services (within 2 hours of picking), whereupon they were placed in a well ventilated laboratory held at 20°C (±1°C), and were labelled in accordance with the experiment design. The following treatments were applied following labelling, washing in a 1% Teepol/water solution, and rinsing in clean water:

1. Control - no hydro-heating
2. Hydro-heating at 50°C for 5 minutes
3. Hydro-heating at 50°C for 7 minutes
4. Hydro-heating at 55°oC for 5 minutes
5. Hydro-heating at 55°C for 7 minutes
6. Hydro-heating at 50°C for 5 minutes + DPA
7. Hydro-heating at 50°C for 7 minutes + DPA
8. Hydro-heating at 55°C for 5 minutes + DPA
9. Hydro-heating at 55°C for 7 minutes + DPA

DPA was used at a concentration of 1.6 ml/l H_2O.

Following treatment, the cartons of fruit were respectively dipped for 20 seconds in water containing prochloraz (Omega, 180 ml/100l H_2O), waxed with TAG, and placed in cold-storage at 11°C (± 0.5°C) (air temperature around the fruit) in a well ventilated cold-room for 28 days. The fruits were placed in cold-storage within 24 hours of them being harvested. After cold-storage, they were allowed to ripen fully in a well ventilated ripening room held at 20°C (±1°C).

During ripening, the degree of softening of each fruit was assessed daily using a densimeter (Heinrich Bareiss, Oberdischingen, Germany). The fruit were evaluated once they were 'firm ripe' (densimeter reading of less than 60 and greater than 40).

Each fruit was evaluated as follows:

Skin colour 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 that was yellow was less than the total area that was green, a rating of 3 if regions of the skin had become yellow and the total area that was yellow exceeded the total area that was green, or a rating of 4 if the skin was completely yellow. The skin area covered with red-blush was not considered.

Disease was rated according to severeness. A rating of 0 was given if the fruit was disease free, a rating of 1 if symptoms were present, but they were localized to a small portion of the fruit surface, a rating of 2 if approximately 1/3 of the fruit surface showed symptoms, a rating of 3 if 2/3 of the fruit surface was affected, or a rating of 4 if the entire fruit surface showed disease symptoms. The diseases occurring were also identified.

Lenticel damage, surface scald or heat scald were rated by approximating the percentage of the skin surface over which injury could be seen. The rating given was either 0, 25, 50, 75 or 100%.

To assess internal quality, the fruit was first cut through twice, i.e., 'longitudinally' along the flattened margins of the seed. Juice from each of the 'cheeks' thus obtained was assessed for its pH (Mettler 320 pH meter), total soluble solids content (N1, Atago hand-held refractometer), and taste.

Taste was rated. A rating of 1 was given if taste was appealing, a rating of 0 if taste was satisfactory but not appealing, or a rating of -1 if taste was unsatisfactory due to the presence of off-flavours.

Mesocarp colour, i.e., the degree of colour intensification of the mesocarp from white to the yellow/orange colour normally seen in a fully ripe Heidi mango, was estimated with the 'Zill' colour chart.

Physiological disorders were rated as was disease, except that the degree to which the mesocarp was affected was taken into consideration. The disorders occurring were also identified.

There were 10 carton-replicates of 9 treatments. Cartons were consecutively numbered and the treatments allocated to the cartons in accordance with the randomized complete blocks design. The numbering order of the cartons was maintained on placement of the fruit in cold-storage and on placement of the fruit in the ripening room. The data (carton percentages or averages) were subjected to analysis of variance. Data transformation was performed when deemed necessary.

RESULTS

Harvest maturity

Signs of mesocarp yellowing were apparent at the time of harvest.

Disease

Disease symptoms were absent.

Surface scald and heat scald (Fig. 2)

The effects of the various hydro-heating treatments on the incidence of surface scald or heat scald are shown in Fig. 2. Hydro-heating for 5 or 7 minutes at 50°C in the absence of DPA significantly reduced the percentage of fruit showing signs of surface scald. The percentage was least following treatment for 5 minutes. Here, 20.5 % of the fruit showed signs of

surface scald, whereas 44% of the 'control' fruit showed signs of surface scald. There was no apparent benefit of the addition of DPA to the water heated to 50°C.

Hydro-heating at 55°C generally gave rise to heat scald (Fig. 3). The greatest percentage of fruit showed symptoms following treatment for 7 minutes in the absence of DPA (99 %) (Fig. 2). Moreover, a positive relationship appeared to exist between heat scald incidence and treatment duration.

Ground skin colouration (Fig. 4)

All the fruit, except those heated in water at 55°C for 7 minutes in the absence of DPA, showed good ground skin colouration on ripening. Hydro-heating at 55°C for 5 minutes significantly increased ground skin colouration. However, this increase was marginal. The reduction in skin colouration found following hydro-heating at 55°C for 7 minutes in the absence of DPA was probably due skin injury caused by this treatment.

Lenticel damage (Fig. 5)

The effect of the various treatments on the occurrence of lenticel damage is shown in Fig. 5. Hydro-heating at 50°C for 5 minutes in the absence of DPA reduced the incidence of lenticel damage. Hydro-heating at 55°C generally increased the incidence of this disorder. The inclusion of DPA apparently increased the occurrence of lenticel damage.

Peripheral browning (Fig. 6)

The percentages of fruit showing peripheral browning, i.e., browning of mesocarp tissue beneath the skin, are shown in Fig. 6. A positive relationship appeared to exist between the percentage of fruit showing symptoms, and the temperature of hydro-heating or the duration of hydro-heating. 32% of the control fruit showed symptoms. The incidence was greater in the remaining treatments, of which hydro-heating at 50°C for 5 minutes resulted in the lowest incidence (37 to 43%).

Internal browning (Fig. 7)

The percentages of fruit showing internal browning, i.e., browning of mesocarp tissue in the vicinity of the seed, are shown in Fig. 7. 22% of the untreated fruit showed symptoms. Hydro-heating at 55°C in the presence of DPA apparently increased the incidence of internal browning. The remaining treatments seemingly had no effect on the occurrence of internal browning.

Internal breakdown (Fig. 8)

The percentages of fruit showing internal breakdown, i.e., 'soft nose' or 'jelly seed', are shown in Fig. 8. 10% or less of the fruit showed symptoms, and there was no apparent effect relating to treatment.

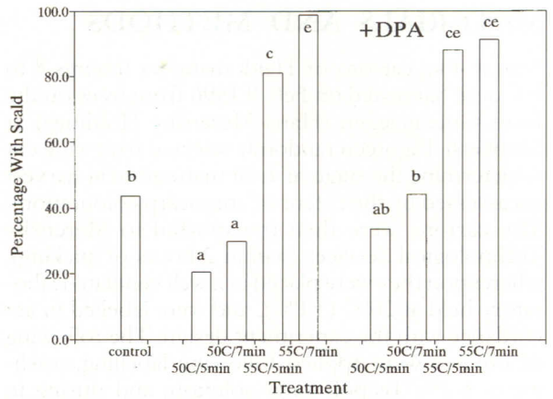

Fig. 2 *Percentages of fruit with surface or heat scald. Bars associated with differing letters differ significantly according to LSD (5%).*

Fig. 3 *Heat scald in Heidi, which is caused by high temperature exposure.*

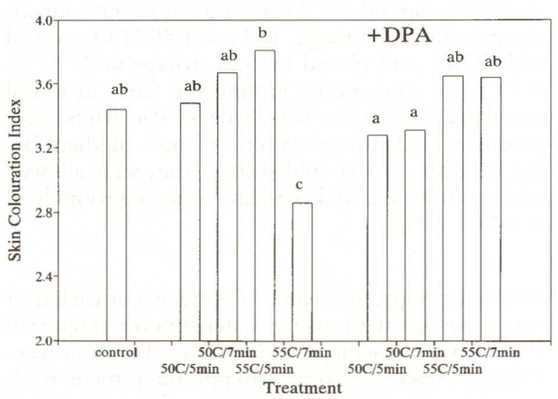

Fig. 4 *Degree of ground skin colouration on ripening. Bars associated with differing letters differ significantly according to LSD (5%).*

Mesocarp colouration (Fig. 9)

Mesocarp colouration was depressed by hydro-heating at 55°C for 7 minutes in the absence of DPA (Fig. 9). This was probably due to injury of the mesocarp. The remaining heating treatments had no apparent effect on mesocarp colouration.

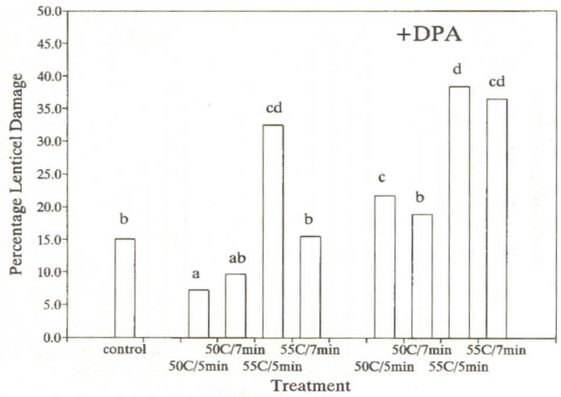

Fig. 5 *Degree of lenticel damage on ripening. Bars associated with differing letters differ significantly according to LSD (5%).*

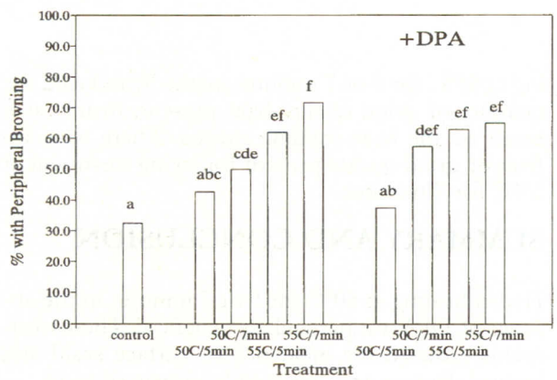

Fig. 6 *Percentages of fruit showing signs of peripheral browning. Bars associated with differing letters differ significantly according to LSD (5%).*

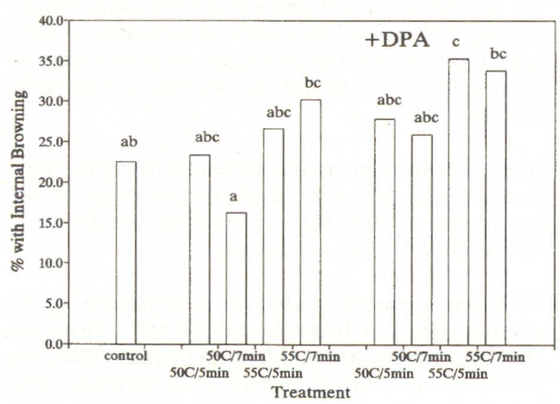

Fig. 7 *Percentages of fruit showing signs of internal browning. Bars associated with differing letters differ significantly according to LSD (5%).*

Total soluble solids content (TSS) (Fig. 10)

TSS on ripening was reduced following hydro-heating at 55°C for 7 minutes in the absence of DPA (Fig. 10). Again, this was probably due to injury of the mesocarp. The remaining heating treatments had no apparent effect on TSS.

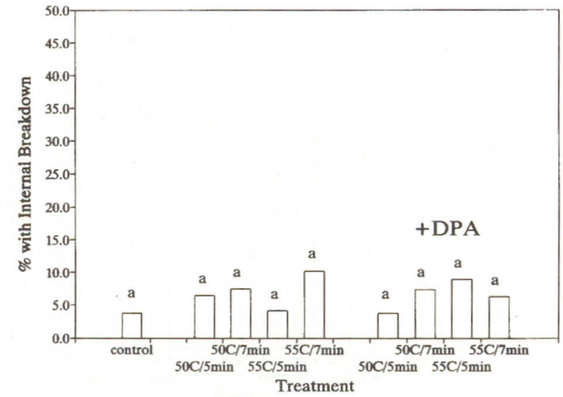

Fig. 8 *Percentages of fruit showing signs of internal breakdown (jelly seed or soft nose). Bars associated with differing letters differ significantly according to LSD (5%).*

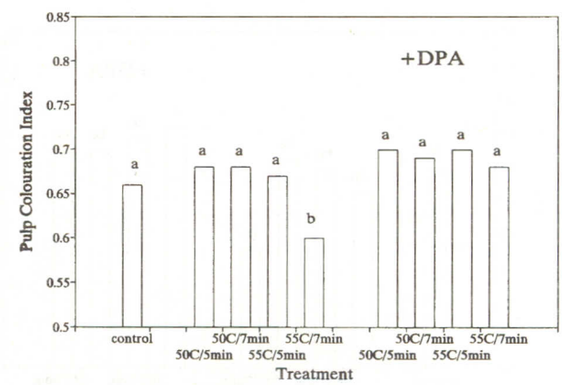

Fig. 9 *Degree of mesocarp (pulp) colouration on ripening [range from 0 (white) to 1 (fully yellow)]. Bars associated with differing letters differ significantly according to LSD (5%).*

pH (Fig. 11)

pH on ripening was reduced by hydro-heating at 55°C for 7 minutes in the absence of DPA (Fig. 11). Again, this was probably due to injury of the mesocarp. The remaining heating treatments had no apparent effect on pH.

Taste Fig. 12)

Taste was enhanced by hydro-heating at 50°C for 7 minutes in the absence of DPA (Fig. 12). The remaining treatments did not have a significant effect on taste.

Good quality fruit (Fig. 13)

Fruits of good quality were defined as those that satisfied the following:

a. Absence of surface or heat scald
b. Absence of physiological disorders
c. 25% or less of the skin surface showing damaged lenticels
d. Taste rating of 0 or 1 (satisfactory or appealing taste)
e. Ground colour exceeding 2 (at least some yellowing apparent)

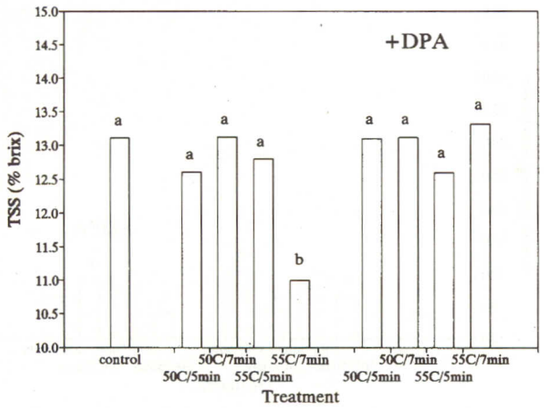

Fig. 10 *Total soluble solids content on ripening. Bars associated with differing letters differ significantly according to LSD (5%).*

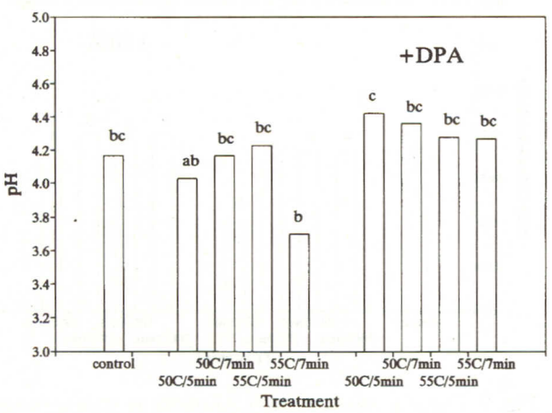

Fig. 11 *pH on ripening. Bars associated with differing letters differ significantly according to LSD (5%).*

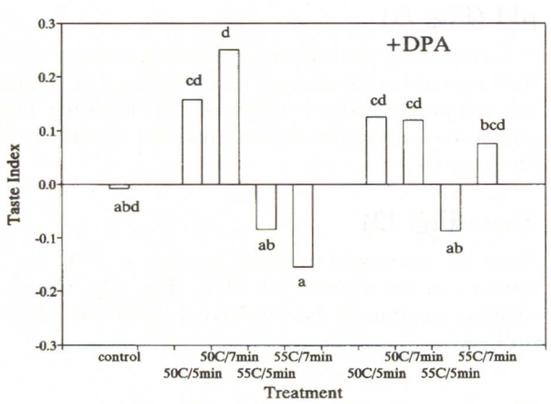

Fig. 12 *Taste on ripening [range from -1 (unacceptable) to 1 (appealing)]. Bars associated with differing letters differ significantly according to LSD (5%).*

The percentages of 'good quality fruit' are shown in Fig. 13. The percentage of good quality fruit was greatest following hydro-heating at 50°C for 5 or 7 minutes in the absence of DPA (30 to 35%). 23% of the 'control' fruit were of good quality. Hydro-heating at 55°C for 5 or 7 minutes markedly reduced the quantity of good quality fruit present, mainly as a result of the heat scalding caused. There were no fruit of good quality present following treatment at 55°C for 7 minutes.

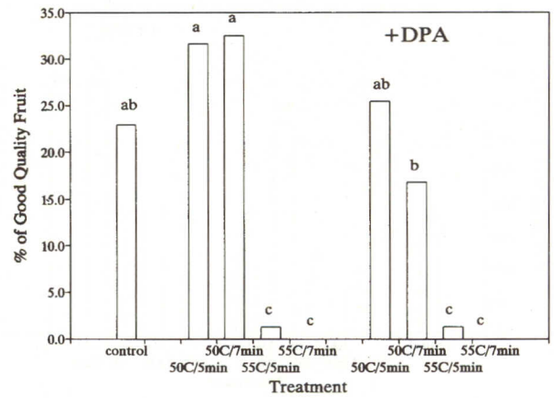

Fig. 13 *Percentages of fruit of good quality. Bars associated with differing letters differ significantly according to LSD (5%).*

SUMMARY AND CONCLUSION

Hydro-heating at 50°C for 5 or 7 minutes in the absence of DPA was particularly beneficial. These treatments reduced the incidence of surface scald and lenticel damage and, apparently, enhanced taste.

Hydro-heating at 55°C for 5 or 7 minutes was particularly detrimental. These treatments generally gave rise to heat scald and peripheral browning. Hydro-heating at 55°C for 7 minutes in the absence of DPA appeared to injure the mesocarp, as is indicated by the negative effect found on mesocarp colouration, TSS, and pH.

Hydro-heating increased peripheral browning. However, a significant or marked positive effect of hydro-heating at 50°C for 5 minutes on the incidence of this disorder was not found.

DPA was apparently effective in ameliorating the adverse effects of hydro-heating at 55°C. However, DPA appeared to increase lenticel damage. DPA was ineffective in reducing surface scald resulting from low temperature storage.

In view of the foregoing results, it might be recommended that Heidi fruit be dipped in water at 50°C for 5 minutes prior to extended cold-storage. The incidence and severity of surface scald on ripening was deemed to be acceptably low following this treatment. In considering the export of Heidi fruit to Europe by sea, it is noteworthy that fruit exposure to air temperatures of lower than 11°C at any stage of transit storage or post-arrival storage may enhance the incidence of surface scald. Moreover, cold-storage durations of greater than 28 days may be detrimental.

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