MARDI Res. J. 16(1) (1988): 85–90

Short communication

Eating quality of ethylene-ripened Harumanis mangoes after cold storage

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Key words: mango, ripening, ethylene, sensory evaluation

Abstrak

Semua buah mangga Harumanis menjadi lembut selepas disimpan satu minggu pada suhu 15 °C. Sebanyak 70% buah yang disimpan pada suhu 10 °C selama seminggu juga menjadi lembut. Mangga Harumanis yang disimpan selama 0 dan 1 minggu pada suhu 10 °C dan kemudiannya diperam pada suhu 25 °C dengan 5 μL/L etilena selama 24 jam dan dibiarkan masak selama 5 hari pada suhu tersebut mempunyai warna mesokarp, kemanisan dan penerimaan keseluruhan yang lebih baik daripada buah yang tidak diperlakukan dengan etilena. Jumlah pepejal larut, pH dan jumlah asid titrat tidak mempunyai perbezaan di antara perlakuan. Buah yang disimpan pada suhu 15 °C selama 1 minggu dan 2 minggu mempunyai mutu yang lebih baik daripada buah yang disimpan pada suhu 10 °C tetapi apabila disimpan sehingga 3 minggu dan 4 minggu, buah yang disimpan pada suhu 10 °C didapati lebih baik.

Abstract

Harumanis mangoes softened after 1 week of storage at 15 °C. Seventy percent of fruit stored at 10 °C also softened after 1 week. Harumanis mangoes stored for 0 and 1 week at 10 °C and then ripened at 25 °C with 5 μL/L ethylene for 24h and left for 5 days had better mesocarp colour, sweetness and overall acceptability than the non-ethylene-treated fruit. There were no differences in the total soluble solids, pH and total titratable acidity between the treatments. Fruit which were stored at 15 °C for 1 week and 2 weeks had better eating quality than fruit stored at 10 °C but when stored for 3 weeks and 4 weeks the fruit from 10°C were better.

Introduction

Harumanis is one of the best commercial mango cultivars grown in Malaysia. It has excellent flavour and is suitable for fresh consumption and processing. Ripening can be controlled by regulating the temperature, modifying the atmosphere, controlling the atmosphere, treating with chemical, irradiating and regulating ethylene in the storage environment. Mangoes are usually kept in cold storage to extend the storage life and ripened fruit are acquired after certain periods of storage. However, the moderately slow rate of ripening at low temperatures (16–19 °C) enhanced the storage life at the expense of good fruit quality while ripening at higher temperatures (20–22

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°C) resulted in sufficiently acceptable quality attributes but shorter storage life (Salinas and Lakshminarayana 1985). Ethylene is normally used to induce fruit ripening. Mattoo and Modi (1969) showed that ethylene synthesized by mango stimulated the respiratory enzymes, catalase and peroxidase, and inactivated the inhibitor(s) of these enzymes before the onset of the climacteric. Tommy Atkin mangoes ripened with ethylene before shipment had better appearance and eating quality than non-treated mangoes (Barmore 1976; Barmore and Mitchell 1977). Treated fruit ripened uniformly and disease was minimal. This paper reports on the eating quality of Harumanis mangoes after storage at 10 °C and 15 °C and ripened with ethylene at 25 °C.

Materials and methods

Preclimacteric mango fruit (*Mangifera indica* L. cv. Harumanis) were harvested from the MARDI orchard at Kuala Kangsar on 3 June 1986. The fruit were transported at ambient temperature (ca. 30 °C) during the day. On arrival at the laboratory, the fruit were stored for 1.5 days at 15 °C before they were used for the experiment.

The fruit were washed with tap water and dipped in benomyl solution (800 μg/mL water) for 5 min within 48 h after harvest and then stored at 10 °C and 15 °C. Two samples of 20 fruit were transferred from each respective storage temperature to 25 °C after 0, 1, 2, 3 and 4 weeks. Each transferred sample was kept in a low density polyethylene bag with a flow through inlet and outlet tube. Humidified air containing ethylene (5 μL/L at a flow rate of 12 L/h was passed through one sample for 24 h. Earlier experiments showed that this level of ethylene softened Harumanis mangoes after 24 h of treatment. The control sample was ventilated with ethylene-free air at the same flow rate for 24 h. Then the number of fruit that softened was recorded. The firmness was observed daily for 5 days. The fruit were treated with ethylene at each transfer from the storage temperature of 10 °C and 15 °C only if they were hard. If the fruit were soft only one sample of 20 fruit was transferred from each respective storage temperature to a temperature of 25 °C and left for 5 days before analysis was carried out. It was not necessary to apply ethylene if the fruit was soft. Hence only one sample was transferred instead of two.

A representative sub-sample of three fruit from each treatment was taken for respiration studies. Each fruit was put into a 3.65-L glass jar ventilated continuously with humidified ethylene-free air at a flow rate of approximately 1 L/h per 100 g of fruit weight at 25 °C. The respiration in terms of carbon dioxide production was determined daily using the Varian series 1420 gas chromatograph fitted with a thermal conductivity detector.

After 5 days at 25 °C, a sub-sample of six fruit was evaluated by 12 panelists on mesocarp colour, texture, sweetness, flavour and overall acceptability. The fruit were evaluated on a 1 to 9 hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely. The middle one-third portion of one cheek of a fruit was used for sensory evaluation while the other was blended for analysis. The total soluble solids (TSS), pH and total titratable acidity (TTA) in terms of anhydrous citric acid were determined by standard AOAC methods (AOAC 1984).

Results

All the fruit stored at 15 °C and 70% of those stored at 10 °C softened after one week. No ethylene treatment was given after the fruit softened.

The control fruit showed a climacteric peak and a climacteric rise at 0 and 1-week of storage respectively *(Figure 1)*. The ethylene-treated fruit showed a declining trend throughout the ripening period.

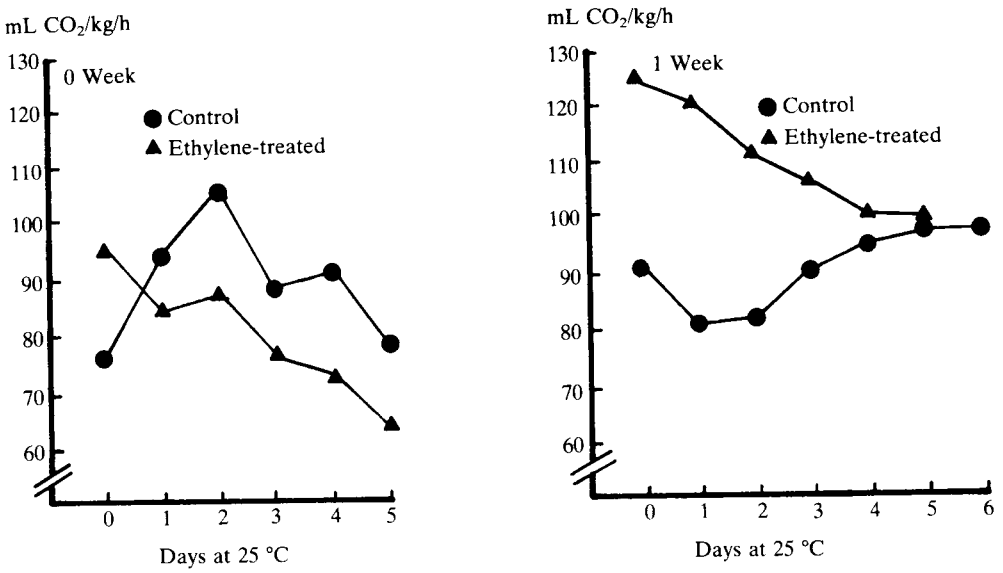

Figure 1. Respiration rates of representative individual Harumanis mango at 25 °C after being kept at 10 °C for 0 and 1 week and treated with 5 μL/L ethylene at 25 °C for 24 h

Table 1. Sensory evaluation of control and ethylene-treated Harumanis mango after being stored at 10 °C for 2 periods and ripened at 25 °C for 5 days

Sensory evaluation attribute	0 week storage		1 week storage	
	Control	Ethylene-treated	Control	Ethylene-treated
Mesocarp colour	6.5b	6.8a	6.3b	6.7a
Flavour	6.3a	6.5a	6.3b	6.8a
Texture	6.7a	6.6a	6.8a	6.9a
Sweetness	6.7b	7.4a	5.8b	6.8a
Overall acceptability	6.5b	7.0a	6.1b	6.8a

Means with the same letter in the same row within each storage period are not significantly different with the LSD test at 5% level

Table 2. Chemical analysis of control and ethylene-treated Harumanis mango after being stored at 10 °C for 2 periods respectively and ripened at 25 °C for 5 days

Chemical attribute	0 week storage		1 week storage	
	Control	Ethylene-treated	Control	Ethylene-treated
Total soluble solids (%)	15.8	16.3	14.3	14.5
pH	4.1	4.7	4.0	4.4
Total titratable acidity	0.17	0.11	0.35	0.14

Test of significance ($p<5\%$) between treatments within each storage period are insignificant

The mesocarp colour, sweetness and overall acceptability scores of the ethylene-treated fruit from the 0 and 1-week stored fruit at 10 °C were significantly higher ($p<0.05$) than the non-treated fruit *(Table 1)*. However, the difference in TTS, pH and TTA, of the ethylene-treated and non-treated fruit were not significant *(Table 2)*.

Fruit stored at 15 °C for 1 week and ripened at 25 °C for 5 days without ethylene treatment were significantly

Table 3. Sensory evaluation of Harumanis mango after being stored at 2 temperatures for 4 periods and ripened without ethylene-treatment at 25 °C for 5 days

Storage (week)	Sensory evaluation attribute	Storage temp. (°C)	
		10	15
1	Mesocarp colour	6.3b	7.4a
	Flavour	6.3b	6.7a
	Texture	6.7b	7.2a
	Sweetness	5.8b	7.3a
	Overall acceptability	6.1b	7.0a
2	Mesocarp colour	6.9b	7.4a
	Flavour	6.8a	6.7a
	Texture	7.1a	7.1a
	Sweetness	6.9a	7.1a
	Overall acceptability	7.0a	7.0a
3	Mesocarp colour	7.0a	6.6b
	Flavour	6.7a	6.8a
	Texture	7.1a	6.3b
	Sweetness	6.9a	7.1a
	Overall acceptability	6.9a	6.7b
4	Mesocarp colour	7.1	na
	Flavour	6.9	na
	Texture	7.3	na
	Sweetness	7.0	na
	Overall acceptability	7.0	na

na = not available as storage period was terminated due to fruit decay

Means with the same letter in the same row are not significantly different with the LSD Test at 5% level

superior to those stored at 10 °C under the same conditions in all sensory evaluation attributes *(Table 3)*. Apart from the mesocarp colour of 2-week stored fruit which was significantly better at 15 °C, the other attributes were not significantly different. After 3 weeks of storage at 15 °C, the mesocarp colour, texture and overall acceptability were significantly inferior to the fruit stored at 10 °C. Fruit from 15 °C after 1 week and 3 weeks of storage had a significantly higher pH than the 10 °C fruit *(Table 4)*. Fruit stored for 2 weeks at 10 °C and 15 °C had no significant difference in TSS, pH and TTA. Most of the fruit stored at 15 °C for 3 weeks were affected by anthracnose.

Discussion

All mango fruit after 1 week of storage at 15 °C and 70% at 10 °C were in the climacteric rise or had the climacteric. This shows that when the mango fruit is sprung (slightly soft) or soft then it is on the climacteric rise or had passed the climacteric peak. These fruit were in the ripening process. Ethylene-treatment at 25 °C of fruit from 10 °C after 1 week of storage hastened the climacteric peak during the period of treatment *(Figure 1)*. The control fruit showed the climacteric peaks.

Ethylene-treated fruit after 0 and 1-week of storage from 10 °C had a better eating quality than the control. This is attributed to the earlier ripening of ethylene-treated fruit and the decrease in TTA and increase in TSS. Similar results were found in the ripening of Boribo mango; the free amino acid and organic acid contents decreased and the total

Table 4. Chemical analysis of Harumanis mango after being stored at 2 temperatures for 4 periods and ripened without ethylene-treatment at 25 °C for 5 days

Storage (week)	Chemical attribute	Storage temp. (°C)	
		10	15
1	Total soluble solids (%)	14.3a	15.8a
	pH	4.0b	5.0a
	Total titratable acidity (%)	0.35a	0.10a
2	Total soluble solids (%)	16.1a	15.8a
	pH	4.5a	4.5a
	Total titratable acidity (%)	0.12a	0.14a
3	Total soluble solids (%)	16.2a	15.7a
	pH	4.3b	4.6a
	Total titratable acidity (%)	0.23a	0.14a
4	Total soluble solids (%)	17.6	na
	pH	4.3	na
	Total titratable acidity (%)	0.24	na

na '= not available as storage period was terminated due to fruit decay
Means with the same letter in the same row are not significantly different with the LSD Test at 5% level

sugars increased (Passera and Spettoli 1981; Kalra and Tandon 1983). Concurrently, the TSS also increased (Murthy and Rao 1982; Kalra and Tandon 1983). The rapid increase in TSS and pH, and decrease in TTA of ethylene-treated mango are similar to the results observed in kiwifruit treated with 5μL/L ethylene (Matsumoto et al. 1983). The panelist could distinguish the fruit with better eating qualities among the treatments but chemical analysis showed insignificant difference. This shows that sensory evaluation is more important than chemical analysis in selecting the treatment that gives the better eating quality.

Fruit stored for 1 week at 15 °C have better eating qualities than those stored at 10 °C. Ripening rate increases at higher temperature. The increase in flesh softening is due to the degradation and depolymerization of cell-wall pectin where pectinesterase increases at initial ripening and falls and then levels off during ripening, concomitantly polygalacturonase and cellulase increases (Roe and Bruemmer 1981). This is also the same in fruit after 2 weeks of storage but after 3 weeks onward of storage fruit from 10 °C are better than 15 °C. The fruit from 10 °C ripened slower and were available after 4 weeks but not the fruit from 15 °C. This shows that fruit that are to be consumed between 1 week and 2 weeks can be stored at 15 °C while those between 3 weeks and 4 weeks can be stored at 10 °C without any ethylene treatment. An ethylene treatment of 5μL/L for 24 h is needed for fruit that are to be consumed within 1 week after harvest or after storage at 10 °C. These fruit can be eaten after 3 days from treatment.

Acknowledgement

This study was supported by the Australian Centre for International Agricultural Research Project No. 8356, Physiological, Chemical and Storage Characteristics of Mangoes (and some other tropical fruits) in South East Asia.

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Accepted for publication on 28 November 1987

VOL. 16 NO. 1 JUNE 1988
ISSN 0128–0686

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