Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 2475-2480
Received: 04-11-2018
Accepted: 06-12-2018

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

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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 (Brecht and Yahia, 2009) [8] 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) [24]. 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) [17, 34] leading to change of colour from green to yellow that a human eye can detect. While in the pulp, additional carotenogenisis results in the eye appealing yellow colour (Bhaskarachary *et al.,* 1995; Mattoo *et al.*, 1968) [7, 27]. 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) [15, 14]. 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) [30]. 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) [30], increase in sugars predominantly sucrose and decrease in citric acid (Medlicott and Thompson, 1985) [29] and flavour imparting monoterpene hydrocarbons (Engel and Trresl, 1983) [10], lactone and some fatty acids (Wilson *et al*., 1990) [36]. Overall 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 ensory 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 (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% 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.

Beta-carotene content (ppm) = 0.01005 + 23.5366 x 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 1: Hedonic scale rating for various sensory attributes

Scale	Peel colour and appearance	Pulp Colour and appearance	Pulp Texture	Pulp taste and flavour	Overall acceptability
1	Poor	Poor	Poor	Poor	Poor
3	Fair	Fair	Fair	Fair	Fair
5	Good	Good	Good	Good	Good
7	Very good	Very good	Very good	Very good	Very good
9	Excellent	Excellent	Excellent	Excellent	Excellent

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

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 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

Peel colour and appearance

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 carbendazim 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 carbendazim 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.

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 1-4.46, 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. Orgenoleptic 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) [13, 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 synthises 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; Nasrijal, 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) [5]. 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], monoterpene hydrocarbons (Engel and Trresl, 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

Treatments	Peel colour and appearance			Pulp colour and appearance		
	Year 1	Year II	Pooled	Year 1	Year II	Pooled
Control	4.35c	4.25c	4.31c	4.58c	5.24c	4.91c
Carbendazim at 0.1%	6.40ab	6.53b	6.47ab	6.41ab	6.71b	6.56b
Tricyclazole at 0.1%	4.64c	4.63c	4.64c	4.67c	5.31bc	4.99c
Azoxystrobin at 01%	7.40a	8.40a	7.91a	7.92a	8.38a	8.15a
Thiophanate methyl at 0.1%	5.05bc	5.53bc	5.52bc	5.64bc	5.73bc	5.69bc
Zineb at 0.1%	5.18bc	5.46bc	5.32bc	5.59bc	5.76bc	5.68bc
Eupatorium odoratum at 5%	5.49bc	5.75bc	5.62bc	5.69bc	5.66bc	5.68bc
Nerium oleander at 5%	4.50c	5.03bc	4.77c	4.72c	5.54bc	5.13bc
Trichoderma viride at 0.5%	5.33bc	5.70bc	5.52bc	5.37bc	5.82bc	5.60bc
Trichoderma harzianum at 0.5%	4.42c	4.67c	4.55c	4.57c	5.52bc	5.05c

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

Treatments	Texture			Taste and flavour		
	Year 1	Year II	Pooled	Year 1	Year II	Pooled
Control	4.48c	5.15c	4.82c	4.43c	4.75c	4.59c
Carbendazim at 0.1%	6.65ab	7.39ab	7.03ab	6.56ab	6.45b	6.51b
Tricyclazole at 0.1%	4.71c	5.61c	5.16c	4.70c	4.43c	4.57c
Azoxystrobin at 01%	8.22a	8.21a	8.22a	8.34a	8.56a	8.45a
Thiophanate methyl at 0.1%	5.63bc	6.55bc	6.10bc	5.84bc	5.83bc	5.83bc
Zineb at 0.1%	5.82bc	5.76c	5.79bc	5.56bc	5.70bc	5.63bc
Eupatorium odoratum at 5%	5.67bc	5.82c	5.75bc	5.63bc	5.65bc	5.65bc
Nerium oleander at 5%	5.19bc	5.42c	5.31c	5.16bc	5.00bc	5.09bc
Trichoderma viride at 0.5%	5.58bc	6.06bc	5.82bc	5.42bc	5.66bc	5.54bc
Trichoderma harzianum at 0.5%	5.63bc	5.26c	5.45c	4.92bc	4.74c	4.83c

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.

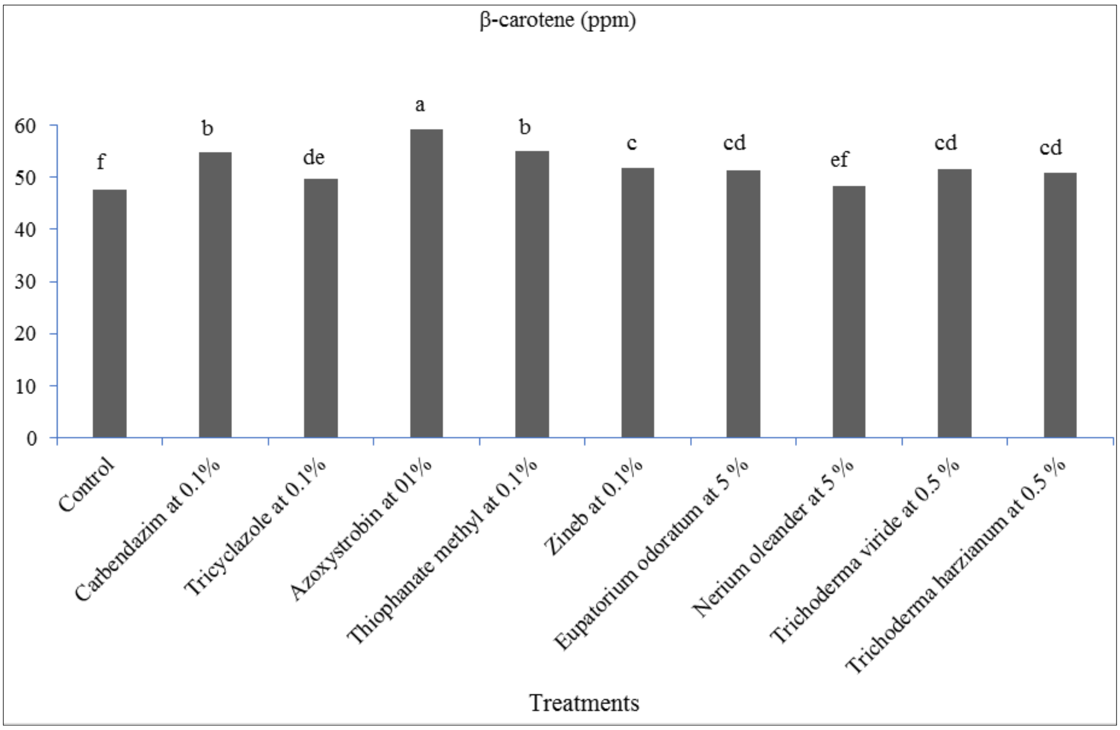

Fig 2: β-carotene (ppm) of mango fruits cv 'Alphonso' as influenced by various pre-harvest treatments. Figure represents the pooled analysis of two year's data. Bars with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

References

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. Ali ZM, Armugam S, Lazan H. β-Galactosidase and its significance in ripening mango fruit. Phytochemistry. 1995; 38:1109-1114.
3. American Association of Cereal Chemists. Approved Methods Committee. Approved methods of the American Association of Cereal Chemists, Edn 9, St. Paul Minn, AOCC, 1995, 14-50.
4. Baldwin EA, Burns JK, Kazokas W, Brecht JK, Hagenmaier RD, Bender RJ, Pesis E. Effect of two edible coatings with different permeability characteristics on mango (*Mangifera indica* L.) ripening during storage. Postharvest Biology and Technology. 1999; 17:215-226.
5. Bandyopadhyay C. Contribution of gas chromatography to food flavour research. Palai Journal. 1983; 5:26-30.
6. Bandyopadhyay, Gholap AS. Relationship of aroma and flavour characters of mango (*Mangifera indica* L.) to fatty acid composition. Journal of Science and Food Agriculture. 1973; 24:1497-1503.
7. Bhaskarachary K, Sankar Rao DS, Deosthale YG, Reddy V. Carotene content of some common and less familiar foods of plant origin. Food Chemistry, 1995; 54:189-193.
8. Brecht JK, Yahia EM. The Mango: Botany, Production and Uses, Edn 2, CABI, Wallingford, 2009, 484-516.
9. Duncan DB. Multiple range and multiple F-tests. Biometrics. 1955; 11:1-42.
10. Engel KH, Tressl R. Studies on the volatile components of two mango varieties. Journal of Agricultural Food Chemistry, 1983; 31:796-801.
11. Gholap AS, Bandyopadhyay C. Fatty acid biogenesis in ripening mango (*Mangifera indica* cv. Alphonso). Journal of Agricultural Food Chemistry. 1980; 28:839-841.
12. Gholap AS, Bandyopadhyay C. Fatty acid composition as a quality index of ripe mango (*Mangifera indica* L.) pulp. Indian Food Packer. 1976; 30:63-64.
13. Gowda IND, Huddar AG. Studies on ripening changes in mango (*Mangifera indica* L.) fruits. Journal of Food Science and Technology. 2001; 38:135-137.
14. John J, Subbarayan C, Cama HR. Carotenoids in three stages of ripening of mango. Journal of Food Science. 1970; 35:262-265.
15. Jungalwala FB, Cama HR. Carotenoids in mango (*Mangifera indica*) fruit. Indian Journal of Chemistry. 1963; 1:36-40.
16. Karmarkar DV, Joshi BM. Respiration studies of the 'Alphonso' mango. Indian Journal of Agricultural Sciences. 1941; 11:993-1005.
17. 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.
18. Lakshminarayana S. Tropical and Subtropical Fruits, AVI Publishing Company, Westport, 1980, 184-257.
19. 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.
20. Lazan H, Ali ZM, Lee KW, Woon J. The potential role of polygalacturonase in pectin degradation of softening of mango. Asian Food Journal. 1986; 2:93-98.
21. Leopold AC. Plant Growth and Development. McGraw-Hill book company, New York and London, 1964.
22. Liu H, Chen F, Yang H, Yao Y, Gong X, Xin Y *et al*. Effect of calcium treatment on nanostructure of chelate-soluble pectin and physicochemical and textural properties of apricot fruits. Food Research International. 2009; 42:1131-1140.
23. Lizada. Biochemistry of Fruit Ripening, Edn 1, Chapman and Hill, London, 1993, 255-271.

24. Mackinney L, Little AC. Colour of foods, AVI publishers, Westport, 1962.
25. 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. Journal of Pharmacognosy and Phytochemistry. 2018a; 7(3):1883-2967.
26. Manasa B, Jagadeesh SL, Thammaiah N, Sandhyarani Nishani, Gangadharappa PM, Jagadeesha RC *et al*. Evaluation of fungicides, bioagents and botanicals on postharvest disease, shelf life and physicochemical properties of 'Alphonso' mango. Journal of Pharmacognosy and Phytochemistry. 2018b; 7(4):1883-1888.
27. Mattoo AK, Modi VV, Reddy VVR. Oxidation and carotenogenesis regulating factors in mangoes. Indian Journal of Biochemistry. 1968; 5:111-114.
28. Mattoo AK, Modi VV. Ethylene and ripening of mangos. Plant Physiology. 1969; 44:308-310.
29. Medlicott AP, Thompson AK. Analysis of sugar and organic acids in ripening mango fruit (*Mangifera indica* var. Keitt) by high performance liquid chromatography. Journal of Science. Food Agriculture. 1985; 36:561-566.
30. Nasrijal NH. Effect of storage temperature on pectin depolymerisation and softening of mango fruit. B.Sc. thesis, Department of Botany, University Kebangsaan, Bangi, Malaysia, 1993.
31. 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.
32. Roe B, Bruemmer JH. Changes in pectic substances and enzymes during ripening and storage of 'Keitt' mangos. Journal of Food Science. 1981; 46:186-189.
33. Saltveit ME. Effect of ethylene on quality of fresh fruits and vegetables. Postharvest Biology Technology. 1999; 15:279-292.
34. Salunke DK, Desai BB. Postharvest Biotechnology of Fruits, vol 2, CRC Press, Boca Raton, 1984.
35. 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.
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.