Effect of Ethylene on Qualitative Changes during Ripening of Mango (*Mangifera indica* L.) cv. Kesar

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**A B S T R A C T**

Mango fruit Cv. Kesar were exposed to ethylene gas (100 ppm) for 12, 18 and 24 hrs in fruit ripening chamber and were then removed from the ripening chamber at the end of exposure period, packed in corrugated fibre board boxes and then kept at ambient condition to study the ripening behaviour. In another trial, the mango fruits were treated with ethephon at the concentration of 500,750 and 1000 ppm for five minutes, drained, packed in corrugated fibre board boxes and then kept at ambient condition. It was found that mango Cv. Kesar exposed to the ethylene gas in the ripening chamber and ethephon dip treatment triggered the ripening process. It was also noticed that more the period of exposure to ethylene gas and more the concentration of ethephon, faster was the ripening process and showed the significant increasing trends in TSS, sugars, β carotene, and decreasing trends in titratable acidity and ascorbic acid in all the treatment combinations during advancement of storage period. It was observed that mango fruits Cv. Kesar ripened by exposing them to 100 ppm ethylene gas in ripening chamber for 18 hrs and storage at ambient condition recorded the maximum shelf life of 6 days and showed better results in respect of high overall acceptability score of 8.77. Similarly, mango fruits ripened by ethephon dip treatment of 750 ppm for 5 minutes and storage at ambient condition recorded the maximum shelf life of 8 days and showed better results in respect of high overall acceptability score of 8.66, respectively. The cost of ripening chamber for 800 kg fruits on per day interest and ethylene gas was considered for calculating the cost of ripening. The cost was found to be Rs. 0.69 per kg.

**Keywords**
Mango, Ripening, Ethylene, Ethephon, Quality

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**Introduction**

Mango (*Mangifera indica* L.) belongs to family Anacardiaceae is the national fruit of India and rightly known as the ‘King of fruits’ owing to its attractive colour, excellent taste, excellent flavour, exemplary nutritive value, processing qualities and its delicacy for the table which provides employment to the millions of poor people during summer. The research efforts have helped to increase the production of mango fruits but the purpose of obtaining maximum profit will not be served unless the increased production is supplemented with similar efforts to minimize their post-harvest losses, which range between 25-30 per cent. India ranks first in the world with total production of 18.31 million tonnes.
from about 2.5 million hectares and productivity is 7.3 tonnes/ha.

The annual production of mango followed by India are China, Thailand, Indonesia, Mexico, Pakistan and Brazil as 4.40, 2.65, 2.37, 1.70, 1.95 and 1.17 million tonnes, respectively.

Uttar Pradesh is leading state with 4.30 million tonnes of mango production followed by Andhra Pradesh (2.73), Karnataka (1.79), Bihar (1.36), Maharashtra (1.21), Gujarat (1.12), and Orissa (0.75) which are the major mango growing states in India (Anon., 2014).

Artificial ripening of mango is very recent concept in post-harvest technology but it has great importance especially in export of mango. The ripening with ethylene gas or ethephon treatment seems to hold promise to get good and uniform quality. Therefore, the present investigation was carried out with the objective to study the effect of ethylene on qualitative changes during ripening behaviour of mango Cv. Kesar.

Materials and Methods

The present research entitled “Effect of ethylene on qualitative changes during ripening of mango (Mangifera indica L.) Cv. Kesar.” was carried out in the Post-Harvest Technology Centre, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2014 - 2015.

Selection of fruits

Physiologically mature, healthy green fruits at optimum maturity of mango Cv. Kesar were collected from mango orchard, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. Harvested fruits were washed, treated and packed in CFB and were used for further investigation.

Ripening chamber

The ripening chamber made up of polypropelene with a dimension of 7 x 7 x 7 ' having capacity to hold 500-700 kg of mango fruits supported with a frame of 1.5 " PVC pipes with a thickness of 0.33 mm.

Ethylene gas cylinder

Ethylene is a natural ripening hormone used for mango ripening in low cost ripening chamber at the concentration of 100 ppm.

Eethephon

Ethephon 39% SL for dip treatment was used under the brand name ethefol.

Post-harvest treatments

Ethylene gas

The selected mango fruits Cv. Kesar were kept in low cost fruit ripening chamber in the Post-Harvest Technology Centre, Department of Horticulture, MPKV, Rahuri. The concentration of ethylene gas in the ripening chamber for each treatment was kept as 100 ppm, as per method developed by (Pujari and Mehta, 2010). The mango fruits were exposed to the ethylene gas in ripening chamber (29.4-31.9°C with 65-84 % R.H) for certain period (Table 1) as per treatment and untreated fruits were kept at ambient temperature. The fruits were then removed from the ripening chamber at the end of exposure period and then kept at ambient condition (26.8-30.6°C with 54.0-62.6% R.H) for studying the ripening behaviour of mango fruits.

Eethephon dip treatment

The selected mango fruits were treated with ethephon dip for 5 minutes at different concentrations as given in Table 1. The treated
fruits were then drained, packed in corrugated fibreboard boxes and kept at ambient condition (26.8-30.6°C with 54.0-62.6% R.H) for further study.

**Statistical analysis**

The data obtained in the present investigation were analyzed for the statistical significance as suggested by Panse and Sukhatme (1995).

**Results and Discussion**

**Chemical composition of fresh mango fruit**

The results for physico-chemical properties of fresh (unripe) mango fruit Cv. Kesar revealed that the fresh (unripe) mango had 6.86ºB total soluble solids, 2.08 per cent acidity, 2.15 per cent reducing sugars, 4.35 per cent total sugars, 88.40 mg/100g ascorbic acid and 268μg/100g β carotene, respectively. The research findings are comparable with the observations reported by Deepa and Preetha (2014) and Venkatram and Pandiarajan (2014) in mango fruit.

The TSS, total sugars, reducing sugars and β carotene was found to be increased statistically whereas titratable acidity and ascorbic acid was found to be statistically decreased in all the treatments during the advancement of storage period (Table 2).

**Total soluble solids (TSS) (ºB)**

At the initial stage, the TSS of mango fruit was found to be 6.86ºB. At the end of 2nd, 4th and 6th day of storage, treatment T4 recorded maximum TSS (10.50, 14.75 and 19.67ºBrix) followed by treatment T3 (9.97, 12.65, 19.67ºBrix) in ethylene gas exposure treatment in the ripening chamber. At the end of 8th day of storage, the treatment T3 recorded maximum TSS (19.42ºBrix) followed by treatment T2 (19.30ºBrix) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd, 4th and 6th and 8th day of storage, treatment T7 recorded maximum TSS (9.86, 14.18, 19.30 and 19.55ºBrix) followed by treatment T6 (9.35, 11.92, 14.78 and 19.30ºBrix) in ethylene dip treatments.

The TSS might be increased due to hydrolysis of starch, cellulose and pectin substances into simpler substances or might be due to decrease in moisture content. Similar results were also reported by Sakhale et al., (2006), Pandarinathan and Sivakumar (2010), Venkatram and Pandiarajan (2014), Zagade and Relekar (2014), Patel et al., (2015) in mango fruits.

**Titratable acidity (%)**

At initial stage, the acidity of mango fruit was found to be 2.08 per cent. At the end of 2nd, 4th, 6th and 8th day of storage, treatment T4 recorded minimum acidity (1.41, 0.83, 0.27 and 0.22%) followed by treatment T3 (1.45, 1.07, 0.67 and 0.27 %) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd, 4th, 6th and 8th day of storage, treatment T7 recorded minimum acidity (1.60, 1.06, 0.25 and 0.19%) followed by treatment T6 (1.65, 1.18, 0.68 and 0.23%) in ethylene dip treatments. At end of 8th day of storage, treatments T3 and T5 recorded acidity as 0.27 and 0.28%, respectively which were at par with each other. This might be due to faster degradation of organic acids into sugars and utilization of acids during respiration. The results obtained in present study are in conformity with the observations of Sakhale et al., (2006) and Deepa and Preetha (2014) in mango fruits.

**Ascorbic acid (mg/100 g)**

At the initial stage, the ascorbic acid content of mango fruit was found to be 88.40mg/100g. At the end of 2nd, 4th, 6th and 8th day of storage, treatment T3 and T5 recorded maximum ascorbic acid content (88.40mg/100g) followed by treatment T2 (87.50mg/100g) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd, 4th and 6th and 8th day of storage, treatment T7 recorded maximum ascorbic acid content (91.30mg/100g) followed by treatment T6 (90.30mg/100g) in ethylene dip treatments.
At the end of 2\textsuperscript{nd}, 4\textsuperscript{th}, 6\textsuperscript{th} and 8\textsuperscript{th} day of storage, treatment T\textsubscript{4} recorded minimum ascorbic acid (68.55, 55.37, 35.32 and 33.20 mg/100g) followed by treatment T\textsubscript{3} (71.52, 58.45, 45.12 and 36.30 mg/100g) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2\textsuperscript{nd}, 4\textsuperscript{th}, 6\textsuperscript{th} and 8\textsuperscript{th} day of storage, treatment T\textsubscript{7} recorded minimum ascorbic acid (68.76, 56.32, 36.25 and 35.19 mg/100g) followed by treatment T\textsubscript{6} (73.20, 64.83, 51.33 and 36.66 mg/100g) in ethephon dip treatments. At the end of 6\textsuperscript{th} day of storage, treatment T\textsubscript{2} and T\textsubscript{6} recorded 51.22 and 51.33 mg/100g and were at par with each other. At the end of 8\textsuperscript{th} day of storage, the treatment T\textsubscript{7} recorded minimum ascorbic acid (mg/100g) followed by treatment T\textsubscript{6} (mg/100g) in ethephon dip treatment.

A decline in ascorbic acid content of the mango fruits might be due to utilization of ascorbic acid in respiration process during ripening at ambient condition. Similar trend was also observed by Sakhole \textit{et al.}, (2006), William \textit{et al.}, (2009), Pandarinathan and Sivakumar (2010), in mango fruits.

**Reducing sugars (%)**

At initial stage, the reducing sugars content of mango fruit was found to be 2.15 per cent. At the end of 2\textsuperscript{nd} and 4\textsuperscript{th} day of storage, treatment T\textsubscript{4} recorded maximum reducing sugars content (3.76 and 5.12%) followed by treatment T\textsubscript{3} (3.46 and 4.78%) in ethylene gas exposure treatment in the ripening chamber.

At the end of 6\textsuperscript{th} day of storage, the treatment T\textsubscript{4} recorded maximum reducing sugars content (6.22%), however it was declined on 8\textsuperscript{th} day (6.12%).

At the end of 8\textsuperscript{th} day of storage, treatment T\textsubscript{3} and T\textsubscript{6} recorded reducing sugars as 6.18 and 6.16 % respectively, which were at par each other.

The significant increase in the total sugars content may be due to the carbohydrates accumulate during maturation in the form of starch. As the fruit ripens, starch was broken down into sugars. These observations are in conformity with research findings of Pandarinathan and Sivakumar (2010), Singh \textit{et al.}, (2012), Zagade and Relekar (2014) in mango fruits.
Table 2: Effect of various treatments on bio-chemical properties of mango during ripening

| Particulars             | Storage period (days) | Control | Ripening chamber | Treatments | Etaphon dip | SE±  | C.D. at 5 % |
|-------------------------|-----------------------|---------|------------------|------------|-------------|------|-------------|
|                         |                       | T₁      | T₂               | T₃         | T₄          | T₅   | T₆          | T₇          |               |
| Total soluble solids (°B) | 2                     | 7.85    | 9.55             | 9.97       | 10.50       | 8.94 | 9.35        | 9.86        | 0.02          | 0.06          |
|                         | 4                     | 10.17   | 12.15            | 12.65      | 14.75       | 11.32| 11.92       | 14.18       | 0.05          | 0.15          |
|                         | 6                     | 12.70   | 15.32            | 15.83      | 19.67       | 14.45| 14.78       | 19.30        | 0.05          | 0.16          |
|                         | 8                     | 15.81   | 19.30            | 19.42      | 18.25       | 19.13| 19.30       | 19.55        | 0.06          | 0.21          |
| Titratable acidity (%)   | 2                     | 1.83    | 1.52             | 1.45       | 1.41        | 1.73 | 1.65        | 1.60        | 0.01          | 0.04          |
|                         | 4                     | 1.45    | 1.15             | 1.07       | 0.83        | 1.25 | 1.18        | 1.06        | 0.01          | 0.04          |
|                         | 6                     | 0.97    | 0.72             | 0.67       | 0.27        | 0.84 | 0.68        | 0.25        | 0.01          | 0.03          |
|                         | 8                     | 0.36    | 0.33             | 0.27       | 0.22        | 0.28 | 0.23        | 0.19        | 0.20          | 0.02          |
| Total sugars (%)         | 2                     | 5.70    | 8.54             | 8.88       | 9.07        | 8.54 | 8.85        | 9.18        | 0.05          | 0.18          |
|                         | 4                     | 7.37    | 10.63            | 11.28      | 12.63       | 10.67| 11.63       | 11.70       | 0.13          | 0.42          |
|                         | 6                     | 9.35    | 13.19            | 13.83      | 16.65       | 14.25| 13.77       | 16.58       | 0.33          | 1.01          |
|                         | 8                     | 13.23   | 16.57            | 16.82      | 15.16       | 16.35| 16.82       | 16.90       | 0.06          | 0.19          |
| Reducing sugars (%)      | 2                     | 2.54    | 3.22             | 3.46       | 3.76        | 3.17 | 3.48        | 3.80        | 0.01          | 0.04          |
|                         | 4                     | 3.12    | 4.25             | 4.78       | 5.12        | 4.28 | 4.95        | 4.98        | 0.01          | 0.03          |
|                         | 6                     | 4.16    | 5.17             | 5.56       | 6.22        | 5.06 | 5.52        | 6.14        | 0.01          | 0.04          |
|                         | 8                     | 5.20    | 6.05             | 6.18       | 6.12        | 6.01 | 6.16        | 6.22        | 0.01          | 0.03          |
| Ascorbic acid (mg/100 g) | 2                     | 81.70   | 73.88            | 71.52      | 68.55       | 75.38| 73.20       | 68.76       | 0.10          | 0.32          |
|                         | 4                     | 76.62   | 62.55            | 58.45      | 55.37       | 66.03| 64.83       | 56.32       | 0.06          | 0.19          |
|                         | 6                     | 69.33   | 51.22            | 45.12      | 35.32       | 53.47| 51.33       | 36.25       | 0.06          | 0.20          |
|                         | 8                     | 62.08   | 39.62            | 36.30      | 33.20       | 40.42| 36.66       | 35.19       | 0.05          | 0.15          |
| β carotene (µg/100 g)   | 2                     | 2654.38 | 3344.72          | 3614.30    | 6074.30     | 2904.52| 3194.34     | 5486.30     | 0.06          | 0.19          |
|                         | 4                     | 4253.20 | 5314.32          | 5805.37    | 10274.85    | 4634.27| 5064.45     | 9286.23     | 3.79          | 11.49         |
|                         | 6                     | 6250.22 | 8084.25          | 8736.22    | 14760.08    | 6334.38| 7684.58     | 13100.02    | 0.10          | 0.32          |
|                         | 8                     | 9600.02 | 12810.22         | 13950.21   | 15900.33    | 11300.31| 11570.25    | 14300.21    | 0.09          | 0.30          |
Table 1: Treatment details

| Treatments | Details |
|------------|---------|
| T1         | Control (Without any treatments). |
| T2         | 12 hrs exposure to ethylene gas 100 ppm in ripening chamber |
| T3         | 18 hrs exposure to ethylene gas 100 ppm in ripening chamber |
| T4         | 24 hrs exposure to ethylene gas 100 ppm in ripening chamber |
| T5         | 500 ppm dip in ethephon for 5 minutes |
| T6         | 750 ppm dip in ethephon for 5 minutes |
| T7         | 1000 ppm dip in ethephon for 5 minutes |

Table 3: Effect of ethylene gas and ethephon on organoleptic score of mango Cv. Kesar during 6th day of storage

| Treatments | Organoleptic score | Colour | Flavour | Taste | Texture | Overall acceptability |
|------------|--------------------|--------|---------|-------|---------|-----------------------|
| Control    |                    | 7.00   | 7.00    | 6.00  | 6.00    | 6.50                  |
| T1         | Without treatment i.e. control |        |         |       |         |                       |
| T2         | Ripening chamber   | 8.50   | 8.50    | 8.00  | 8.50    | 8.37                  |
| T3         | 12 hrs exposure to ethylene gas | 8.80   | 8.75    | 8.75  | 8.80    | 8.77                  |
| T4         | 18 hrs exposure to ethylene gas | 8.50   | 8.75    | 8.20  | 8.40    | 8.46                  |
| T5         | 24 hrs exposure to ethylene gas | 8.00   | 7.50    | 7.75  | 8.20    | 7.85                  |
| T6         | Ethphon dip         | 8.25   | 8.50    | 8.25  | 8.00    | 8.25                  |
| T7         | 500 ppm ethephon dip treatment | 8.00   | 8.00    | 7.75  | 8.00    | 8.18                  |
| T8         | 750 ppm ethephon dip treatment | 8.70   | 8.60    | 8.75  | 8.60    | 8.66                  |
| T9         | 1000 ppm ethephon dip treatment | 8.00   | 8.10    | 7.75  | 7.80    | 7.91                  |

Table 4: Effect of ethylene gas and ethephon on organoleptic score of mango cv. Kesar during 8th day of storage

| Treatments | Organoleptic score | Colour | Flavour | Taste | Texture | Overall acceptability |
|------------|--------------------|--------|---------|-------|---------|-----------------------|
| Control    |                    | 7.20   | 7.45    | 7.00  | 7.25    | 7.22                  |
| T1         | Without treatment i.e. control |        |         |       |         |                       |
| T2         | Ripening chamber   | 8.40   | 8.50    | 8.25  | 8.50    | 8.40                  |
| T3         | 12 hrs exposure to ethylene gas | 8.30   | 8.10    | 8.00  | 8.00    | 8.10                  |
| T4         | 18 hrs exposure to ethylene gas | 8.00   | 7.50    | 7.75  | 8.20    | 7.85                  |
| T5         | 24 hrs exposure to ethylene gas | 8.25   | 8.00    | 8.50  | 8.00    | 8.18                  |
| T6         | Ethphon dip         | 8.70   | 8.60    | 8.75  | 8.60    | 8.66                  |
| T7         | 500 ppm ethephon dip treatment | 8.00   | 8.10    | 7.75  | 7.80    | 7.91                  |
| T8         | 750 ppm ethephon dip treatment | 8.00   | 8.10    | 7.75  | 7.80    | 7.91                  |
| T9         | 1000 ppm ethephon dip treatment | 8.00   | 8.10    | 7.75  | 7.80    | 7.91                  |
It might be due to release of sugars by hydrolysis of starch reserve during ripening stage. The results are also supported by Sakhale et al., (2006), William, (2009), Pandarinathan and Sivakumar (2010), Bhatt et al., (2012). Zagade and Relekar (2014) and Patel et al., (2015) in mango fruit.

**β carotene (µg/100 g)**

At the initial stage, the β carotene content of mango fruit was found to be 268.00 µg/100g. At the end of 2nd, 4th, 6th and 8th day of storage, treatment T4 recorded maximum β carotene content (6074.30,10274.85,14760.08 and 15900.33 µg/100g) followed by treatment T3 (3614.30, 5805.37, 8736.22 and 13950.21 µg/100g) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd, 4th, 6th and 8th day of storage, treatment T7 recorded maximum β carotene content (5486.30, 9286.23, 13100.02 and 14300.21 µg/100g) followed by treatment T6 (3194.34, 5064.45, 7684.58 and 11570.25 µg/100g) in ethephon dip treatments.

This might be due to accelerated biosynthesis with chlorophyll degradation and increase in carotene was accompanied by a decrease in acid and increase in sugar content. The results are in line with those reported by Dhemre (2001) in Kesar mango.

**Sensory quality**

The data on effect of ethylene gas exposure treatment in the ripening chamber as compared to ethephon dip treatments on changes in sensory quality are presented in Table 3 and 4. The sensory quality of mango Cv. Kesar was influenced by different ethylene gas exposure treatments in ripening chamber and ethephon dip treatments.

The organoleptic rating of mango Cv. Kesar in terms of overall acceptability on 6th day of storage was found to be maximum in the treatment T3 (8.77) followed by the treatment T4 (8.46) and treatment T2 (8.37) in ethylene gas exposure treatments in ripening chamber. Whereas the mango fruits treated with ethephon dip treatments recorded the highest overall acceptability in treatment T7 (8.25) followed by treatments T6 (8.06) and T5 (7.93). The lowest sensory score was recorded in the treatment T1 (6.50) i.e. control.

Similarly, the organoleptic rating of mango Cv. Kesar in terms of overall acceptability on

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**Table 5 Cost of ripening of Kesar mango fruit**

| Sr. No. | Particulars                      | Quantity | Rate (Rs.) | Cost (Rs.) |
|---------|----------------------------------|----------|------------|------------|
| I. Working cost                             |          |           |            |            |
| 1.      | Interest @10% on fixed assets of Rs. 5250/- for one day. |          |            | 1.44       |
| 2.      | Ethylene cylinder                | 1.0 L    | 160/cylinder | 160.00     |
| 3.      | Bio-safe                         | 200ml    | 850/lit    | 170.00     |
|         | Total                            | -        | -          | 331.44     |
| II. Variable cost                            |          |           |            |            |
| 1.      | Labour                           | -        | -          | 224.00     |
|         | Total                            |          |            | 224.00     |
|         | Total cost (Rs) for 800 kg       |          |            | 555.44     |
|         | Total cost (Rs) for 1 kg         |          | -          | 0.69       |

Assets: Ripening chamber of capacity 800 kg
8th day of storage was found to be maximum in the treatment T6 (8.66) followed by the treatment T3 (8.18) and treatment T7 (7.91) in ethephon dip treatments. Whereas the mango fruits treated in ethylene gas exposure treatments in ripening chamber recorded the maximum sensory score in treatment T2 (8.40) followed by treatments T3 (8.10) and T4 (7.85). The lowest sensory score was recorded in the treatment T1 (7.22) i.e. control.

The uniform and sustainable colour development of the fruit during ripening may be associated with faster degradation of chlorophyll and functional activity of ethylene as a degreening agent. Generally the distinct flavor development is function of adequate sugar acid blend coupled with suitable combination of other bio-chemicals and volatiles, which might have developed adequately during the ethylene, induced ripening of fruits.

Similar findings were recorded by Dhemre (2001) in mango Cv. Kesar, Daware (2012), Zagade and Relekar (2014), Venkatram and Pandiarajan (2014) in mango Cv. Alphonso.

Cost of ripening of Kesar mango fruits

It could be observed from the Table 5 that the cost of ripening of 1 kg mango fruits was worked on per day basis. The cost of ripening chamber for 800 kg fruits on per day interest and ethylene gas was considered for calculating the cost of ripening. The cost was found to be Rs 0.69 per kg.

It was found that mango Cv. Kesar exposed to the ethylene gas in the ripening chamber and ethephon dip treatment triggered the ripening process. It was also noticed that more the period of exposure to ethylene gas and more the concentration of ethephon, faster was the ripening process and showed the significant increasing trends in TSS, sugars, β carotene and decreasing trends in titratable acidity and ascorbic acid in all the treatment combinations during advancement of storage period in ambient condition.

It was observed that mango fruits Cv. Kesar ripened by exposing them to 100 ppm ethylene gas in ripening chamber for 18 hrs and storage at ambient condition recorded the maximum shelf life of 6 days and showed better results in respect of high overall acceptability score of 8.77. Similarly, mango fruits Cv. Kesar ripened by ethephon dip treatment of 750 ppm for 5 minutes and storage at ambient condition recorded the maximum shelf life of 8 days and showed better results in respect of high overall acceptability score of 8.66, respectively.

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