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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, ß 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.

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 7.3tonnes/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.

Ethephon

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^{0}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^{0}C with 54.0-62.6% R.H) for studying the ripening behaviour of mango fruits.

Ethephon 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^{0}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 6.86 ºB 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 ß 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) (^{0}B)

At the initial stage, the TSS of mango fruit was found to be 6.86 ^{0} Brix. At the end of 2nd, 4th and 6th day of storage, treatment T_4 recorded maximum TSS (10.50, 14.75 and 19.67^{0}Brix) followed by treatment T_3 (9.97, 12.65, 19.67 ^{0}Brix) in ethylene gas exposure treatment in the ripening chamber. At the end of 8th day of storage, the treatment T_3 recorded maximum TSS (19.42^{0}Brix) followed by treatment T_2 (19.30^{0}Brix) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd, 4th and 6th and 8th day of storage, treatment T_7 recorded maximum TSS (9.86, 14.18, 19.30 and19.55 ^{0}Brix) followed by treatment T_6 (9.35, 11.92, 14.78 and 19.30 ^{0}Brix) in ethephon 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 T_4 recorded minimum acidity (1.41, 0.83, 0.27 and 0.22%) followed by treatment T_3 (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 T_7 recorded minimum acidity (1.60, 1.06, 0.25 and 0.19%) followed by treatment T_6 (1.65, 1.18, 0.68 and 0.23%) in ethephon dip treatments. At end of 8th day of storage, treatments T_3 and T_5 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 T_4 recorded minimum ascorbic acid (68.55, 55.37, 35.32 and 33.20 mg/100g) followed by treatment T_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 2nd, 4th, 6th and 8th day of storage, treatment T_7 recorded minimum ascorbic acid (68.76, 56.32, 36.25 and 35.19 mg/100g) followed by treatment T_6 (73.20, 64.83, 51.33 and 36.66 mg/100g) in ethephon dip treatments. At the end of 6th day of storage, treatment T_2 and T_6 recorded 51.22 and 51.33 mg/100g and were at par with each other. At the end of 8th day of storage, the treatment T_7 recorded minimum ascorbic acid (mg/100g) followed by treatment T_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 Sakhale *et al.,* (2006), William *et al.,* (2009), Pandarinathan and Sivakumar (2010), in mango fruits.

Total sugars (%)

At initial stage, the total sugars content of mango fruit was found to be 4.35 per cent. At the end of 2nd, 4th, and 6th day of storage, treatment T_4 recorded maximum total sugars content (9.07, 12.63, 16.65%) followed by treatment T_3 (8.88, 11.28 and 13.83 %). At the end of 8th day of storage, the treatment T_3 recorded maximum total sugars content (16.82%) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd and 4th day of storage, treatment T_7 recorded maximum total sugars content (9.18 and 11.70%) followed by treatment T_6 (8.85 and 11.63 %) in ethephon dip treatments. At the end of 8th day of storage, the treatment T_7 recorded maximum total sugars content (16.90%) followed by treatment T_6 (16.82%) in ethephon dip treatments.

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 *et al.,* (2012), Zagade and Relekar (2014) in mango fruits.

Reducing sugars (%)

At initial stage, the reducing sugars content of mango fruit was found to be 2.15per cent. At the end of 2nd and 4th day of storage, treatment T_4 recorded maximum reducing sugars content (3.76 and 5.12%) followed by treatment T_3 (3.46 and 4.78%) in ethylene gas exposure treatment in the ripening chamber.

At the end of 6th day of storage, the treatment T_4 recorded maximum reducing sugars content (6.22%), however it was declined on 8th day (6.12%).

At the end of 8th day of storage, the treatment T_3 recorded maximum reducing sugars content (6.18%) followed by treatment T_4 (6.12 %) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2nd, 4th, 6th and 8th day of storage, treatment T_7 recorded maximum reducing sugars content (3.80, 4.98, 6.14 and 6.22 %) followed by treatment T_6 (3.48, 4.95, 5.52 and 6.16 %) in ethephon dip treatments.

At the end of 8th day of storage, treatment T_3 and T_6 recorded reducing sugars as 6.18 and 6.16 % respectively, which were at par each other.

Table.2 Effect of various treatments on bio- chemical properties of mango during ripening

Particulars	Storage period (days)	Treatments								
		Control	Ripening chamber			Ethephon dip				
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	SE±	C.D. at 5 %
Total soluble solids (^oB)										
	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/100g)										
	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
T_1	Control (Without any treatments).
T_2	12 hrs exposure to ethylene gas 100 ppm in ripening chamber
T_3	18 hrs exposure to ethylene gas 100 ppm in ripening chamber
T_4	24 hrs exposure to ethylene gas 100 ppm in ripening chamber
T_5	500 ppm dip in ethephon for 5 minutes
T_6	750 ppm dip in ethephon for 5 minutes
T_7	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						
T_1	Without treatment i.e. control	7.00	7.00	6.00	6.00	6.50
Ripening chamber						
T_2	12 hrs exposure to ethylene gas	8.50	8.50	8.00	8.50	8.37
T_3	18 hrs exposure to ethylene gas	8.80	8.75	8.75	8.80	8.77
T_4	24 hrs exposure to ethylene gas	8.50	8.75	8.20	8.40	8.46
Ethphon dip						
T_5	500 ppm ethephon dip treatment	8.00	8.00	7.75	8.00	7.93
T_6	750 ppm ethephon dip treatment	8.50	8.50	7.25	8.00	8.06
T_7	1000 ppm ethephon dip treatment	8.25	8.50	8.25	8.00	8.25

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						
T_1	Without treatment i.e. control	7.20	7.45	7.00	7.25	7.22
Ripening chamber						
T_2	12 hrs exposure to ethylene gas	8.40	8.50	8.25	8.50	8.40
T_3	18 hrs exposure to ethylene gas	8.30	8.10	8.00	8.00	8.10
T_4	24 hrs exposure to ethylene gas	8.00	7.50	7.75	8.20	7.85
Ethphon dip						
T_5	500 ppm ethephon dip treatment	8.25	8.00	8.50	8.00	8.18
T_6	750 ppm ethephon dip treatment	8.70	8.60	8.75	8.60	8.66
T_7	1000 ppm ethephon dip treatment	8.00	8.10	7.75	7.80	7.91

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) for1 kg		-	0.69

Assets: Ripening chamber of capacity 800 kg

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 268.00µg/100g. At the end of 2^{nd}, 4^{th}, 6^{th} and 8^{th} day of storage, treatment T_4 recorded maximum β carotene content (6074.30,10274.85,14760.08 and 15900.33 µg/100g) followed by treatment T_3 (3614.30, 5805.37, 8736.22 and 13950.21 µg/100g) in ethylene gas exposure treatment in the ripening chamber.

At the end of 2^{nd}, 4^{th}, 6^{th} and 8^{th} day of storage, treatment T_7 recorded maximum β carotene content (5486.30, 9286.23, 13100.02 and 14300.21 µg/100g) followed by treatment T_6 (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 3and 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 6^{th} day of storage was found to be maximum in the treatment T_3 (8.77) followed by the treatment T_4 (8.46) and treatment T_2 (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 T_7 (8.25) followed by treatments T_6 (8.06) and T_5 (7.93). The lowest sensory score was recorded in the treatment T_1 (6.50) i.e. control.

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

8th day of storage was found to be maximum in the treatment T_6 (8.66) followed by the treatment T_5 (8.18) and treatment T_7 (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 T_2 (8.40) followed by treatments T_3 (8.10) and T_4 (7.85).The lowest sensory score was recorded in the treatment T_1 (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, ß 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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