Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2019; 8(1): 2466-2470
Received: 28-11-2018
Accepted: 30-12-2018

**Manasa B**
Ph.D (Horticulture), Kittur Rani Chennamma College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot, Karnataka, India

**SL Jagadeesh**
Professor & Head, Department of Postharvest Technology, College of Horticulture, Udyanagiri, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

**N Thammaiah**
Professor & Head, Department of Plant Pathology, College of Horticulture, Mysuru, University of Horticultural Sciences, Bagalkot, Karnataka, India

**Nethravathi**
Assistant Professor, Department of Postharvest Technology, College of Horticulture, Udyanagiri, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

**Correspondence**
**Manasa B**
Ph.D (Horticulture), Kittur Rani Chennamma College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot, Karnataka, India

# Colour measurement of ripening mango fruits as influenced by pre-harvest treatments using *L* a* b** coordinates

**Manasa B, SL Jagadeesh, N Thammaiah and Nethravathi**

## Abstract
Colour development is one of the important ripening processes for determining the quality of mango fruits. In this experiment, pre-harvest treated 'Alphonso' mango fruits were measured objectively for peel and pulp colour using Hunter ($L^*$ $a^*$ $b^*$) colour system. Azoxystrobin at 0.1% treatment resulted in brighter and superior reddish yellow colour development of peel of mango. Peel values of fruits under this treatment for $L^*$ (63.38), $a^*$ (17.66) $b^*$ (61.03), $C^*$ (62.13) and $h^0$ (70.48) were significantly higher than control and other treatments. Mango fruits under the same treatment achieved greater colour development for the pulp with $L^*$ (64.16), $a^*$ (28.43) $b^*$ (66.34), $C^*$ (75.18) and $h^0$ (68.54) that were in significance with rest of the treatments. Control fruits on the other hand showed poor values for each of colour coordinates indicating lack of proper colour development during ripening.

**Keywords:** Mango, $L^*$, $a^*$, $b^*$, $C^*$, $h^0$, Azoxystrobin, ripening, colour

## Introduction
Mango is one of the most popular fruits in India and many countries in the world. 'Alphonso', the choicest mango cultivar known for its appealing reddish-yellow colour, unique taste and flavour with subtle blend of acid and sugar stands first in the export market of our country. Mango colour development involves significant physiological changes during ripening. The fruit shows climacteric pattern of respiration during ripening (Lalel *et al*., 2003; Brecht and Yahia, 2009) [10, 2] that coincides with the increased ethylene production (Mattoo and Modi, 1969) [14] boosting respiration and breakdown of peel carotenoids (yellowing) (Krishnamurthy and Subramanyam, 1970; Akamine and Goo, 1973) [8, 1]. Peel colour of mango fruits alters from dark green to yellow colour where chloroplasts in the peel are converted to chromoplasts comprising red and yellow pigments, (John *et al*., 1970; Lizada, 1993) [5, 11] facilitated through the action of enzyme chlorophyllase, oxidative system and pH change or photo degradation (Gowda and Huddar, 2001; Wills *et al.*, 1982) [4, 18]. Alphonso mango pulp upon ripening was proposed to have 16 carotenoid fractions with β- carotene occupying 50 per cent of total carotenoids (Jungalwala and Cama, 1963; John *et al*., 1970) [6, 5]. Mango carotenogenesis in the pulp is mediated by phosphatase enzyme (Mattoo *et al.*, 1968) [13]. Measurement of colour is one of the important aspects for determining the ripening quality of mango fruits. Hunter ($L^*$, $a^*$, $b^*$) is most commonly used colour system for measuring colour. It uses rectangular coordinates that is labelled with three dimensions of a colour as $L^*$, $a^*$, $b^*$. The $L^*$ coordinate denotes lightness, the $a^*$ coordinate represents redness ($+a^*$) or greenness ($–a^*$), and the $b^*$ coordinate symbolizes yellowness ($+b^*$) or blueness ($–b^*$). In this system, an object for colour measure is assigned $L$, $a$, $b$ value that defines the colour and its location in the three-dimensional colour space. The distance between two colours, each with their own colour space location, refers to a computable colour difference. Chroma or saturation ($C^*$) indicate purity of the hue and measures colour to a neutral grey of the same lightness (Shafiee *et al.*, 2010; Kevin, 2002) [17, 7]. (Hue ($h^o$) angle is represented in degrees, with 0° for $+a^*$ axis (red), till 90° for the $+b^*$ axis (yellow), 180° for $-a^*$ (green) and lastly 270° for $-b^*$ (blue) (Kevin, 2002) [7]. Mango fruits despite being attractive and delicious, suffers with many postharvest diseases and anthracnose caused by the fungus *Colletotrichum gloeosporioides* Penz being the deadliest of all. The disease is carried as latent infection from the field and becomes conspicuous upon ripening of fruits leading to rotting. The appearance of the fruit is thus affected resulting in low market value. Current investigation is the continuation of the previous experiment which included pre-harvest treatment of mango fruits with different fungicides, bioagents and botanicals for anthracnose management. In this experiment the resultant fruits from the latter experiment were studied at ripening for colour changes using Hunter $L^*$ $a^*$ $b^*$

colour coordinates to know the influence of pre-harvest treatments on mango colour development.

**Materials and Methods**

Twelve year old, uniformly grown, Alphonso mango trees aged 12 years, raised by approach grafting were imposed with fungicides like carbendazim (Bavistin 50 DF), tricyclazole (Beam 75 WP), Azoxystrobin (Amistar 250 SC), thiophanate methyl (Topsin M 70 WP) at 0.1% each and Zineb (Dithane Z -78) at 0.2%; botanicals like *Eupatorium odoratum* and *Nerium oleander* each at 5% and bioagents like *Trichoderma viride* and *Trichoderma harzianum* each at 0.5% three times before harvest during pre-flowering (Dec), peanut (Feb) and marble (March) stages of fruits during the years 2012-13 (year I) and 2013-14 (year II) respectively. Three replications per treatment and two trees per replication were assigned. Non-sprayed trees were considered as control. During harvest, 25 mango fruits with uniform maturity, size, free from diseases were selected per treatment, packed in CFB boxes and brought to the laboratory, Department of Post-Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, India. The fruits were stored at ambient temperature and allowed for natural ripening to study the colour change.

**Preparation of fungicides, bioagents and botanicals**

Fungicides were obtained from Karnataka Agro Chemicals, Dharwad. Systemic fungicides like Azoxystrobin (Amistar, 250 SC), thiophanate methyl (Topsin-M, 70 WP), carbendazim (Bavistin, 50 DF), Tricyclazole (Beam, 75 WP) were prepared at 0.1 per cent by dissolving 1 g/ 1 ml of each fungicide was dissolved in 100 ml of water and volume made up to 1000 ml. While Zineb of 0.2% was prepared with 2 g of Zineb in 100 ml of water and then making up the volume to 1000 ml. Bioagents, *Trichoderma viride* and *Trichoderma harzianum* were obtained from the Department of Plant Pathology, University of Agricultural Sciences, Dharwad. Each were set at 0.5 per cent concentration by dissolving 5 g of respective culture in 100 ml of water and then making up the volume to 1000 ml. Leaves of botanicals *Eupatorium odoratum* (Siam weed) and *Nerium oleander* (Oleander) were collected, rinsed, extracted juice and the solution was then made up to 1000 ml volume with distilled water to achieve 5 per cent concentration. According to the concentration adopted each for fungicides, bioagents and botanicals, 6 litres of spray solution were prepared for the complete canopy coverage.

**Instrumental analysis of peel and pulp colour ($L^*$ $a^*$ $b^*$, $C^*$, $h^0$)**

The colour of samples was measured using a Lovebird colour meter (Lovebird RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with 8mm diameter aperture. The instrument was calibrated using the black and white tiles provided. Colour was expressed in Lovebird units $L^*$ (Lightness/darkness), $a^*$ (redness/greenness), $b^*$ (yellowness/blueness), $C^*$ (chroma) and $h^0$ (hue angle). Ripened mango fruits were directly placed under the aperture of the colour meter and measured on three sides per fruit for both peel and pulp colour analysis and the values were averaged.

**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 $P \leq 0.05$ were determined by post hoc tests using Duncan's multiple range test (Duncan, 1955) [3].

**Results**

**Peel colour**

The observations on peel colour of mango fruits as influenced by different pre-harvest treatments registered significant differences with respect to $L^*$, $a^*$, $b^*$, $C^*$ and $h^0$ (Table 1, 2). The $L^*$ values were significantly higher in the fruits of mango trees subjected to the treatment Azoxystrobin at 0.1% during year I (63.23), year II (63.52) and in pooled analysis (63.38). Conversely, in year I and year II, the control (37.52 and 42.07) documented significantly low $L^*$ values for peel colour. However, the treatments *Nerium oleander* at 5% (39.48 and 43.06) and *Trichoderma harzianum* at 0.5% (40.78 and 43.65) were found to be on par with control. In pooled analysis, control with minimum peel $L^*$ value (39.80) was found to vary non-significantly with *Nerium oleander* at 5% (41.27). Perusal of data on $a^*$ values of mango peel colour indicated that the treatment Azoxystrobin at 0.1% was remarkably superior during year I, year II and even after pooled analysis of data (16.73, 18.59 and 17.66 respectively). In contrast, the fruits of control (2.61, 3.69, 3.15) contained minimum $a^*$ values during both the years and even when pooled. In addition, the fruits of *Nerium oleander* at 5% (3.61, 4.43, 4.02 respectively, *Trichoderma harzianum* at 0.5% (4.36, 5.61, 4.99) and Tricyclazole at 0.1% (4.84, 5.95, 5.40) were at statistical parity with control during year I, year II and in combined analysis. Significantly higher $b^*$ values of mango peel colour was established in Azoxystrobin at 0.1% (60.39, 61.66, 61.03) for two years and when average was analyzed. The least $b^*$ values were found in the fruits of control (41.58, 42.58, 42.08). Control fruits did not differ statistically with fruits of *Nerium oleander at 5%* (42.48, 43.56, 43.02) and Tricyclazole at 0.1% (43.69, 45.44, 44.57) when observed during year I, year II and in pooled analysis. The study on $C^*$ of mango peel colour connoted that the Azoxystrobin at 0.1% stood significantly than all the treatments during year I (61.31), year II (62.95) and in pooled analysis (62.13). Distinctively, significantly minimum $C^*$ values were observed in control during the two years of investigation (44.60, 46.12) and even when combined (45.36). The treatments *Nerium oleander* at 5% (45.58, 47.26, 46.42) and *Trichoderma harzianum* at 0.5% (45.68, 47.21, 46.45) were statistically at parity with control at similar intervals. However, the treatment Tricyclazole at 0.1% (47.51) exhibited non-significance with the control during year I (48.11) and in pooled analysis (47.82). Hue angle ($h^0$) of mango peel colour was significantly minimum in the treatment Azoxystrobin at 0.1% during year I, year II and even after combined analysis (72.55, 68.40, 70.48). The maximum ($h^0$) value was observed in control (88.81, 87.59 and 88.20) and it was found to be on par with *Nerium oleander* at 5% (87.06, 84.99 and 86.02), *Trichoderma viride* at 0.5% (86.34, 84.65 and 85.50) and *Trichoderma harzianum* at 0.5% (86.16, 84.88 and 85.52) throughout the investigation.

**Pulp colour**

Pulp colour of mango fruits as influenced by different pre-harvest treatments showed significant differences with respect to $L^*$, $a^*$, $b^*$, $C^*$ and $h^0$ (Table 3, 4). The $L^*$ (Lightness) values were observed to be significantly higher in the treatment Azoxystrobin at 0.1% during year I (63.55), year II

(64.75) and in pooled analysis (64.16). Minimum and almost close values of *L** in year I was noticed in the treatments control (46.25), Tricyclazole at 0.1% (46.49), *Nerium oleander* at 5% (46.69) and *Trichoderma harzianum* at 0.5% (45.61) and they were on par with *Trichoderma viride* at 0.5% (48.34). During year II, the control fruits control (47.32) recorded the least *L** value and it was followed non-significantly by Tricyclazole at 0.1% (49.68). Statistical analysis of combined data revealed that the control (46.79) continued to document the least *L** value and it was on par with the treatments Tricyclazole at 0.1% (48.09), *Nerium oleander* at 5% (49.01) and *Trichoderma harzianum* at 0.5% (48.63). The inspection of data on *a** (Redness) values of mango pulp colour indicated that treatment Azoxystrobin at 0.1% was significantly higher during year I, year II and even after analysing the pooled data (27.04, 29.82 and 28.43 respectively). In year I, minimum *a** value was noticed in control (13.48) followed by *Trichoderma harzianum* at 0.5% (13.97), *Nerium oleander* at 5% (14.03) and *Trichoderma viride* at 0.5% (15.14). However, in year II, both control (13.22) and *Nerium oleander* at 5% (13.42) were found to record the least and intimate values of *a** and both were at parity with control (15.40) Tricyclazole at 0.1% (16.45). Pooled analysis registered almost similar trend as in year II with lower *a** value in control (13.36) closely followed by *Nerium oleander* at 5% (13.73) and *Trichoderma harzianum* at 0.5% (14.69). The highest significant *b** (Yellowness) values of mango pulp colour was seen in Azoxystrobin at 0.1% (65.42, 67.26 and 66.34) during the two years and when the average was analysed. The least *b** values in year I and year II were found in the fruits of control (48.29 and 50.01) and the treatment was statistically like *Nerium oleander* at 5% (48.95 and 50.85), *Trichoderma harzianum* at 0.5% (49.50 and 51.71) and Tricyclazole at 0.1% (49.43 and 51.50). But after analysis of pooled data, control (49.15) with minimum *b** value was had no significant difference with *Nerium oleander* at 5% (49.90), *Trichoderma harzianum* at 0.5% (50.61) and Tricyclazole at 0.1% (50.47). Mango pulp colour with respect to *C** (Chroma) presented significantly higher values in Azoxystrobin at 0.1% during the individual years and after pooling them (year I- 73.73, year II- 76.64 and pooled- 75.18). On the other hand, lower *C** values were observed in control (52.80) and this treatment was at parity with *Nerium oleander* at 5% (55.27), *Trichoderma harzianum* at 0.5% (55.69) and Tricyclazole at 0.1% (55.81) during the experimental year I. While in year II and pooled analysis, control (54.21 and 53.51) registered lower *C** value and it did not differ statistically with *Nerium oleander* at 5% (55.39 and 55.33) and *Trichoderma harzianum* at 0.5% (55.30 and 55.50). Hue angle ($h^0$) of pulp colour during year I was minimum in Azoxystrobin at 0.1% (70.32) followed by carbendazim at 0.1% (72.33). Both Azoxystrobin at 0.1% and carbendazim at 0.1% at this period registered significant difference over rest of the treatments. However, in year II and in pooled analysis Azoxystrobin at 0.1% (66.76, 68.54) excelled with significantly minimum $h^0$ value. In opposition, the maximum and close values of $h^0$ were shared by the treatments *Trichoderma harzianum* at 0.5% (87.62) and control (87.23) and they were found at parity with *Nerium oleander* at 5% (84.59) and *Trichoderma viride* at 0.5% (84.51). Similarly, in year II and combined data analysis, control with maximum $h^0$ value (85.18 and 86.21) was followed by *Nerium oleander* at 5% (82.96 and 83.78), *Trichoderma viride* at 0.5% (82.47 and 83.49) and *Trichoderma harzianum* at 0.5% (82.49 and 85.06).

**Discussion**

Quality of ‘Alphonso’ mango is characterized by unique aroma and flavour, perfect sugar-acid blend influencing taste and the presence of appealing colour at edible ripe stage. Anthracnose disease is one of the major constraints for the ‘Alphonso’ mango growers as it affects the appearance of fruits thereby lowering their quality and market value. In the present investigation, the peel colour of the mango fruits showed superiority with Azoxystrobin at 0.1% in respect of *L** (lightness) (63.38), *a** (redness) (17.66), *b** (yellowness) (61.03), *C** (chroma) (62.13) and $h^0$ (hue angle) (70.48) values (Table 1, 2). During ripening, dark green chloroplasts in the peel of mango fruits converts into yellow red chromoplasts (John *et al.*, 1970; Lakshminarayana, 1980) [5] [9]. Unripe mango peel encompasses well-arranged grana and osmiophilic globules in the chloroplast cells. This granal membrane loses integrity through ripening and osmiophilic globules appear signifying the conversion of chloroplasts to chromoplast with red or yellow pigments (Parikh *et al*., 1990) [15]. Thus, significant reduction of latent infection in the field and its manifestation in the storage by pre-harvest application of fungicide Azoxystrobin at 0.1% as seen in the previous experiment (Manasa *et al.*, 2018) [12] appears to have facilitated the proper conversion of peel colour indicating the normal process of ripening in mango fruits. Diseased tissue tends to have higher respiration rates resulting in enhanced ethylene production thus impairing the ripening behaviour (Schiffmann-Nadel *et al*., 1985) [16]. On the other hand, control fruits that suffered maximum disease stress recorded significantly minimum peel colour values of *L** (lightness) (39.80), *a** (redness) (3.15), *b** (yellowness) (42.08), *C** (chroma) (45.36) and $h^0$ (hue angle) (88.20). For similar reasons, the treatments *Nerium oleander* at 5%, *Trichoderma viride* at 0.5% and *Trichoderma harzianum* 0.5% followed the control fruits with respect to peel colour. Correspondingly, pulp colour of the fruits showed similar trend where the pre-harvest sprays of Azoxystrobin at 0.1% recorded significantly maximum pulp colour parameters with respect to *L** (lightness) (64.16), *a** (redness) (28.43), *b** (yellowness) (66.34), *C** (chroma) (75.18) and $h^0$ (hue angle) (70.48) (Table 3, 4). This result can be correlated with the significant increment in the β carotene content (data not shown) obtained under the same treatment in this work. Among the 16 fractions of carotenoids present in the ripe pulp of Alphonso mango, β-carotene occupies 50 per cent of total carotenoids (Jungalwala and Cama, 1963) [6]. Mango carotenogenesis mechanisms involve dephosphorylation with increase in the geraniol and mevalonic acid content and a concurrent surge in carotene content. The enzyme phosphatase that catalyzes carotenogenesis in ripe mangoes (Mattoo *et al*., 1968) [13] was probably effectively functional in pre-harvest treatment with azoxistrobin than other treatments employed in the study. On the other hand, pulp colour of control fruits was significantly lower with *L** (lightness) (46.79), *a** (redness) (13.36), *b** (yellowness) (49.15), *C** (chroma) (53.51) and $h^0$ (hue angle) (86.21) values and β-carotene (data not shown) content during storage.

**Table 1:** Influence of pre-harvest sprays of fungicides, botanicals and bioagents on instrumental analysis of colour of peel (*L**, *a**, *b**) of mango fruits cv. 'Alphonso

| Treatments | Peel colour | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***L** (Lightness)** | | | ***a**(Redness)** | | | ***b** (Yellowness)** | | |
| | **Year I** | **Year II** | **Pooled** | **Year I** | **Year II** | **Pooled** | **Year I** | **Year II** | **Pooled** |
| Control | 37.52g | 42.07f | 39.80g | 2.61f | 3.69f | 3.15f | 41.58h | 42.58g | 42.08h |
| Carbendazim at 0.1% | 58.06b | 59.26b | 58.66b | 13.63b | 14.80b | 14.22b | 55.61b | 57.02b | 56.32b |
| Tricyclazole at 0.1% | 44.12de | 49.17d | 46.64d | 4.84ef | 5.95ef | 5.40ef | 43.69gh | 45.44g | 44.57gh |
| Azoxystrobin at 0.1% | 63.23a | 63.52a | 63.38a | 16.73a | 18.59a | 17.66a | 60.39a | 61.66a | 61.03a |
| Thiophanate methyl at 0.1% | 52.49c | 54.54c | 53.51c | 11.95bc | 13.46bc | 12.71bc | 54.42bc | 54.60bc | 54.52bc |
| Zineb at 0.1% | 46.50d | 50.96d | 48.74d | 9.70c | 10.74cd | 10.22cd | 51.70cd | 53.37cd | 52.54cd |
| *Eupatorium odoratum* at 5% | 44.14de | 51.50cd | 47.82d | 9.48cd | 10.55d | 10.02d | 50.28de | 50.14de | 50.21de |
| *Nerium oleander* at 5% | 39.48fg | 43.06ef | 41.27fg | 3.61f | 4.43f | 4.02f | 42.48gh | 43.56g | 43.02gh |
| *Trichoderma viride* at 0.5% | 41.54ef | 45.51e | 43.53e | 6.89de | 7.52e | 7.20e | 47.46ef | 49.14ef | 48.30ef |
| *Trichoderma harzianum* at 0.5% | 40.78efg | 43.65ef | 42.22ef | 4.36ef | 5.61ef | 4.99ef | 45.02fg | 45.89fg | 45.46fg |

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

**Table 2:** Influence of pre-harvest sprays of fungicides, botanicals and bioagents on instrumental analysis of colour of peel (*C**, $h^0$) of mango fruits cv. 'Alphonso

| Treatments | Peel colour | | | | | |
|---|---|---|---|---|---|---|
| | ***C** (Chroma)** | | | **$h^0$ (Hue angle)** | | |
| | **Year I** | **Year II** | **Pooled** | **Year I** | **Year II** | **Pooled** |
| Control | 44.60g | 46.12f | 45.36g | 88.81a | 87.59a | 88.20a |
| Carbendazim at 0.1% | 57.39b | 59.18b | 58.29b | 74.15e | 73.01d | 73.58e |
| Tricyclazole at 0.1% | 47.51ef | 48.11ef | 47.82fg | 84.28bc | 83.35bc | 83.82bc |
| Azoxystrobin at 0.1% | 61.31a | 62.95a | 62.13a | 72.55e | 68.40e | 70.48f |
| Thiophanate methyl at 0.1% | 54.21c | 56.29bc | 55.25c | 77.54d | 76.04d | 76.79d |
| Zineb at 0.1% | 51.66cd | 54.66d | 53.16cd | 82.20c | 80.82c | 81.51c |
| *Eupatorium odoratum* at 5% | 49.10de | 52.75d | 50.93de | 82.34c | 80.76c | 81.56c |
| *Nerium oleander* at 5% | 45.58fg | 47.26ef | 46.42fg | 87.06ab | 84.99ab | 86.02ab |
| *Trichoderma viride* at 0.5% | 48.48e | 49.33e | 48.91ef | 86.34ab | 84.65ab | 85.50ab |
| *Trichoderma harzianum* at 0.5% | 45.68fg | 47.21ef | 46.45fg | 86.16ab | 84.88ab | 85.52ab |

**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:** Influence of pre-harvest sprays of fungicides, botanicals and bioagents on instrumental analysis of colour of pulp (*L**, *a**, *b**) of mango fruits cv. 'Alphonso

| Treatments | Pulp colour | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***L** (Lightness)** | | | ***a**(Redness)** | | | ***b** (Yellowness)** | | |
| | **Year I** | **Year II** | **Pooled** | **Year I** | **Year II** | **Pooled** | **Year I** | **Year II** | **Pooled** |
| Control | 46.25f | 47.32g | 46.79f | 13.48f | 13.22f | 13.36e | 48.29f | 50.01g | 49.15g |
| Carbendazim at 0.1% | 59.04b | 60.75b | 59.90b | 23.55b | 25.66b | 24.61b | 61.58b | 63.76b | 62.67b |
| Tricyclazole at 0.1% | 46.49f | 49.68fg | 48.09ef | 16.44de | 16.45ef | 16.44d | 49.43ef | 51.50fg | 50.47fg |
| Azoxystrobin at 0.1% | 63.55a | 64.75a | 64.16a | 27.04a | 29.82a | 28.43a | 65.42a | 67.26a | 66.34a |
| Thiophanate methyl at 0.1% | 56.79bc | 59.03bc | 57.91b | 21.30bc | 23.39bc | 22.34bc | 57.61c | 60.25c | 58.94c |
| Zineb at 0.1% | 54.43cd | 56.10cd | 55.27c | 19.33cd | 21.80c | 20.57c | 56.58cd | 57.08cd | 56.83cd |
| *Eupatorium odoratum* at 5% | 52.13de | 53.58de | 52.86cd | 19.50c | 21.17cd | 20.34c | 54.83d | 55.82de | 55.33de |
| *Nerium oleander* at 5% | 46.69f | 51.33ef | 49.01ef | 14.03ef | 13.42f | 13.73e | 48.95ef | 50.85fg | 49.90g |
| *Trichoderma viride* at 0.5% | 48.34ef | 52.51ef | 50.43de | 15.14ef | 18.09de | 16.62d | 51.58e | 53.75ef | 52.67ef |
| *Trichoderma harzianum* at 0.5% | 45.61f | 51.65ef | 48.63ef | 13.97ef | 15.40ef | 14.69de | 49.50ef | 51.71fg | 50.61fg |

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

**Table 4:** Influence of pre-harvest sprays of fungicides, botanicals and bioagents on instrumental analysis of colour of pulp (*C**, $h^0$) of mango fruits cv. 'Alphonso

| Treatments | Pulp colour | | | | | |
|---|---|---|---|---|---|---|
| | ***C** (Chroma)** | | | **$h^0$ (Hue angle)** | | |
| | **Year I** | **Year II** | **Pooled** | **Year I** | **Year II** | **Pooled** |
| Control | 52.80f | 54.21g | 53.51g | 87.23a | 85.18a | 86.21a |
| Carbendazim at 0.1% | 68.47b | 72.72b | 70.59b | 72.33f | 71.68f | 72.01e |
| Tricyclazole at 0.1% | 55.81ef | 57.32ef | 56.57ef | 82.63bcd | 81.60bcd | 82.12bc |
| Azoxystrobin at 0.1% | 73.73a | 76.64a | 75.18a | 70.32f | 66.76g | 68.54f |
| Thiophanate methyl at 0.1% | 65.54bc | 67.74c | 66.64c | 76.47e | 76.62e | 76.55d |
| Zineb at 0.1% | 63.48cd | 65.49cd | 64.49cd | 79.59de | 79.36cde | 79.48cd |
| *Eupatorium odoratum* at 5% | 61.72d | 63.47d | 62.60d | 80.55cd | 78.51de | 79.53cd |
| *Nerium oleander* at 5% | 55.27f | 55.39fg | 55.33fg | 84.59ab | 82.96ab | 83.78ab |
| *Trichoderma viride* at 0.5% | 58.65e | 59.39e | 59.02e | 84.51abc | 82.47abc | 83.49ab |
| *Trichoderma harzianum* at 0.5% | 55.69ef | 55.306fg | 55.50fg | 87.62a | 82.49abc | 85.06ab |

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

## References


1. Akamine EK, Goo T. Respiration and ethylene production during ontogeny of fruits. Journal of American Society for Horticultural Science. 1973; 98:381-383.
2. Brecht JK, Yahia EM. The Mango: Botany, Production and Uses, Edn 2, CABI, Wallingford, 2009, 484-516.
3. Duncan DB. Multiple range and multiple F-tests. Biometrics. 1955; 11:1-42.
4. Gowda IND, Huddar AG, Studies on ripening changes in mango (*Mangifera indica* L.) fruits. Journal of Food Science and Technology. 2001; 38:135-137.
5. John J, Subba rayan C, Cama HR. Carotenoids in three stages of ripening of mango. Journal of Food Science. 1970; 35:262-265.
6. Jungalwala FB, Cama HR. Carotenoids in mango (*Mangifera indica*) fruit. Indian Journal of Chemistry. 1963; 1:36-40.
7. Kevin L. Handbook of Food Analytical Chemistry, A John Wiley & Sons, Inc. 2002; F5.1.1-F5.1.13.
8. Krishnamurthy S, Subramanyam H., Respiratory climacteric and chemical changes in the mango fruit *Mangifera indica* L. Journal of American Society for Horticultural Science. 1970; 95:333-337.
9. Lakshminarayana S. Tropical and Subtropical Fruits, AVI Publishing Company, Westport, 1980, 184-257.
10. Lalel H, Singh Z, Tan S. Maturity stage at harvest affects fruit ripening, quality and biosynthesis of aroma volatile compounds in Kensington Pride mango. Journal of Horticultural Science and Biotechnology. 2003; 78:225-233.
11. Lizada. Biochemistry of Fruit Ripening, Edn 1, Chapman and Hill, London, 1993, 255-271.
12. Manasa B, Jagadeesh SL, Thammaiah N, Jagadeesh RC, Gangadharappa PM, Nethravathi. Pre-harvest application of Azoxystrobin minimised anthracnose of mango (cv. 'Alphonso') both at field and postharvest level enhancing yield and quality of fruits. J Pharmacognosy and Phytochemistry. 2018; 7(3):2962-2967.
13. Mattoo AK, Modi VV, Reddy VVR. Oxidation and carotenogenesis regulating factors in mangoes. Indian Journal of Biochemistry. 1968; 5:111-114.
14. Mattoo AK, Modi VV. Ethylene and ripening of mangos. Plant Physiology. 1969; 44:308-310.
15. Parikh HR, Nair GM, Modi VV. Some structural changes during ripening of mangoes (*Mangifera indica* var. Alphonso) by abscisic acid treatment. Annals Botany. 1990; 65:121-127.
16. Schifman-Nadel M, Michaely H, Zauberman G, Chet I. Physiological changes occurring in picked climacteric fruit infected with different pathogenic fungi. Phytopathologische Zeitschrift. 1985; 13:277-284.
17. Shafiee M, Taghavi TS, Babalar M. Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. Scientia Horticulturae. 2010; 24:40-45.
18. Wills RB, Lee TH, Graham D, Glasson WB, Hall, EG. Postharvest: An introduction to the physiology and handling of fruits and vegetables, Edn 1, AVI Publishing, Westport, 1982, 34-35.