Varietal Response of Exogenous Ethylene Application on Fruit Quality and Storage Life of Mango (*Mangifera indica* L.)

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Physiologically mature freshly harvested Dashehari, Chausa and Langra mango fruits were subjected to 100 ppm ethylene dosing for 24 hours in a ripening chamber maintained with 24 ± 2°C temperatures, 95% relative humidity. After 48 hours holding in chamber, ripened fruits were taken out and stored at ambient condition (25 ± 2°C, 85 ± 5% RH) for 8 days. Dashehari reached to optimum soft eating stage on the 4th days after ethylene dosing. Chausa and Langra reached at optimum ripening stage on 6th day, while Dashehari spoiled and could not be stored further. Chausa and Langra lasted up to 8 days in storage, while their response to ethylene was found different. Ethylene evolution peak was observed maximum (1.81 µl C₂H₄ kg⁻¹ h⁻¹) in Dashehari and lowest (0.40 µl C₂H₄ kg⁻¹ h⁻¹) in Langra on 4th day of storage. Climacteric peak was declined on 8th day and lowest peak (0.31 µl C₂H₄ kg⁻¹ h⁻¹) was noticed in Langra fruits closely followed by Chausa. Finally we found ethylene sensitivity of these three varieties as Dashehari < Chausa < Langra.

Keywords: Mango, Ethylene, Ripening, Quality, Storage Life.

Introduction

Mango, the national fruit of India is one of the choicest tropical fruit of the world. India ranks first in mango production and half of the world's mangoes (42% or 18 million tons) are produced in India. It is mainly grown in the states like Uttar Pradesh, Bihar, Bengal, Andhra Pradesh, Karnataka and Maharashtra. Mangoes are also grown in Australia, China, Sri Lanka, Malaysia, Indonesia and Thailand. Mango is known for its attractive colour, exotic flavour, delicious taste and rich nutritional properties, particularly vitamin A (beta-carotene), potassium, and antioxidants. The fruit is highly perishable in nature having shelf life of only 4–8 days at ambient condition⁴. The colour and quality of ripened mangoes are twin prime factors which decide consumer appeal and market price. Being climacteric in nature mangoes respond very quickly to ethylene or acetylene exposure and ripen rapidly, showing respiration peaks within 24-36 hours at ambient temperature¹². Ethylene is important in plant growth and post harvest physiology of most horticulture crops and its use for initiating ripening in mango, banana and avocado is well documented¹¹. For the initiating of ripening, exposure to ethylene has to exceed to threshold level based on concentration and period of exposure. Now ethylene is commercially used for safe ripening of fruits worldwide, but its gainful potential can be achieved only with proper understanding of varietal response and storage environment (ethylene concentration, exposure time, temperature and humidity) as suggested by several researchers ⁷,¹⁸. Therefore, there is a need to standardize the ethylene doses for individual mango variety.

Materials and Methods

Fruits from three different varieties (Dashehari, Chausa and Langra) were randomly harvested at commercial maturity stage from experimental orchard of Indian Agricultural Research Institute, New Delhi, India. Prior to ethylene treatment, healthy and uniform fruits from all three cultivars were selected, de-sapped and cleaned. A total 200 fruits were selected for the experiments which were randomly divided into 4 lots containing 50 fruits in each lot. Thereafter, fruits were placed in plastic crates and kept for ripening in ethylene chamber. The ripening chamber was maintained with 24 ± 2°C temperatures, 95% relative humidity (RH) and 100 ppm ethylene dosing was allowed for 24 hours. After 48 hours holding in chamber, ripened fruits were taken out and stored at ambient condition (25 ± 2°C, 85 ± 5% RH) for 08 days. At 2 days interval, fruits from each

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varietal lot were sampled at random and subjected to analysis for different physico-chemical attributes. Total soluble solids (TSS) were determined by hand refractometer model-PAL-3 (ATAGO, Japan). Hand refractometer prism was carefully washed with double distilled water and swapped with tissue paper. Juice was extracted by straining of pulp with muslin cloth. Then two drops of juice was placed on prism and corresponding refraction index was read and expressed as °Brix. Total carotenoids content in the fruit pulp was estimated by extracting the carotenoid pigments from the fruit pulp with a mixture of petroleum ether and acetone which was then estimated in a spectrophotometer (HALO DB-20S, UV-VIS Double beam spectrophotometer, Australia) at 452 nm and the results were expressed as mg 100 g⁻¹. Percent titratable acidity was determined by a known volume of filtered mango juice titrated with standard sodium hydroxide (0.1N) using phenolphthalein as indicator. Total sugars were determined by taking a known quantity of mango sample. The fruit respiration rate of three varieties during storage, highest TSS content of 25.87°brix was in Dashehari than other varieties. After 6 days of storage, highest TSS content was recorded in Dashehari fruits increased with the progression in storage period as sources of variation. Duncan’s multiple range test was used to compare means among different treatments at a significance level of P ≤ 0.05. All analyses were performed using SAS 9.2 (SAS Institute, Cary, NC, USA).

Results and Discussions

Total Soluble Solid (TSS)
Irrespective of varieties, TSS in the treated mango fruits increased with the progression in storage period (Table 1). Rapid increase in TSS content was recorded in Dashehari than other varieties. After 6 days of storage, highest TSS content of 25.87°brix was in Dashehari fruits whereas Langra and Chausa fruit attained the optimum range of TSS (24-26°Brix) on 8th day. Interestingly, fruits of

<table>
<thead>
<tr>
<th>Character</th>
<th>Varieties</th>
<th>Control (0)</th>
<th>2nd</th>
<th>4th</th>
<th>6th</th>
<th>8th</th>
<th>C.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (°Brix)</td>
<td>Dashehari</td>
<td>9.57 ± 0.09</td>
<td>16.43 ± 0.32</td>
<td>22.93 ± 0.09</td>
<td>25.87 ± 0.62</td>
<td>-</td>
<td>1.064</td>
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<tr>
<td></td>
<td>Langra</td>
<td>8.20 ± 0.12</td>
<td>12.17 ± 0.09</td>
<td>15.20 ± 0.35</td>
<td>21.23 ± 0.41</td>
<td>24.77 ± 0.33</td>
<td>0.921</td>
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<tr>
<td></td>
<td>Chausa</td>
<td>8.13 ± 0.32</td>
<td>13.43 ± 0.38</td>
<td>16.23 ± 0.47</td>
<td>20.37 ± 0.75</td>
<td>26.90 ± 0.38</td>
<td>1.549</td>
</tr>
<tr>
<td>Acidity (%)</td>
<td>Dashehari</td>
<td>0.92 ± 0.22</td>
<td>0.31 ± 0.11</td>
<td>0.24 ± 0.04</td>
<td>0.23 ± 0.00</td>
<td>-</td>
<td>0.366</td>
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<tr>
<td></td>
<td>Langra</td>
<td>1.13 ± 0.15</td>
<td>0.49 ± 0.11</td>
<td>0.38 ± 0.04</td>
<td>0.29 ± 0.04</td>
<td>0.21 ± 0.04</td>
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<tr>
<td></td>
<td>Chausa</td>
<td>0.98 ± 0.04</td>
<td>0.42 ± 0.11</td>
<td>0.31 ± 0.04</td>
<td>0.17 ± 0.04</td>
<td>0.12 ± 0.00</td>
<td>0.193</td>
</tr>
<tr>
<td>Total carotenoids (mg 100 g⁻¹)</td>
<td>Dashehari</td>
<td>2.30 ± 0.78</td>
<td>6.50 ± 1.27</td>
<td>6.47 ± 0.19</td>
<td>12.97 ± 0.95</td>
<td>-</td>
<td>2.84</td>
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<tr>
<td></td>
<td>Langra</td>
<td>1.53 ± 0.18</td>
<td>2.77 ± 0.72</td>
<td>6.70 ± 2.07</td>
<td>7.07 ± 1.15</td>
<td>10.50 ± 2.91</td>
<td>5.45</td>
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<td>Chausa</td>
<td>2.20 ± 0.35</td>
<td>3.27 ± 0.37</td>
<td>7.17 ± 1.35</td>
<td>9.03 ± 1.08</td>
<td>11.27 ± 0.84</td>
<td>2.84</td>
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<tr>
<td>Total sugars (%)</td>
<td>Dashehari</td>
<td>2.94 ± 0.51</td>
<td>10.59 ± 1.16</td>
<td>18.36 ± 1.54</td>
<td>25.82 ± 0.97</td>
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<td>3.45</td>
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<tr>
<td></td>
<td>Langra</td>
<td>3.01 ± 0.56</td>
<td>8.17 ± 1.81</td>
<td>14.66 ± 2.14</td>
<td>18.47 ± 1.37</td>
<td>20.78 ± 1.48</td>
<td>2.44</td>
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<tr>
<td></td>
<td>Chausa</td>
<td>4.68 ± 0.64</td>
<td>12.12 ± 1.12</td>
<td>15.35 ± 1.75</td>
<td>19.43 ± 1.91</td>
<td>21.67 ± 0.96</td>
<td>2.06</td>
</tr>
</tbody>
</table>

Data are means ± standard error of three replicate determinations (n=3).

Table 1—Effect of exogenous ethylene application on fruit quality attributes of three mango varieties during storage.
Dashehari variety spoiled at 6th day, but Chausa and Langra fruits lasted up to 8 days. The probable reasons for fast TSS surge in Dashehari variety fruits might be due to higher sensitivity to ethylene, higher respiration rate and faster conversion of starch into soluble form of sugars.

**Titratable acidity**

A significant difference in the fruits acid content among varieties was observed during different storage days (Table.1). Titratable acidity of all varieties showed a liner declining trend during storage and was found to be 2 fold higher (0.21%) in Langra compared to Chausa at the end of storage of 8 days. Titratable acidity was relatively higher at zero day and then it decrease very fast during storage, which is a natural senescence linked phenomenon. Furthermore, comparatively rapid depletion organic acid in Dashehari may be attributed to differential metabolic response of individual variety to ethylene and organic acid substrate utilization in respiration process.

**Total carotenoids**

The fruit carotenoids content, that contribute to the colour of mango pulp were significantly affected by the varietal difference (Table 1). The results showed that all of them increased during mango storage, reaching maximum value at 12.97 mg /100g pulp fresh weight (FW) on the 6th day storage in Dashehari, Chausa and Langra fruits had got their fullest potential of carotenoids (10-11 mg/100 g FW) at 8th day of storage. Lower levels of carotenoids in fruit pulp of Langra and Chausa at early days of storage exposed to equal level of ethylene (100 ppm) are quite surprising, because the ethylene hormone would supposed to have the same triggering effect on all the varieties. The differential rate (low) of total carotenoids pigments development in pulp of Chausa and Langra samples could be due to delayed ethylene biogenesis. Earlier researchers also explained diverse ethylene effect on gene expression and carotenoids biosynthesis in fruits. 

**Total sugars**

Mango fruit pulp sugar content continuously increased during storage irrespective of variety (Table 1). Sharp increase in total sugars content was recorded in Dashehari over other varieties and reached at maximum (25.82%) on 6th day of storage (2 days earlier than Langra and Chausa). As anticipated differential response varieties to of ethylene treatment, Dashehari obtained early increase of soluble sugars followed by Chausa and Langra. No appreciable mean difference was observed in the development of total sugars in Langra (20.78) and Chausa (21.67) at the end of 8th day of storage. This different pattern in sugar development of tested varieties could be due to the rapid induction of pre-climacteric and climacteric phases and onset of climacteric peak in respiratory metabolic pathways of starch hydrolysis. Moreover, in addition to starch hydrolysis and accumulation of soluble sugars, it is also possible to speculate that some mechanisms of cell wall disassembly could provide a source of carbon for sugar synthesis during ethylene induced ripening.

**Fruit colour (L value)**

Surface colour was measured by L, value and its values are given in fig. 1. L value indicating that brightness has increase gradually during storage from zero day treatment till the end of storage life. Fruit colour was consistent increase in redness (a value) and yellowness of fruit peel with the advancement in the storage period of all three varieties. Irrespective of the variety, negative a-value (greenness) decreased from first day of treatment till the end of their storage life. However, Dashehari and Chausa mango lost their greenness in almost 3 days of storage while Langra was found laggard. The colour change is a consequence of the chlorophyll breakdown and formation of carotenoid pigments. Slower breakdown of chlorophyll in Langra may be due to the lower metabolic activity compared to Dashehari.

**Fruit firmness**

The data on fruit firmness revealed that the firmness of mango fruits during storage was significantly varied among selected varieties. It followed a declining trend commensurate with

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*Fig.1—Effect of exogenous ethylene on ‘L’ value of Dashehari, Chausa and Langra mango during storage.*
advancement in ripening period (Fig. 2). In the present investigation, Langra fruit maintained the highest mean firmness (3.76 N) followed by Chausa (2.43 N) and Dashehari (2.31 N) till 8 days of storage life. Softening of the fruits is caused either by breakdown of insoluble proto-pectins into soluble pectin or by hydrolysis of starch. Dashehari fruit registered the lowest mean firmness (2.31 N) which may be due to rapid breakdown of insoluble proto-pectin into soluble pectin or by cell wall disintegration leading to membrane permeability\textsuperscript{17}. The loss of pectin substance in the middle lamella of cell wall is perhaps the key step in the ripening process that leads to the loss of cell wall integrity thus cause loss of firmness and softening\textsuperscript{14}. Moreover, covering of the cuticle and lenticels and their antifungal activity also influence the fruit firmness during storage\textsuperscript{10}.

Respiration rate
Initially, respiration rate of fruits continuously increased from upto 4 days and thereafter it declined sharply (Fig. 3). All three varieties fruits (Dashehari, Langra and Chausa) have shown a respiration peak on 4\textsuperscript{th} day. Highest respiratory peak value (63.20 ml CO\textsubscript{2} kg\textsuperscript{-1} h\textsuperscript{-1}) was observed in Dashehari fruits whereas lowest peak (38.66 ml CO\textsubscript{2} kg\textsuperscript{-1} h\textsuperscript{-1}) was observed in Langra fruits on 4\textsuperscript{th} day of storage. The probable reason for differential respiration rate among tested varieties might be attributed to variation in resistant starch, cell wall degrading enzymes, internal tissue ethylene contents and lenticels distribution pattern\textsuperscript{3}.

Ethylene evolution rate
Ethylene evolution was not detected in freshly harvested fruits but evolution started from 2\textsuperscript{nd} day onwards (Fig. 4). As mango is a climacteric fruit, evolution peak was observed maximum (1.81 µl C\textsubscript{2}H\textsubscript{4} kg\textsuperscript{-1} h\textsuperscript{-1}) in Dashehari and lowest (0.40 µl C\textsubscript{2}H\textsubscript{4} kg\textsuperscript{-1} h\textsuperscript{-1}) in Langra on 4\textsuperscript{th} day of storage. Climacteric peak was declined during 8\textsuperscript{th} day and lowest peak (0.31 µl C\textsubscript{2}H\textsubscript{4} kg\textsuperscript{-1} h\textsuperscript{-1}) was noticed in Langra fruits closely followed by Chausa. Ethylene is a ripening hormone which slowly increased internally and ripened the fruits. The possible reasons for least ethylene evolution rate in Langra and higher in Dashehari fruits might be linked with varietal genetic makeup, level of anti senescence hormones like auxins and gibberellins and activities of pectin methyl esterase and polygalacturonase activity enzymes\textsuperscript{3}.

Conclusions
The present study showed that mango varieties like Dashehari, Langra and Chausa requires different doses of ethylene treatment for their fruit ripening. Dashehari gives optimal ripening with <100 ppm ethylene dosing while Chausa and Langra varieties requires around 100 ppm ethylene dosing for 24 hours at 24 ± 2°C temperatures, 95% relative humidity. Over dosing of ethylene treatment shortened the fruit shelf-life and also results in wastage of precious inputs. Therefore based on the findings, it can be suggested that there is a need to work out an optimum
ethylene dose and dosing period for ripening of each mango variety in order to preserve fruit quality and extend shelf life during storage without any adverse effects on consumer’s health.

Reference