Effect of ethrel on the physiochemical changes of off-season fruits of mango (Mangifera indica L. var. Neelum) during ripening

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Received 25 November 2013; accepted 15 December 2013

Abstract
An attempt was made to the effect of ethrel on the ripening of off–season fruits of Mangifera indica L. var. Neelum. The control fruits were kept in the laboratory naturally while the experimental fruits were treated with different concentrations of ethrel (100, 200 and 300ppm). In control fruits, partial ripening led to incomplete metabolic changes, which did not alter the presence of sourness in the fruits. Hence, they were not fit to be eaten. On the other hand, the fruits treated with different concentrations of 100, 200 and 300ppm of ethrel the fruits ripened on 13th day, 11th day and 9th day respectively after treatment. The fruit firmness, titratable acidity were decreased during the ripening, period in the treated and control fruits than in control fruits. On the other hand, total soluble solid, pH was increased in the ethrel treated fruits.

Key Words: Fruits firmness, titratable acidity, Total soluble solid, pH fruit ripening ethrel.

Introduction
Fruit ripening is complex phenomenon with drastic changes in chemical composition, which enhance important quality attribute such as flavor, softness, sweetness and color (1). Ripening in mangoes involves numerous metabolic activities leading to changes in carbohydrates and acids resulting in declined sugar - acid ratio, development of colour, flavour characteristics, and softening of the texture are acceptable quality. These changes take place in harvested fruits, within a short period of 9 to 12 days at ambient temperature, depending on the variety and stage of maturity. Each mango variety on ripening has distinct characteristics and flavour. Unlike unripe fruits which are astringent, acidic, and rich in vitamin C, the ripe fruits are sour and/or sweet, rich in carotenoids, moderate in vitamin C and highly aromatic (2) and (3) reported that the fruit maturity periods are varied from 83 to 121 days in the on-season (March to August) and from 109 to 135 days in the off-season (September to February) in sixteen varieties at Kanyakumari. They have attributed that the lowest quantum of heat units and higher humidity and rainfall during off-season to the extension of the fruit maturity period for all the varieties. According to (4) in Langra,(5) in Alphonso, (6) in Fazli the required time period for harvesting maturity was 110 – 120 days. However, variety Mallika took 94 days (7). Physical attributes such as weight, external colour, shape, specific gravity and fruit firmness are in conjunction with chemical attributes, such as total soluble solids, total acidity, sugar - acid ratio, reducing sugars, starch and alcohol, insoluble solids and colour of pulp which have been used to assess the harvest maturity (8). Mangoes weighing around 300 ± 20g with total soluble solids of 8.0 unit acidity 3.5 per cent and specific gravity 1.01 to 1.02 unit even without grown shoulder in a prominent pit at the olive green stalk end were considered optimum standards for harvest (9; 10), (11) argue that the physio-chemical changes were associated with the growth and development of mango. The changes in physio–chemical characteristic features during ripening was studied in detail by earlier researchers (3,12,13,14,15,16,5,6,8,9,10,7,17,2,18, 19,20,21,22,and 23).

In ripening mango, sharp physio-chemical changes that occur are softening of the fruit, change in odour and flavor, increase in sugar content, reduction in organic acids and formation of pigments, especially carotenoids (12). In banana, changes in mechanical properties of pulp and peel during ripening leading to decreasing fruit firmness which are associated with fruit softening (20). The effect of various concentrations of ethanol or acetaldehyde vapour
on banana during ripening showed that the weight loss, less fruit firmness, decreased titratable acidity and total soluble solid (24),(25) studied the changes in the physico-chemical and biochemical compositions of custard apple (Annona squamosa L.) fruits during growth, development, and ripening. Fruit firmness and grape berry maturation and development of different rheological parameters during ripening were studied by (26),(27) observed the physio-chemical changes such as fruit firmness, titratable acidity and pH during the storage and ripening of papaya fruit. Though no change was observed in titratable acidity, the slightly increased pH and decrease Organic acids as the fruits ripens. The predominant acid is citric acid, followed by varying amounts of glycollic, malic, tartaric and oxalic acids. Non-volatile organic acids are among major cellular constituents undergoing changes in fruits. There is which leads to a considerable accumulation of acidity with variable degree of fruit maturity (28,14). Accumulated acids undergo active metabolism during ripening of several fruits (29). In addition, the decline in acidity brings about shifting of pH from 2.0 to 5.5, as in the case of mango (30). Sugar: acid ratio serves as an index of degree of ripeness and basically determines the flavour of the fruit. Certain individual acids show greater changes than others in which citric and malic acids are frequently predominate (14). Malate predominates in apple, banana, cherry, peach, pear and plum, whereas citrate predominates in the citrus fruits such as figs, guava, strawberry and pineapple, and also the mixture of both acids occur in equal in the fruits of tomato and gooseberry. In apples, there appears to be an additional cytoplasmic malate decarboxylating system leading to decline in acidity during ripening. Certain individual acids undergo rapid metabolic changes in the course of ripening of several fruits including litchi, mango. Studied the efficacy of 1-MCP treatment in tomato fruit during cultivar and ripening stage at harvest. An extensive report has recently been published on predictions of acidity, soluble solids and firmness of pear by using electronic nose technique (30),(31) noticed that the quality and volatile of fruit attributes of attached and detached pluk mai lie' Papaya during fruit ripening. (23) observed that the effect of chitosan coatings on the physicochemical characteristics of eksotika II Papaya (Carica papaya L.) fruit during cold storage. (31) studied the modulation of mango ripening by chemicals, physiological and biochemical aspects. The objective of this study was to find out the effect of ethrel on the physiochemical changes during the ripening of off-session fruits of Mango.

Material and Methods
The detached fruits of Mangifera indica L. var. Neelum were selected for the present study. The off-season (September to February) green mature unripe fruits were harvested from Auroville near Pondicherry union territory, India and stored in cortons in the Department of Botany at room temperature 28±2°C with the relative humidity of 85 per cent. They were treated with different concentrations of ethrel (100, 200 and 300 ppm). All the experiments were conducted with seven replicates. The peel and pulp of the fruit material were used to study the ripening process. Fruit firmness was determined by using screw gauge, by hand force. Total soluble solids in the fruits were determined by using a refractometer P30 model RL2 and their concentration was designated in Brix degree at 33°C. The fruit juice was obtained from 100 g of the fruit. The total titratable acidity was determined by diluting the juice with 25 ml of deionized water, and titrating to pH 8.1 with 0.1 M sodium hydroxide. Results were expressed in citric acid equivalent in 100 g of fresh weight. 100 g of pericarp tissue was ground with mortar and pestle. Fruit juice was diluted with 25 ml of deionized water and the pH was measured by.(31).

Results And Discussion
Mangifera indica is a climacteric fruit. The climacteric and non-climacteric fruits considerably differed in their ripening processes. Ripening in mangoes involves numerous metabolic activities leading to changes in declined ratio of carbohydrates and acids, development of colour and flavour characteristics and softening of the texture are acceptable quality. These changes take place in harvested fruits, within a short period of 9 to 12 days at ambient temperature, depending on the variety and the stage of maturity. Each mango variety on ripening has distinct characteristics and flavour. Unlike fruits which are astringent, acidic and rich in vitamin C, the ripe fruits are sour and/or sweet, rich in carotenoids, moderate in vitamin C and highly aromatic (2). Table 1 shows the changes of fruit firmness during the different stages of fruit ripening of Mangifera indica. Fruit firmness was gradually decreased from the initial stage to the final stage of ripening. This decrease was more in the treated fruits than in the control fruits. The percentage loss of firmness was more in the fruits treated with 200ppm ethrel than with 100 and 300ppm ethrel treated fruits and control group. Decreasing fruit firmness might be associated with fruit softening which in coincide with the report of (20). In ripening mango, sharp Physio-chemical changes that occur are softening of the fruit, change in odour and flavour, increase in sugar content, reduction in organic acids, and formation of pigments, especially carotenoids (12). In banana, changes in mechanical properties of pulp and peel were observed during ripening. (27) observed the physio-chemical changes such as fruit firmness, titratable acidity and pH during the storage and ripening of papaya fruit. Though no change was occurred in titratable acidity where the pH was slightly increased. In our findings the treatment with ethrel and increased the rate of softening as compared to their respective controls. In contrast to the ethrel treatment, 1- Methylcyclopropene (1-MCP), Silver nitrate (AgNO3), and Gibberlic acid (GA3) did not reduce softening compiled to their respective in delaying softening. (31). Fruit flesh firmness of the two tomato cultivars showed a progressive decline during ripening. Most of this decline occurred between the light-pink and canning-ripe stages. A similar drop in flesh firmness was reported in guava, banana and mango. The Table 2 reveals that the changes of total soluble solid during the different stages of fruit ripening of Mangifera indica. The percentage of total soluble solid increased during the course of ripening in the treated fruits than in the control fruits. Among the treated fruits, the fruits
Table – 1 Effect of ethrel on the fruit firmness changes during the ripening of off-season fruits of *Mangifera indica* L. var. Neelum

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>100 ppm</th>
<th>200 ppm</th>
<th>300 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
</tr>
<tr>
<td>1</td>
<td>25.8 ± 1.54</td>
<td>25.5 ± 1.56</td>
<td>25.6 ± 1.79</td>
<td>25.8 ± 1.66</td>
</tr>
<tr>
<td>3</td>
<td>22.8 ± 1.41</td>
<td>20.6 ± 1.48</td>
<td>20.3 ± 1.42</td>
<td>21.3 ± 1.38</td>
</tr>
<tr>
<td>5</td>
<td>16.6 ± 0.99</td>
<td>15.7 ± 0.78</td>
<td>9.3 ± 0.73</td>
<td>12.1 ± 0.97</td>
</tr>
<tr>
<td>7</td>
<td>14.2 ± 0.99</td>
<td>10.7 ± 0.72</td>
<td>8.0 ± 0.48</td>
<td>9.2 ± 0.64</td>
</tr>
<tr>
<td>9</td>
<td>12.1 ± 0.87</td>
<td>11.0 ± 0.55</td>
<td>7.0 ± 0.49</td>
<td>8.6 ± 0.43</td>
</tr>
<tr>
<td>11</td>
<td>11.0 ± 0.55</td>
<td>10.5 ± 0.73</td>
<td>6.5 ± 0.33</td>
<td>8.2 ± 0.49</td>
</tr>
<tr>
<td>13</td>
<td>10.1 ± 0.61</td>
<td>9.4 ± 0.47</td>
<td>5.6 ± 0.34</td>
<td>7.4 ± 0.44</td>
</tr>
<tr>
<td>15</td>
<td>9.0 ± 0.63</td>
<td>8.5 ± 0.60</td>
<td>4.2 ± 0.29</td>
<td>6.0 ± 0.30</td>
</tr>
</tbody>
</table>

(Values are Mean ± SE of 7 samples expressed in kg/cm²)

Table – 2 Effect of ethrel on the titratable acidity changes during the ripening of off-season fruits of *Mangifera indica* L. var. Neelum

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>100 ppm</th>
<th>200 ppm</th>
<th>300 ppm</th>
</tr>
</thead>
<tbody>
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<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
</tr>
<tr>
<td>1</td>
<td>20.8 ± 0.90</td>
<td>19.2 ± 1.05</td>
<td>17 ± 0.85</td>
<td>14 ± 0.70</td>
</tr>
<tr>
<td>3</td>
<td>23 ± 1.61</td>
<td>19 ± 1.33</td>
<td>16 ± 1.12</td>
<td>17 ± 1.19</td>
</tr>
<tr>
<td>5</td>
<td>26 ± 0.52</td>
<td>24 ± 2.36</td>
<td>20 ± 1.20</td>
<td>24 ± 1.68</td>
</tr>
<tr>
<td>7</td>
<td>30 ± 0.81</td>
<td>26 ± 1.28</td>
<td>22 ± 1.68</td>
<td>26 ± 1.42</td>
</tr>
<tr>
<td>9</td>
<td>32 ± 0.83</td>
<td>30 ± 1.28</td>
<td>27 ± 1.28</td>
<td>30 ± 3.03</td>
</tr>
<tr>
<td>11</td>
<td>34 ± 0.92</td>
<td>33 ± 1.28</td>
<td>32 ± 2.08</td>
<td>33 ± 2.40</td>
</tr>
<tr>
<td>13</td>
<td>24 ± 1.4</td>
<td>21 ± 1.47</td>
<td>16 ± 0.80</td>
<td>19 ± 1.14</td>
</tr>
<tr>
<td>15</td>
<td>21 ± 1.05</td>
<td>17 ± 0.85</td>
<td>14 ± 0.70</td>
<td>15 ± 0.75</td>
</tr>
</tbody>
</table>

(Values are Mean ± SE of 7 samples expressed in percentage basis citric acid equivalent)

Table – 3 Effect of ethrel on the total soluble solid changes during the ripening of off-season fruits of *Mangifera indica* L. var. Neelum

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>100 ppm</th>
<th>200 ppm</th>
<th>300 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
</tr>
<tr>
<td>1</td>
<td>12.7 ± 0.67</td>
<td>12.9 ± 0.22</td>
<td>12.74 ± 0.68</td>
<td>12.6 ± 0.32</td>
</tr>
<tr>
<td>3</td>
<td>14.6 ± 0.99</td>
<td>13.9 ± 0.58</td>
<td>13.7 ± 0.76</td>
<td>13.0 ± 0.58</td>
</tr>
<tr>
<td>5</td>
<td>17.8 ± 0.89</td>
<td>15.0 ± 0.59</td>
<td>14.2 ± 0.85</td>
<td>15.2 ± 0.82</td>
</tr>
<tr>
<td>7</td>
<td>16.8 ± 1.17</td>
<td>15.9 ± 0.82</td>
<td>14.9 ± 0.58</td>
<td>15.8 ± 1.11</td>
</tr>
<tr>
<td>9</td>
<td>17.5 ± 1.23</td>
<td>16.2 ± 0.81</td>
<td>15.1 ± 0.76</td>
<td>16.8 ± 0.84</td>
</tr>
<tr>
<td>11</td>
<td>18.2 ± 1.09</td>
<td>16.9 ± 0.85</td>
<td>16.3 ± 0.81</td>
<td>17.5 ± 1.23</td>
</tr>
<tr>
<td>13</td>
<td>19.2 ± 0.96</td>
<td>17.9 ± 1.07</td>
<td>17.2 ± 0.86</td>
<td>18.5 ± 1.11</td>
</tr>
<tr>
<td>15</td>
<td>20.8 ± 1.25</td>
<td>18.5 ± 0.93</td>
<td>17.9 ± 1.07</td>
<td>19.4 ± 1.16</td>
</tr>
</tbody>
</table>

(Values are Mean ± SE of 7 samples expressed in % of Brix)

Table – 4 Effect of ethrel on the pH changes during the ripening of off-season fruits of *Mangifera indica* L. var. Neelum

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>100 ppm</th>
<th>200 ppm</th>
<th>300 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
</tr>
<tr>
<td>1</td>
<td>3.1 ± 0.24</td>
<td>3.2 ± 0.57</td>
<td>3.3 ± 0.25</td>
<td>3.4 ± 0.42</td>
</tr>
<tr>
<td>3</td>
<td>3.9 ± 0.10</td>
<td>4.2 ± 0.92</td>
<td>4.8 ± 0.19</td>
<td>4.2 ± 0.52</td>
</tr>
<tr>
<td>5</td>
<td>4.2 ± 0.56</td>
<td>4.7 ± 0.52</td>
<td>6.4 ± 0.28</td>
<td>4.9 ± 0.42</td>
</tr>
<tr>
<td>7</td>
<td>5.5 ± 0.86</td>
<td>5.6 ± 0.33</td>
<td>6.8 ± 0.48</td>
<td>5.8 ± 0.41</td>
</tr>
<tr>
<td>9</td>
<td>5.9 ± 0.22</td>
<td>6.2 ± 0.37</td>
<td>7.2 ± 0.50</td>
<td>6.5 ± 0.33</td>
</tr>
<tr>
<td>11</td>
<td>6.5 ± 0.39</td>
<td>6.8 ± 0.48</td>
<td>7.9 ± 0.40</td>
<td>7.2 ± 0.43</td>
</tr>
<tr>
<td>13</td>
<td>7.3 ± 0.51</td>
<td>7.5 ± 0.38</td>
<td>8.5 ± 0.51</td>
<td>8.2 ± 0.57</td>
</tr>
<tr>
<td>15</td>
<td>7.8 ± 0.39</td>
<td>8.4 ± 0.50</td>
<td>9.5 ± 0.48</td>
<td>8.9 ± 0.45</td>
</tr>
</tbody>
</table>

(Values are Mean ± SE of 7 samples expressed)
treated with 200 ppm ethrel, the percentage of increase was more than that of fruits treated with 100, 300 ppm and control. The statistical analysis on fruit firmness and total soluble solid between control and treated group showed a negative correlation. The correlation coefficient values were -0.917, -0.940, -0.927 and -0.940. All observed values on correlation coefficient were statistically significant at 1% level. In mango, the TSS increased gradually during fruit ripening in both treated and control samples. The similarly trend of difference in TSS between days 0 and 11 was studied in the same chemical of ethrel treated fruits. (31). (7) Studies of (18) showed that the cherimoya fruits, during its ripening, there was a considerable loss in fruit firmness leads to an increase in total soluble solid. studied the physical and mechanical properties of mango during growth and storage to assess the stage of maturity. In some varieties of mango fruits traded commercially for consumption as ripe fruits all were harvested green and ripened after harvest. If picked immature, however, fruits develop white patches or air patches and show lower amounts of brix or total soluble solids (TSS) to acid ratio, taste and flavor, whereas over-mature fruits lose their storage life. Such fruits pose a lot of problems during handling. Mango fruits attained physiological maturity in about 90 days and the increase in size and weight almost stopped 4 to 5 weeks before harvest in Dashehari, Langra, Fazli, Zafrani, Alphonso, and kishanbhog varieties. In Aphonso, the titratable acidity increased from the sixth to the tenth week after fruits set and steadily declined thereafter as the fruits matured. Although in the presence of endogenous ethylene, the induction of the ripening process appear to be involved in the later stages of maturation and enhance uniformity of the process. However, some of it persists through ripening. The changes of titratable acidity during the different stages of fruit ripening of Mangifera indica in provided in Table 3. The titratable acidity gradually decreased throughout the ripening period of both control and treated fruits. The percentage of decrease was more pronounced in the treated with 200 ppm ethrel than in the 100, 300 ppm and control. Organic acids decrease as the fruit ripens. The predominant type of acid in ripened fruit is citric acid, followed by varying amounts of glycolic, malic, tartaric, and oxalic acids. pH was gradually increased during the course of ripening in control and treated fruits. However percentage of pH was more in the fruit treated with 200 ppm ethrel than with 100, 300 ppm ethrel and control. The statistical analysis of pH and titratable acidity both in control and treated showed a positive correlation. The correlation coefficient values were 0.99, 0.98 and 0.98. The observed correlation coefficient values were significant at 1% level (Table 4). Declined acidity brings about the shifting of pH from 2.0 to 5.5, as in the case of mango in Mangifera indica, titratable acidity decreased during ripening, in the treated fruits than in the control. Treatment of fruits with ethrel led to an increase in pH (from 3.1 to 8.9), as compared to untreated controls during ripening which is closely associated with the report of (31). In general, the level of organic acid declined during fruit ripening probably due to its utilizatio metabolism. (14).

CONCLUSION
Among the different 100, 200, and 300 ppm ethrel treatment the 200 ppm alone had the optimum effect on the ripening of off-season fruits of Mangifera indica L. var Neelum.

REFERENCES
15. Martinez, G., Serrano, M., Pretel, M. T., Riquelme,


Source of support: Nil; Conflict of interest: None declared