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EFFECT OF HOT ETHRAL-DIP TREATMENT FOR IMPROVING PEEL COLOUR DEVELOPMENT AND REDUCING STEM-END-ROT OF 'KARUTHACOLOMBAN' MANGO

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ABSTRACT

Poor colour development of the peel and high incidence of stem-end-rot development are the major reasons for excessive postharvest losses in mango, variety 'Karuthacolomban'. Experiments were conducted to investigate the effect of artificial ripening by application of ethral at ambient (26°C), 48° and 52°C on reducing postharvest losses. Time taken for ripening was shortened when the treated temperature was increased. Peel colour development was improved when fruits were treated at 52°C. Total soluble solids and titratable acidity of induced fruits remained similar to those of control at table ripe stage. No difference observed in the sensory evaluation of ripe mango indicated that the taste, smell and flavour were not affected by the application of ethral. Fruits inoculated with *Lasiodiplodia theobromae* showed less severity of stem-end-rot when those fruits were induced for ripening at 52°C with ethral. When inoculated fruits were allowed to ripen naturally a high disease severity was observed. Therefore, after harvesting, mature 'Karuthacolomban' mangoes could be treated with hot ethral (1 ml/l H_2O) at 52°C for 3 minutes to induce ripening resulting in an attractive peel colour and a low severity of stem-end-rot.

KEYWORDS: Hot ethral, Mango, Peel colour, Stem-end-rot.

INTRODUCTION

Poor peel colour development and high susceptibility to stem-end-rot are two major problems of mango (*Mangifera indica*), variety Karuthacolomban, resulting in excessive postharvest losses. Stem-end-rot causing fungi in mango are endophytic, and such pathogens are activated when fruits begin to ripe. Symptoms are expressed at the ripe stage and continue until complete degradation of the tissues (Mitra and Baldwin, 1997). The relatively long time taken for natural ripening allows endophytic fungi to multiply rapidly producing stem-end-rot before ripening process is completed. If the time taken for ripening is decreased, fruit ripening can be completed before the endophytic fungi are multiplied to cause the disease.

Ethylene is the major determinant of the onset and rate of ripening of climacteric fruits (Medlicott and Jeger, 1987). Ethylene gas, however, cannot be used to induce ripening of mango in Sri Lanka due to the high costs involved. Ethylene gas released from Ethral at neutral and alkaline pH can be used as an alternative to commercially available ethylene gas (Salisbury and

Ross, 1991). Hot water treatment is widely used for disinfection of mango against postharvest diseases (Jacob and Wong, 1992). Anthracnose has been controlled by immersion in hot water at 50-55ºC up to 15 minutes. In addition to disease control, hot water dip (52-53ºC) for 5-10 minutes increases the colour intensity of both pulp and peel of mango (Mitra and Baldwin, 1997). This study was carried out to investigate the response of 'Karuthacolomban' mango to induction of ripening using Ethral and hot water.

MATERIALS AND METHODS

Fully mature green fruits of mango (*Mangifera indica*), variety Karuthacolomban, were harvested with fruit stalk attached, from a well-managed orchard at Galkiriyagama. The fruits were carefully transported to the laboratory using plastic crates. Stems of the fruits were detached and latex was allowed to drain by inverting the fruits. Fruits were then divided into 3 groups, each group containing 20 fruits. Each fruit was labeled and weighed. Ten ml of Ethral was added to 10 l of H_2O and stirred well. One group of fruits was dipped in this solution at ambient temperature (26˚C) for 4 minutes. The second group of fruits was dipped for 4 minutes in a fresh Ethral solution, which was prepared as described above and heated up to 48ºC. Fruits of the remaining group were dipped for the same duration in an Ethral solution held at 52˚C. All the treated fruits were surface dried and each group of fruits were separately placed in 45 l plastic bins. The lids of the bins were tightly closed. Twenty-four hours later the lids of the bins were opened and then partially closed in order to provide sufficient ventilation while maintaining a moist environment.

Time taken to reach table ripe stage and percentage weight loss of fruits at that stage was recorded. Peel colour index of the fruits was recorded using an index of 1=Green, to 6=Over ripe. The flesh colour of ripe mango was recorded using an index of 1=Pale /orange yellow, to 4=Dark orange. The flesh colour of ripe mango was also recorded using the Minolta colorimeter 2000 (Minolta, Japan). Colour measurements were obtained as L, 'a*' and 'b*', where L=lighter (+ve) to darker (-ve), a*=greener (-ve) to redder (+ve), and b*=bluer (-ve) to yellower (+ve) coordinates colour sphere axes (McGuire, 1992).

Fruits were assessed for disease development using disease index with respect to peel discolouration as a result of anthracnose and stem-end-rot. Disease severity was recorded using an index: 1=1-10% surface discolouration, to 4=greater than 30% surface discolouration. Sensory evaluation of odour, flavour and overall acceptability were recorded by a trained taste panel using the Hedonic scale.

Visual quality rating of fruits was recorded using a numerical scale (Sarananda and Amarakoon, 1999). The index used was 1=not edible, to 9=excellent. Juice of the middle one-third of the flesh of fruits was used to measure the total soluble solids using a hand refractometer. Extracted juice from 1g of middle one third of the flesh was taken, and volumerized up to 100 ml adding distilled water. The titration was done against 0.1 N NaOH using phenolphthalein as an indicator to measure the titratable acidity.

Another experiment was carried out to study the effect of hot ethral treatment on disease development of inoculated mango. Sixty mature fruits were used for the experiment. Conidial spore suspension was prepared from mature pycnidia harvested from two-week-old pure cultures of *Lasiodiplodia theobromae*. Conidia were released by crushing pycnidia in sterile distilled water. The concentration of conidia was adjusted to 5×10^5 per ml using a Haemocytometer. Thirty fruits were inoculated at stem end with 0.1 ml of the spore suspension and incubated for 3 hours. Half of the inoculated and un-inoculated fruits were dipped in hot ethral (52ºC) for 5 minutes. Peel colour development and intensity of stem-end-rot were recorded.

The experiments were conducted in a Completely Randomized Design. The parametric data were subjected to ANOVA in SAS statistical package, while the non-parametric data was analyzed using Kruscal Wallis test and Friedman test using Minitab computer software.

RESULTS AND DISCUSSION

Untreated fruits took a significantly longer time ($p<0.05$) for ripening with excessively high weight loss (table 1). However, time taken to reach table ripe stage and percentage weight loss of ripe fruits remained unaffected irrespective of the temperature of ethral used to induce the ripening process. Percentage weight loss of all Ethral treated mangoes also remained unaffected irrespective of the temperature (table 1). However, fruits in the control treatment had a significantly higher weight loss than that of induced-ripen fruits.

Significantly higher L values showed that the peel of ripe fruits dipped in hot water at both 48ºC and 52ºC had a darker colour than that of fruits in the control treatment and those treated at 26ºC (table 2). Significantly higher a* value of mango treated at 52ºC indicated that the peel colour has more red components than those treated at 48ºC, 26ºC and in the control treatment. No significant difference in b* values of Ethral-treated fruits indicated that yellow colour remained unaffected by the temperature of Ethral treatment. The highest median of peel colour index was recorded in fruits treated with Ethral at 52^0C (table 2).

Table 1. Mean time taken to reach table ripe stage and percentage weight loss as affected by ethral at different temperatures

Treatment	*Time taken to reach table ripening (days)*	*% Weight loss*
Ethral 26ºC	11.1 b	10.41 b
Ethral 48ºC	10.6 b	11.33 b
Ethral 52ºC	10.6 b	12.42 b
Control	16.3 a	17.86 a

Within a column, means followed by the same letter are not significantly different by DMRT at p=0.05.

Table 2. Means of L, a*, b* and medians of peel colour index of 'Karuthacolomban' mango at table ripe stage as affected by ethral at different temperatures

Treatment	*L value*	*a* value*	*b* value*	*Colour Index*
Ethral 26ºC	45.62 [b]	5.08 [b]	26.56 [a]	3.0
Ethral 48ºC	48.29 [a]	6.01 [b]	26.68 [a]	4.5
Ethral 52ºC	49.14 [a]	10.41 [a]	27.75 [a]	5.0
Control	40.32 [c]	2.63 [c]	23.42 [b]	2.6
Significant level				p=0.05

Within a column means followed by the same letter are not significantly different by DMRT at p=0.05; Colour index: 1=green, 2=colour break, 3=more green than yellow, 4=more yellow than green, 5=full yellow/orange, and 6=over ripe.

In contrast to peel colour, the L component of flesh colour remained unaffected by the treatment temperature (table 3). The L value of Ethral-treated flesh was similar to that in control fruits. Significantly higher ($p<0.05$) a* value of flesh indicated that both 48º and 52ºC dip-treatments enhanced the red colour development when compared to those at 26ºC and the controls. However, no change in b* value was observed with treatment temperature. A significantly higher colour index ($p<0.05$) was observed fruits dipped in hot water at 52ºC, indicating that the treatment was more effective in increasing the flesh colour than that at 48ºC and 26ºC, respectively (table 3).

Table 3. Means of L, a*, b* and medians of flesh colour index of 'Karuthacolomban' mango at table ripe stage as affected by ethral treatment at different temperatures.

Treatment	*L value*	*a* value*	*b* value*	*Colour Index*
Ethral 26ºC	45.19 a	12.02 b	25.60 a	3.0
Ethral 48ºC	44.17 a	19.77 a	24.61 a.	3.5
Ethral 52ºC	48.58 a	19.64 a	26.12 a	4.0
Control	44.26 a	10.52 a	24.62 a	2.6
Significant level				p=0.05

Within a column means followed by the same letter are not significantly different by DMRT at p=0.05; Colour index: 1=green, 2=colour break, 3=more green than yellow, 4=more yellow than green, 5=full yellow/orange, and 6=over ripe.

The highest visual quality rating (VQR) and the lowest disease index was recorded in fruits treated with ethral at 52ºC (table 4). The minimum VQR and the highest disease index were observed in fruits treated at 48ºC. Further investigations showed that the major disease responsible for surface discolouration of ripe mango was stem-end-rot. No anthracnose incidence was observed in all fruits. The initiation of stem-end-rot was observed before peel colour development in mangoes treated with Ethral at 48ºC (table 4).

Table 4. Medians of visual quality rating and disease index of 'Karuthacolomban' mango at table ripe stage as affected by Ethral at different temperatures.

Treatment	*Visual Quality Rating*	*Disease Index*
Ethral 26ºC	4.0	2.0
Ethral 48ºC	2.5	3.0
Ethral 52ºC	7.0	0.5
Control	4.6	2.3
Significant level	p=0.05	p=0.05

Visual quality rating: 1=Not edible, 3=Limit of edible, 5=Moderate defects, 7=Slight defects, and 9=Excellent; Disease Index: 1=1-10% surface discolouration, 2=11-20% surface discolouration, 3=21-30% surface discolouration, and 4=over 30% surface discolouration.

Total soluble solids of mango at ripe stage were unaffected by dipping temperature of Ethral solutions (table 5). However, a significant increase in titratable acidity was recorded in fruits treated at 48ºC and 52ºC.

Table 5. Means of total soluble solids and titratable acidity of 'Karuthacolomban' mango at table ripe stage as affected by ethral at different temperatures.

Treatment	*Total soluble solids (ºBrix)*	*Titratable acidity (%)*
Ethral 26ºC	11.96 [a]	0.17 [b]
Ethral 48ºC	9.70 [a]	0.21 [a]
Ethral 52ºC	12.01 [a]	0.19 [a]
Control	11.62 [a]	0.18 [ab]

Within a column means followed by the same letter are not significantly different by DMRT at p=0.05.

All three dipping temperatures had no significant effect on sensory evaluations tested, off odour, flavour and overall acceptability compared to those of control (table 6).

Table 6. Percentage of odour, flavour and overall acceptability of 'Karuthacolomban' mango at table ripe stage as affected by Ethral at different temperatures.

Treatment	*Off odour*	*Flavour*	*Overall acceptability*
Ethral 26ºC	9.54	83.49	83.48
Ethral 48ºC	10.45	77.80	77.15
Ethral 52ºC	8.49	86.23	878.11
Control	9.62	85.63	80.23
Significance level	p=0.05	p=0.05	p=0.05

The higher medians of peel colour development were observed in hot ethral treated fruits (table 7). When fruits were treated with hot water, the peel colour development was higher regardless of the inoculation. Irrespective of the inoculation, the Ethral treatment at room temperature showed lesser peel colour development when compared to that of hot Ethral. In inoculated fruits, hot Ethral treatment reduced the stem-end-rot development. Similarly, hot Ethral reduced the disease development of un-inoculated fruits.

Table 7. The mean peel colour index and severity of stem end rot of aruthacolomban" mangoes as affected by inoculation of *L. theobromae.*

Treatment	*Peel colour index (median)*	*Disease index Stem-end-rot*
Inoculated + hot ethral	4.73	1.8
Inoculated + ethral	3.00	2.6
Un-inoculated + hot ethral	4.78	0.5
Un-inoculated + ethral	3.27	1.2
Significant level	p=0.05	p=0.05

Peel Colour Index: 1=green, 2=colour break, 3=more green than yellow, 4=more yellow than green, 5=full yellow, 6=yellow with brown blotches; Disease Index: 1=1-10% surface discolouration, 2=11-20% surface discolouration, 3=21-30% surface discolouration and 4=over 30% surface discolouration.

Rate of artificial ripening of 'Karuthacolomban' mango was enhanced when Ethral was used at a concentration of 1ml/l H_2O and the treatment temperature was increased. Early peel colour and flesh colour development was observed when fruits were treated with ethral at 52ºC. At this temperature, the amount of ethral penetrated through the skin may be higher than those at lower temperatures resulting in earlier induction of ripening process. This idea could be applicable for dipping temperature of 48ºC where fruit ripening was enhanced, but susceptibility to stem-end-rot was higher. As initiation of the autocatalytic ethylene production induces mango ripening, early accumulation of ethylene in mangoes heated for 52^0C would have accelerated ripening. Occurrence of stem-end-rot in mangoes is mainly due to endophytic fungi that infect when fruits are attached to the tree (Johnson *et al*., 1992). In addition, the major fungus responsible for stem-end-rot *Lasiodiplodia theobromae*, cannot directly penetrate into the plant tissue and hence requires wounds to facilitate penetration. Dormancy of *Colletotrichum gloeosporioides* has been removed when fruits are exposed to ethylene (Flaishman and Kotattukudy, 1994). Ethylene produced in the fruits when treated with Ethral at 48ºC may be sufficient to break the dormancy of endophytic fungi. Since fruit ripening is delayed when fruits were treated at this temperature, a reasonable time is left for the pathogen to multiply and cause the rot. When fruits are treated with ethral at 26ºC ethylene is liberated at a slow rate, hence breaking of the dormancy of endophytic fungi may not happen. When the fruit ripening process is induced, ethylene liberated by the fruit may break the dormancy of

pathogen. This may be the reason for higher rate of stem-end-rot incidence in mangoes treated with ethral at 26ºC. Thus, if hot ethral is used to induce ripening process of mango, the suitable temperature would be 52ºC with a dipping duration of 3 minutes. Inoculated studies with *L. theobromae* showed that hot Ethral was effective in reducing the stem-end-rot development mainly due to early ripening before the pathogen has multiplied. Thus, the observed delay in rot development in mango when fruits are treated with hot Ethral may be due to accelerated ripening. This makes treated fruits consumable before the pathogen multiplies. Early induction of ripening when fruits were treated with hot water alone as reported by Ram *et al. (*1984) was observed in a similar manner in the present study with 'Karuthacolomban' mango.

No impairment of quality with the Ethral and high temperature treatments used in this study shows that there is no practical limitation for commercial application of the technology. Improvement of quality in Ethral-treated mango at 52^0C permits commercial application of the technique.

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