Evaluation of sensory attributes of mango fruits CV ‘Alphonso’ as influenced by pre-harvest treatments

Manasa B, SL Jagadeesh, N Thammaiah and Netravati

Abstract
In the present investigation, fruits of trees treated with Azoxystrobin sprays at 0.1 per cent scored higher for the colour and appearance of peel and pulp (7.91 and 8.15). This is further confirmed by the presence of significantly higher β-carotene content (59.12 ppm) in the pulp of the mango fruits under the same treatment imparting a bright yellow colour to the pulp. Unimpeded and coordinated ripening process facilitated by Azoxystrobin lead to the maintenance of sensory quality of mango fruits. For similar reasons, this treatment scored significantly higher for texture (8.22), and taste and flavour (8.45) and therefore scored organoleptic ally superior for overall acceptability (8.18). Lack of colour development with lower β-carotene (47.68 ppm) content followed by minimum sensory scores for peel (4.31), pulp (4.91), texture (4.82) and taste (4.59) of the control fruits made the control fruits organoleptic ally less acceptable (4.65).

Keywords: β-carotene, ripening, taste, flavor, colour, texture

Introduction
Mango is the most popular fruit crop grown in many states of India. The pulp of the mango has a major share among export commodities from India. ‘Alphonso’ amid different other varieties is renowned for its attractive reddish yellow colour, rich aromatic flavor and delicious sugar acid blend taste. Ripening of mango is initiated by climacteric method of respiration along with ethylene evolution (Brechtl and Yahia, 2009) resulting in various physiological changes with respect to colour, aroma, taste, flavor and texture of the fruit. These changes can be perceived through our sense organs eye, nose, ear and skin and quality of the fruit can be evaluated. Sensory analysis is a scientific discipline to measure, analyze and interpret the characteristics of any food based on responses from the sense organs. Various sensory neurons present in these sense organs are responsible for getting the suitable response. Colour and appearance perceived by eye plays a prominent role for determining quality as it solely can accept or reject the food (Mackinney and Little, 1962). Human eyes through experience can differentiate three important colour pigments like chlorophyll (green), carotenoids (yellow) and anthocyanins (red). In mango, with the onset of climacteric respiration during ripening, chlorophyll in the peel breakdowns to carotenoids (Krishnamurthy and Subramanyam, 1970; Salunke and Desai, 1984) leading to change of colour from green to yellow that a human eye can detect. While in the pulp, additional carotenogenesis results in the eye appealing yellow colour (Bhaskarachary et al., 1995; Mattoo et al., 1968). β-carotene, one of the carotenoid fractions occupies 50 per cent of total carotenoids in the ripe pulp of ‘Alphonso’ mango (Jungalwala and Cama, 1963; John et al., 1970). Thus, colour is an important quality trait in mango sensory evaluation. Texture analysis is a physical stimulus resulting from touching the fruits like firm, soft or juicy. In mango, softness during ripening is an important sensory attribute for texture evaluation. Softening of the mango fruit is characterized by an increase in the solubility of cell wall pectins (Nasrijal, 1993). Taste and flavor of the fruit are the chemical senses influenced by the proportion of sugars, acidity, volatiles and firmness factors perceived by mouth-feel. A human taste buds can recognize four basic tastes like sour, bitter, sweet and salt based on the chemical senses. In ripe mango, appreciable mouth-feel due to fruit softening (Nasrijal, 1993), increase in sugars predominantly sucrose and decrease in citric acid (Medlicott and Thompson, 1985) and flavour imparting monoterpenes hydrocarbons (Engel and Trresl, 1983) lactone and some fatty acids (Wilson et al., 1990). Over all acceptability is the average of all the sensory attributes of a food. Hedonic tests are mostly commonly used sensory evaluation that include ranking of individual sensory characteristics of any food based on which results are interpreted and evaluated for its...
quality. In the present experiment, resultant fruits of mango trees applied with different pre-harvest treatments for anthracnose management were used for physico-chemical and sensory evaluation.

Materials and Methods
Mango fruits cv ‘Alphonso’ of uniform size and maturity were obtained from a farmers’s orchard at Kittur, Karnataka at the fortnight of May during the experimental years I (2012-13) and II (2013-14) respectively. These fruits were the resultant of previous experiment where trees were given three sprays with fungicides like carbendazim (Bavistin 50 DF), tricyclazole (Beam 75 WP), Azoxystrobin (Amistar 250 SC), thiophanate methyl (Topspin M 70 WP) at 0.1% each and Zineb (Dithane Z -78) at 0.2%; botanicals like Euypatorium odoratum and Nerium oleander each at 5% and bioagents like Trichoderma viride and Trichoderma harzianum each at 0.5% before harvest for anthracnose management. The experiment followed RBD (Randomized Block Design) with three replications and two trees per replication. Fruits were brought to the laboratory, Department of Post-Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, India where damaged, bruised, punctured and infected fruits were discarded manually. The fruits were further pre-cooled in cold storage at 13±1°C for twelve hours to remove field heat. After removal from the cold room, all fruits were thoroughly washed in 0.2 per cent sodium hypochlorite solution for five minutes to remove the surface microbial load and dirt. Immediately, fruits were air dried under fan to remove the moisture on the surface before packing. Fruits were then packed in ventilated corrugated fibre board (CFB) boxes and cushioning was provided with paper sheds between the fruits to avoid direct contact with each other. This simulated the commercial way of packing the mangoes. The boxes containing fruits of respective treatments were stored under ambient condition in the laboratory for natural ripening. Upon ripening, fifteen fruits per treatment, replicated thrice were taken out for β-carotene and organoleptic evaluation at storage.

β – Carotene (ppm)
β-Carotene was estimated by using water saturated n-butanol (AOCC, 1995) [3]. A sample of 5g was dispersed in 25ml water saturated n-butanol to make a homogeneous suspension. It was shaken gently and allowed to stand overnight (16 hours) at room temperature in complete darkness. The suspension was again shaken and filtered through the Whatman filter paper No. 1 and the volume of filtrate was made to 50ml. The absorbance was measured at 440 nm in spectronic 20 using saturated n-butanol as a blank. The amount of beta-carotene was calculated using the following equation.

\[
\text{Beta-carotene content (ppm)} = 0.01005 + 23.5366 \times \text{Absorbance}
\]

Organoleptic evaluation of fruits
Organoleptic evaluation of ripe fruits was carried out by a panel of semi-trained judges. The sensory characters like skin colour, pulp colour and appearance, pulp texture, taste and flavour, and overall acceptability were evaluated on a 9-point Hedonic scale using the score card as mentioned in table 1. The mean of scores given by the judges were used for statistical analysis.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Peel colour and appearance</th>
<th>Pulp Colour and appearance</th>
<th>Pulp Texture</th>
<th>Pulp taste and flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>3</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>5</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>7</td>
<td>Very good</td>
<td>Very good</td>
<td>Very good</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>9</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Statistical analysis
Statistical analysis Statistical analysis was performed for both the years separately and then pooled. All data were collected and analysed by randomized block design (RBD). Significant differences among means at P ≤ 0.05 were determined by post hoc tests using Duncan’s multiple range test (Duncan, 1955) [3].

Results
β-carotene (ppm)
The pooled data of β-carotene of mango fruits showed significant changes for various pre-harvest treatments during the storage (fig 2). In the study, it was observed that the significantly maximum β-carotene (ppm) concentration in the fruits of Azoxystrobin at 0.1% during year I, year II and in pooled analysis (58.44 ppm, 59.80 ppm and 59.12 ppm respectively). During year II, the least β-carotene (ppm) content was recorded in the treatment control (47.82 ppm) and it was statistically non-significant with Nerium oleander at 5% (48.79 ppm) and tricyclazole at 0.1% (49.50 ppm). During year II and pooled analysis, control (47.54 ppm and 47.68 ppm) was recorded minimum β-carotene and was at parity only with Nerium oleander at 5% (47.95 ppm and 48.37 ppm).

Sensory evaluation
Organoleptic scores for peel colour and appearance were maximum in the treatment Azoxystrobin at 0.1% during year I, year II and in pooled analysis (7.40, 8.40 and 7.91 respectively) (Table 2). However, the treatment carbenazim at 0.1% was found statistically on par with Azoxystrobin at 0.1% during year I (6.40) and in pooled analysis (6.47). Minimum score for peel colour was associated with control (4.35, 4.25 and 4.31) and it did not differ statistically with rest of the treatments.

Pulp colour and appearance
The pulp colour of mango observed visually also obtained maximum score in the treatment Azoxystrobin at 0.1% during year I (7.92), year II (8.38) and in pooled analysis (8.15) (Table 2). The next best scoring treatment was carbenazim at 0.1% and it was found on par with Azoxystrobin at 0.1% during year I (6.41) and in pooled analysis (6.56). Control (4.58, 5.24 and 4.91) scored the least for pulp colour and appearance and it was found at parity with all other treatments.

The mean of scores given by the judges were used for statistical analysis.
Texture
Mango texture revealed high scores for the treatment Azoxystrobin at 0.1% during both the years (8.22 and 8.21) and in combined analysis (8.22) (Table 3). This treatment was non-significantly followed by carbendazim at 0.1% (6.65, 7.39 and 7.03). The lowest score for texture was noted in control (4.48, 5.15 and 4.82) throughout the investigation and it was found to be at parity with rest of the treatments.

Taste and flavour
Taste and flavour of mango fruits during year I, year II and pooled analysis recorded maximum scores in the treatment Azoxystrobin at 0.1% (8.34, 8.56 and 8.45) (Table 3). The treatment Azoxystrobin at 0.1% did not show statistical difference with carbendazim at 0.1% only during year I (6.56) but showed significant difference over all the treatments during year II as well as in pooled data analysis. The lowest score for taste and flavour was noted in control (4.43, 4.75 and 4.59) throughout the investigation and it was found to be at parity with rest of treatments.

Overall acceptability
Pooled analysis of overall acceptability showed that the Azoxystrobin at 0.1% continued to score higher values for overall acceptability (8.18) (fig 1) that registered significant differences among rest of the treatments. Similar trend was observed in years I and II (7.97 and 8.39) under the same treatment. The lowest score for overall acceptability was noted in control during combined analysis (4.65) and individual years (year I-4.46, year II-4.85) it was on par with rest of treatments.

Discussion
As recorded in our previous paper (Manasa et al., 2018a; 2018b)[25, 26] disease incidence and index (3.3% and 1%) were minimum in the fruits of trees treated with Azoxystrobin at 0.1 per cen. Organeoleptic scores of the fruits in the same treatment Azoxystrobin at 0.1 per cent scored significantly maximum for colour of peel (7.91) and pulp (8.15) in this investigation (Table 2). However, studies on influence of Azoxystrobin on colour of the fruit have not been reported. Higher instrumental values ($L^*$, $a^*$, $b^*$) (data not shown) for peel and pulp colour obtained for fruits under this treatment support their better appearance as adjudged by the sensory panel. ‘Alphonso’ mango fruit reaches the climacteric respiratory peak at five days after harvest followed by ripening within seven or eight days (Karmarkar and Joshi, 1941) [16]. However, ripening was delayed by 14 days in the mango fruits under treatment Azoxystrobin as observed in our previous paper under the same study (Mansi et al., 2018b)[26]. Respiratory climacteric coincides with increased ethylene production (Mattoo and Modi, 1969) and carotenoids breakdown in the peel of fruits (Krishnamurthy and Subramanyam, 1970; Akamine and Goo, 1973; Salunke and Desai, 1984)[17, 1, 34]. Unripe mango peel comprises of well-organized grana and osmiophilic globules in the chloroplast cells. This granal membrane loses integrity during ripening and osmiophilic globules appear indicating the transformation of chloroplasts to chromoplast resulting in colour change in mango peel from green to yellow (John et al., 1970; Lakshminarayana, 1980; Parikh et al., 1990; Lizada, 1993)[14, 18, 31, 23]. This colour change of skin augments with intensification in carotenoid synthesis (Saltveit, 1999) [33] and is facilitated by enzyme chlorophyllase (Gowda and Huddar, 2001; Wills et al., 1982)[33, 35]. Superior colour of fruits in this treatment Azoxystrobin might be due to its favorable effect on ripening process in the absence or reduced presence of disease infestation. Correspondingly, higher scores were observed for pulp colour (8.15) (Table 2) of mango fruits under the same treatment. Carotenoid syntheses in mango pulp involves the increment in the geraniol and mevalonic acid content catalyzed by the enzyme phosphatase (Mattoo et al., 1968)[27]. β- carotene occupies nearly fifty per cent of the total carotenoids in the ripe pulp of ‘Alphonso’ (Jungalwala and Cama, 1963; John et al., 1970)[15, 14]. Coordinated ripening events that might have led to appreciable colour quality of fruits in the treatment Azoxystrobin may be further justified beyond doubt by the presence of maximum β-carotene (59.12 ppm) in the pulp (fig 2). The fruits of Azoxystrobin recorded significantly higher firmness values with pressure tester (339.38 g) as recorded in our previous investigation (Manasa et al., 2018b)[26]. This is in correspondence to the present study, where the fruits under Azoxystrobin at 0.1% recorded significantly maximum sensory scores for pulp texture (8.22) (Table 3). Textural firmness during ripening of mango fruits declines due to variations in the pectic substances cementing the cell wall, hemicelluloses and cellulose during the ripening of fruit (Leopold, 1964)[21]. Softening of mango occurs by increased solubility of cell wall pectins (Roe and Bruemmer, 1981; Lazan et al., 1986; Nasrial, 1993)[32, 20, 30] regulated by increased activity of β-galactosidase enzyme (Ali et al., 1995)[2] resulting in disintegration of cellulose and the hemicellulose network (Liu et al., 2009)[22]. Mango fruits under azoxistrobin at 0.1% recorded significantly maximum scores for taste and flavour (8.45) (Table 3.) and were composed of optimal sugar acid ratio (47.64) as observed in our previous experiment of the same study (Manasa et al., 2018b)[26]. Sugar mainly glucose and acids predominantly citric acid, the ratio of two is responsible for the subtle blend of sweet-sour taste of ‘Alphonso’ mango. Ripe ‘Alphonso’ mango consists of different aroma compounds like fruity esters like aldehydes and esters; burnt sugars like Benzonitrile etc (Bandyopadhyay, 1983) [8]. Loss of organic acids during ripening may produce necessary flavours in mango fruits (Baldwin et al., 1999)[4]. Fatty acids palmitoleic and palmitic acids (Gholap and Bandyopadhyay, 1976 and 1980)[12, 11], monoterpenins hydrocarbons (Engel and Tresl, 1983) [10] and lactone (Bhandopadhyay and Gholap, 1973; Wilson et al., 1990)[6, 37] determines the flavour quality of mango fruits during ripening at ambient temperature. A noticeable mouth-feel of taste and flavour contributed by softening of peel, sweet-acid ratio along with production of desirable flavour might have impressed panel members. The overall acceptability thus might have resulted in significantly higher scores (8.18) for this treatment (fig 1). It is interesting to note that though the treatment Azoxystrobin delayed ripening, it was able to preserve the superior sensory quality of the mango fruits upon ripening.
### Table 2: Sensory evaluation of peel and pulp colour of mango fruits as influenced by various pre-harvest treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Peel colour and appearance</th>
<th>Pulp colour and appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year I</td>
<td>Year II</td>
</tr>
<tr>
<td>Control</td>
<td>4.35c</td>
<td>4.25c</td>
</tr>
<tr>
<td>Carbendazim at 0.1%</td>
<td>6.40ab</td>
<td>6.53b</td>
</tr>
<tr>
<td>Tricyclazole at 0.1%</td>
<td>4.64c</td>
<td>4.63c</td>
</tr>
<tr>
<td>Azoxystrobin at 01%</td>
<td>7.40a</td>
<td>8.40a</td>
</tr>
<tr>
<td>Thiophanate methyl at 0.1%</td>
<td>5.05bc</td>
<td>5.53bc</td>
</tr>
<tr>
<td>Zineb at 0.1%</td>
<td>5.18bc</td>
<td>5.46bc</td>
</tr>
<tr>
<td><em>Eupatorium odoratum</em> at 5%</td>
<td>5.49bc</td>
<td>5.75bc</td>
</tr>
<tr>
<td><em>Nerium oleander</em> at 5%</td>
<td>4.50c</td>
<td>5.03bc</td>
</tr>
<tr>
<td><em>Trichoderma viride</em> at 0.5%</td>
<td>5.33bc</td>
<td>5.70bc</td>
</tr>
<tr>
<td><em>Trichoderma harzianum</em> at 0.5%</td>
<td>4.42c</td>
<td>4.67c</td>
</tr>
</tbody>
</table>

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

### Table 3: Sensory evaluation of texture and taste and flavour of mango fruits as influenced by various pre-harvest treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Texture</th>
<th>Taste and flavour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year I</td>
<td>Year II</td>
</tr>
<tr>
<td>Control</td>
<td>4.48c</td>
<td>5.15c</td>
</tr>
<tr>
<td>Carbendazim at 0.1%</td>
<td>6.65ab</td>
<td>7.39ab</td>
</tr>
<tr>
<td>Tricyclazole at 0.1%</td>
<td>4.71c</td>
<td>5.61c</td>
</tr>
<tr>
<td>Azoxystrobin at 01%</td>
<td>8.22a</td>
<td>8.21a</td>
</tr>
<tr>
<td>Thiophanate methyl at 0.1%</td>
<td>5.63bc</td>
<td>6.55bc</td>
</tr>
<tr>
<td>Zineb at 0.1%</td>
<td>5.82bc</td>
<td>5.76c</td>
</tr>
<tr>
<td><em>Eupatorium odoratum</em> at 5%</td>
<td>5.67bc</td>
<td>5.82c</td>
</tr>
<tr>
<td><em>Nerium oleander</em> at 5%</td>
<td>5.19bc</td>
<td>5.42c</td>
</tr>
<tr>
<td><em>Trichoderma viride</em> at 0.5%</td>
<td>5.58bc</td>
<td>6.06bc</td>
</tr>
<tr>
<td><em>Trichoderma harzianum</em> at 0.5%</td>
<td>5.63bc</td>
<td>5.26c</td>
</tr>
</tbody>
</table>

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

**Fig 1:** Overall acceptability of mango fruits cv ‘Alphonso’ as influenced by various pre-harvest treatments. Figure represents the pooled analysis of two year’s data.

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Fig 2: β-carotene (ppm) of mango fruits cv ‘Alphonso’ as influenced by various pre-harvest treatments. Figure represents the pooled analysis of two year’s data. Bars with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

References
36. Wilson EW, Shaw PE, Knight RI. Importance of some lactones and 2.5 dimethyl-4-hydroxy-3(2H)-furanone to mango (Mangifera indica L.) aroma. Journal of Agricultural and Food Chemistry. 1990; 38:1556-1559.
37. Wilson EW, Shaw PE, Knight RI. Importance of some lactones and 2.5 dimethyl-4-hydroxy-3(2H)-furanone to mango (Mangifera indica L.) aroma. Journal of Agricultural and Food Chemistry. 1990; 38:1556-1559.