

# Effect of Long-term Controlled Atmosphere Storage on Fruit Quality in Heidi Mango

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## ABSTRACT

Heidi mangoes were harvested at the conventional stage of maturation, and later when at an advanced stage of maturation. Following the commercial packline treatment, the fruit were either placed under controlled atmosphere storage and refrigeration, or under normal refrigeration. 12.5°C was adopted as the storage temperature. After 21 days, the mangoes were allowed to ripen at 20°C under normal atmosphere. In each fruit, quality was assessed on ripening.

The mangoes harvested at an advanced stage of maturation did not appear to benefit from atmosphere storage. Pulp browning in these fruit was elevated. In the fruit harvested at the conventional stage of maturation, atmosphere storage reduced surface scald, pulp browning and internal breakdown, and enhanced shelf-life and taste. In view of these results, the semi-commercial adoption of controlled atmosphere storage in Heidi mango is recommended for the coming season.

## INTRODUCTION

Heidi mangoes develop skin and pulp injury when placed in cool-storage for prolonged periods. The pulp becomes brown and the skin develops darkened indentations which are referred to as surface scald (Fig. 1). Scald severity was previously found to negatively correlate with storage temperature (do, unpublished). Skin and pulp discoloration have been ascribed to chilling injury in mango (Medlicott *et al.*, 1986; Medlicott and Jager, 1987; Chaplin, 1987; Lizada, 1991). It has been found that sensitivity to chilling injury in mango decreases with stage of maturation at harvest (Thompson 1971; Medlicott *et al.*, 1990a; Medlicott *et al.*, 1990b).

Packline hot-water treatment (50°C for 5 minutes) was previously shown to reduce, but not to prevent, scald development during cool-storage (Oosthuysen, 1996).

Controlled atmosphere storage of mangoes has been found to be beneficial. A delay in ripening has been shown by a number of researchers (Feng *et al.*, 1991; Yahia and Vazquez-Moreno, 1993; Gonzalez-Aguilar *et al.*, 1995; Noomhorm and Tiasuwan, 1995, 1988). It has been shown to reduce chilling injury (O'Hare and Prasad, 1993) and postharvest disease manifestation (Feng *et al.*, 1991) in mango. "Extreme" atmosphere exposure for a short period may be effective as an insect disinfestation treatment for mango fruits (Yahia and Tiznado-Hernandez, 1993; Yahia and Vazquez-Moreno, 1993; Yahia *et al.*, 1995).

The main aim of the present study was to determine the effect of controlled atmosphere storage (CA) on surface scald and internal and peripheral browning in Heidi mango. The effect of atmosphere storage on shelf-life and various other quality attributes of relevance was also determined, and differences in relation to stage of maturation at harvest were considered.

## MATERIALS AND METHODS

Two similar experiments were performed (referred to as Expt. I and Expt. II). Fruit were harvested from an orchard block at Hamawasha (close to Tzaneen) on March 5 (Expt. I) and on March 19, 1997 (Expt. II).

### Experiment I

Sixty fruit were harvested, given the commercially adopted packline treatment [fruit respectively washed in a 1% soap solution (By-Prox), dipped in hot-water at 50°C for 5 minutes, dipped in prochloraz (180 ml Omega/100l H<sub>2</sub>O) for 20 seconds, and hand waxed with TAG], and placed in cool-storage at 12.5°C for three days [storage under normal atmosphere for three days prior to storage under atmosphere was done to effect commercial representation, i.e., pre-storage at a packhouse, followed by refrigerated trucking to Cape Town harbour, followed by cool-storage until ship loading when controlled atmosphere storage would commence]. After this period of cool-storage, 20 randomly selected fruits were placed in air containing CO<sub>2</sub> at a low concentration (Atmos. 1), and 20 randomly selected fruits were placed in air containing CO<sub>2</sub> at a high concentration (Atmos. 2). The remaining fruits were stored in normal air (controls). All of the fruits were placed in cool-storage [in a cool-storage room, the fruit under atmosphere being in especially designed Transfresh bins] for a further 18 days, after which they were placed, under normal atmosphere, in a well ventilated laboratory maintained at 20°C (±1°C) to continue ripening. During the latter period, the stage of ripening of each fruit was assessed daily with a densimeter (Heinrich Bareiss, Oberdischingen, Germany). Each fruit was evaluated when it was firm-ripe (densimeter reading of less than 60 and greater than 40). The date on which each fruit was evaluated was recorded to assess shelf-life.

A completely randomized design, (comprising 20 single fruit replicates of three treatments), was employed.

## Experiment II

Expt. II was identical to Expt. I, except that 108 fruit were harvested, and the atmosphere high in CO<sub>2</sub> differed with respect to CO<sub>2</sub> concentration (new atmosphere referred to as Atmos. 3). There were 36 single fruit replicates of three treatments.

### Fruit quality evaluation

Fruit evaluation on ripening comprised the following:

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 in each fruit was rated according to 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.

Lenticel damage, blotch (green patchiness of skin) and surface scald were 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.

To assess internal quality in each fruit, each 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.

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 Heidi "black" colour chart.

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.

Analysis of variance incorporating multiple range testing (5% LSD) was employed, when the data was suitable

for such an analysis. Data transformation was performed when deemed necessary.

## RESULTS

### Stages of maturation at harvest

The pulp of the fruit in Expt. I was a light yellow at harvest [index 0.1 ( $\pm$  0.2)], and the pulp of the fruit in Expt. II was a more intense yellow at harvest [index 0.3 ( $\pm$  0.2)]. An index value of 0.1 to 0.2 indicates the recommended stage of maturation at which to harvest Heidi mangoes.

### Surface scald

Atmos. 1 reduced surface scald in Expt. I, and Atmos. 3 reduced surface scald in Expt II (Fig. 2). The fruit in Expt. II appeared to be less prone to this disorder.

### Shelf-life

Atmos. 2 in Expt. I increased shelf-life by approximately two days (Fig. 3). Differences in shelf-life relating to treatment were not apparent in Expt. II.

### Taste

Atmos. 1 in Expt. I markedly enhanced taste (Fig. 4). This difference could not be explained in terms of differences in total soluble solids content nor in terms of differences in pH (data not shown). Differences in taste relating to treatment were not apparent in Expt. II.

### Internal breakdown (jelly-seed or soft-nose)

Atmos. 1 in Expt. I reduced the severity of internal breakdown (Fig. 5). Differences relating to treatment were not apparent in Expt. II.

### Peripheral browning

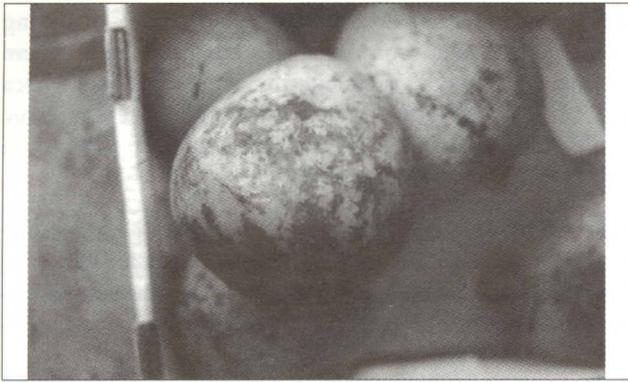
Atmos. 1 in Expt. I reduced the severity of peripheral browning (browning of the pulp just beneath the skin) (Fig. 6). The severity of peripheral browning appeared to be slightly elevated in Expt. II. Differences relating to treatment were not apparent in Expt. II.

### Pulp colour

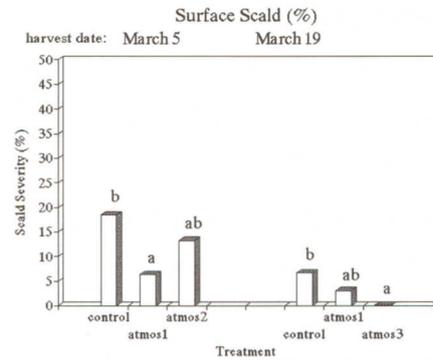
Atmos. I in Expt. I increased pulp colour slightly (Fig. 7). Differences in pulp colour relating to treatment were not apparent in Expt. II.

### Blotch

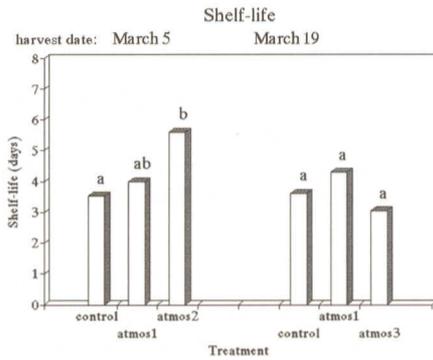
The incidence of blotch was low. Blotch appeared to be slightly more prevalent in Expt. II. Atmos. 3 in Expt. II slightly increased the severity of blotch. Differences in blotch severity relating to treatment were not apparent in Expt. I.



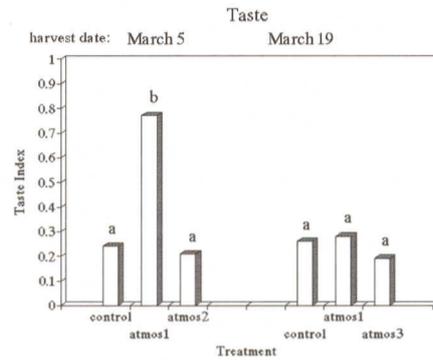
**Fig. 1** Surface scald on a Heidi mango.



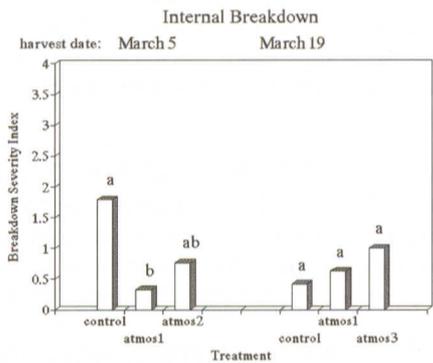
**Fig. 2** Severity of surface scald on ripening (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).



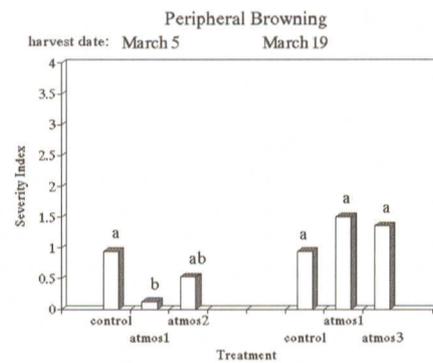
**Fig. 3** Shelf-life after cool-storage at 12.5°C. (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).



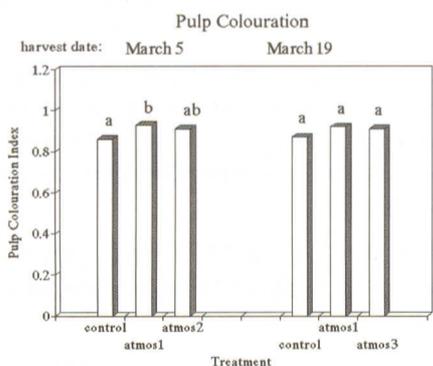
**Fig. 4** Taste on ripening. (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).



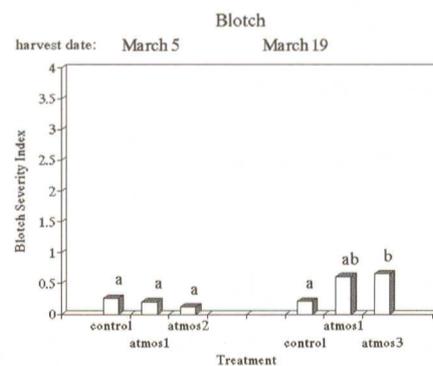
**Fig. 5** Severity of internal breakdown on ripening ("soft-nose" and jelly-seed") (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).



**Fig. 6** Severity of peripheral browning (browning of the pulp just beneath the skin) on ripening ("soft-nose" and jelly-seed") (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).



**Fig. 7** Pulp colour on ripening (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).



**Fig. 8** Blotch severity on ripening (left: Expt. I; right: Expt. II). In each experiment, bars headed by differing letters differ significantly according to LSD (5%).

### Other quality parameters

Differences relating to treatment and experiment (maturation) in lenticel damage, ground skin colouration, total soluble solids content, pH, and internal browning were not apparent (data not shown).

### DISCUSSION AND CONCLUSION

Controlled atmosphere storage did not show any clear benefit in the fruit harvested at an advanced stage of maturation (Expt. II). These fruit generally showed a greater degree of pulp browning than the fruit harvested earlier (those in Expt. I).

In the fruit harvested at the conventional stage of maturation (those in Expt. I), atmosphere storage reduced surface scald, pulp browning and internal breakdown, and enhanced shelf-life (reduced ripening rate) and taste. O'Hare, and Prasad (1993) specifically associated the alleviation of chilling injury symptoms to enhanced CO<sub>2</sub> atmospheres. In their study, reduced O<sub>2</sub> concentrations had no significant effect on chilling injury. Reports on reductions in ripening rate during controlled atmosphere storage are numerous. However, specific atmospheres are required for normal ripening of mangoes during and after controlled atmosphere storage. Unsuitable atmospheres may give rise to anaerobic respiration (O'Hare and Prasad, 1993; Bender *et al.*, 1994), and to an elevated acid content on ripening (McLauchlan *et al.*, 1994). An enhancement in taste following atmosphere storage has also been found in fig (Turk *et al.*, 1994), apple (Jankovic and Drobnjak, 1992), kiwifruit (Sawada *et al.*, 1993) and plum (Ben and Gaweda, 1992). Storage of various fruit types in specific atmospheres is likely favour biochemical processes which enhance taste appeal. A reduction in internal breakdown following atmosphere storage was also found in plum (Ben and Gaweda, 1992; Truter and Combrink, 1992; Argenta *et al.*, 1994); and nectarine (Lurie, 1992; Lurie *et al.*, 1992). Controlled atmosphere storage has been found to retard cell membrane degradation (Wang and Herner, 1989; Deschene *et al.*, 1991). The reduction in internal breakdown found might thus be ascribed to the maintenance of membrane integrity by controlled atmosphere.

In view of the beneficial results obtained in the present study, semi-commercial sea export of Heidi mangoes under atmosphere might be considered. Further experiments, to show the effects of controlled atmosphere storage on mangoes grown in South Africa for export, are to be performed during the coming season.

### ACKNOWLEDGEMENT

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### LITERATURE CITED

ARGENTA, L.C., BRACKMANN, A., AND MONDARDO, M. 1994. Postharvest quality of apples stored at different temperatures and CO<sub>2</sub> and O<sub>2</sub> concentrations. *Revista Brasileira de Fisiologia Vegetal* 6:121-126.

BEN, J. AND GAWEDA, M. 1992. The effect of increasing concentration of carbon dioxide in controlled atmosphere storage of plums cv. Wegierka Zwycła (*Prunus domestica* L.). II. Changes in the content of soluble sugars, organic acids and total phenols in the aspect of fruit taste. *Acta Physiologiae Plantarum* 14:151-158.

BEN, J. AND GAWEDA, M. 1992. Effect of increasing concentrations of CO<sub>2</sub> in controlled atmosphere storage on the development of physiological disorders and fungal diseases on plums (*Prunus domestica* L.). *Folia Hort.* 4:87-100.

CHAPLIN, G.R. 1987. Ripening in mango fruit and its manipulation by low temperature. In R.T. Prinsley and G. Tucker, eds. *Mangoes - a review*. Commonwealth Science Council, London.

DESCHENE, A., PALIYATH, G., LOUGHEED, E.C., DUMBROFF, E.B., AND THOMPSON, J.E. 1991. Membrane deterioration during postharvest senescence of broccoli florets: modulation by temperature and controlled atmosphere storage. *Postharvest Biology and Technology* 1:19-31.

FENG S.Q., CHEN Y.X., WU H.Z., AND ZHOU S.T. 1991. The methods for delaying ripening and controlling postharvest diseases of mango. *Acta Agriculturae Universitatis Pekinensis* 17:61-65.

GONZALEZ-AGUILAR, G., VASQUEZ, C., FELIX, L., BAEZ, R., SILLER, J., AIT-OUBAHOU, A., AND EL-OTMANI, M. 1995. Low O<sub>2</sub> treatment before storage in normal or modified atmosphere packaging of mango. Proceedings of an international symposium held at Agadir, Morocco, 16-21 January 1994.

JANKOVIC, M. AND DROBNJAK, S. 1992. The influence of the composition of cold room atmosphere on the changes of apple quality. Part 1. Changes in chemical composition and organoleptic properties. Review of Research Work at the Faculty of Agriculture, Belgrade 37:135-138.

LURIE, S. 1992. Controlled atmosphere storage to decrease physiological disorders in nectarines. *International Journal of Food Science and Technology* 27:507-514.

LURIE, S., ZEIDMAN M., ZUTHI, Y, AND BEN ARIE, R. 1992. Controlled atmosphere storage to decrease physiological disorders in peaches and nectarines. *Hassadeh* 72:1118-1122.

MEDLICOTT, A.P. AND JAGER, M.J. 1987. The development and application of post-harvest treatments to manipulate ripening in mangoes. In R.T. Prinsley and G. Tucker, eds. *Mangoes - a review*. Commonwealth Science Council, London.

MEDLICOTT, A.P., SIGRIST, J.M.M., AND SY, O. 1990a. Ripening of mangoes following low temperature storage. *J. Amer. Soc. Hort. Sci.* 115:430-434.

MEDLICOTT, A.P., N'DIAYE, M., AND SIGRIST, J.M.M. 1990b. Harvest maturity and concentration and exposure time to acetylene influence initiation of ripening in mangos. *J. Amer. Soc. Hort. Sci.* 115:426-430.

- NOOMHORM, A., AND TIASUWAN, N. 1988. Effect of controlled atmosphere storage for mango. *American Society of Agricultural Engineers*, No. 88-6589, p. 8.
- NOOMHORM, A., AND TIASUWAN, N. 1995. Controlled atmosphere storage of mango fruit, *Mangifera indica* L. cv. Rad. *Journal of Food Processing and Preservation* 19:271-281.
- O'HARE, T.J., AND PRASAD, A. 1993. The effect of temperature and carbon dioxide on chilling symptoms in mango. *Acta-Hort.* 343:244-250.
- OOSTHUYSE, S.A. 1996. Effect of packline hydro-heating treatments on Heidi fruit quality after four weeks of cold-storage. *S.A. Mango Growers' Assoc. Yearbook* 16:6-11.
- SAWADA, T., SEO, Y., AND MORISHIMA, H. 1993. Studies on storage and ripening of kiwifruit. Part 3. *Journal of the Japanese Society of Agricultural Machinery* 55:59-68.
- THOMPSON, A.K. 1971. The storage of mango fruits. *Trop. Agric.* 48:63-70.
- TRUTER, A.B. AND COMBRINK, J.C. 1992. Controlled atmosphere storage of peaches, nectarines and plums. *Journal of the Southern African Society for Horticultural Sciences* 2:10-13.
- TURK, R., ERIS, A., OZER M.H., TUNCELLI, E., AND SASS, P. 1994. Research on the CA storage of fig cv. Bursa Siyahi. *Acta Hort.* 368:830-839.
- WANG, H. AND HERNER, R.C. 1989. Effect of CA storage on the ultrastructure of chloroplasts and chlorophyll content of Chinese mustard. Proceedings of the Fifth International Controlled Atmosphere Research Conference, Wenatchee, Washington, USA, 14-16 June, 2:9-17.
- YAHIA, E.M., AND TIZNADO-HERNANDEZ, M. 1993. Tolerance and responses of harvested mango to insecticidal low-oxygen atmospheres. *HortScience* 28:1031-1033.
- YAHIA, E.M., AND VAZQUEZ-MORENO, L. 1993. Responses of mango to insecticidal oxygen and carbon dioxide atmospheres. *Lebensmittel Wissenschaft und Technologie* 26:42-48.
- YAHIA, E.M., KUSHWAHA, L., SERWATOWSKI, R., AND BROOK, R. 1995. Insecticidal atmospheres for tropical fruits. Proceedings of the International Conference, Guanajuato, Mexico, 20-24 February, 1995.

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