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Influence of Ripening Agent(s) on Post-Harvest Physiology and Enzymatic Activity of Mango (*Mangifera indica*) cv. Dashehari

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A B S T R A C T

This study was carried out to evaluate the best ripening agent(s) for mango cv. Dashehari. For this mangoes were treated with ripening agent(s) in fourteen configuration viz., without treatment (T_0), ethephon (T_1), dried plash leaves (T_2), wet kachnar leaves (T_3), wet amaltas leaves (T_4), wheat straw (T_5), rice straw (T_6), newspaper (T_7), white paper (T_8), tissue Paper (T_9), brown paper bag (T_{10}), wheat grain (T_{11}), jute bag (T_{12}), and cardamom (T_{13}), upto six days, replicated four times under complete randomized design. The results revealed that at ambient storage condition treatment T_2 (Dried plash leaves) was better with post-harvest physiology and enzymatic activity attributes viz., Ripening Index, Ethylene, Respiration rate, Polygalacturonase (PG), Pectin methyl esterase (PME), value higher and Physiological loss of weight lower during the ripening period (up to 6 days).

Introduction

Mango (*Mangifera indica* L.) known as "King of all fruits" is one of the oldest and choicest tropical fruits of the world. It has delicious taste, excellent flavor and attractive fragrance, it is rich in vitamins A and C. It is a climacteric fruit, exhibiting a climacteric pattern of respiration and an increase in ethylene production during ripening (Cua and Lizada, 1990 and Reddy and Srivastava, 1999). The initiation of ethylene production within the fruit triggers and coordinates the changes that occur during ripening. These include: (i) flesh colour greenish yellow to yellow to orange in all cultivars; (ii) skin colour from green to yellow in some cultivars; (iii) chlorophyll decreases and carotenoid content increases; (iv) flesh firmness decreases and juiciness increases; (v) conversion of starch into sugars; (vi) total soluble solids content increases; (vii) titratable acidity decreases; (viii) characteristic aroma volatiles increase; (ix) CO_2 production rate increases from about 40-50 to 160-200 mg $kg^{-1}h^{-1}$ at 20°C and (x) ethylene production rate increases from about 0.1-0.2 to 1-3 µL $kg^{-1}h^{-1}$ at 20°C (Yahia, 2011). Respiration patterns and ripening behavior vary among cultivars, with different

climatic conditions and growing locations (Krishnamurthy and Subramanyam, 1970). The respiratory peak in 'Alphonso' mangoes harvested mature-green occurs 5 days after harvest, and the fruit ripens within 7 to 8 days (Karmarkar and Joshi, 1941), while, in 'Kent' and 'Haden' mangoes the peak occurs on days 9 and 11, respectively (Burg and Burg, 1962), and in 'Pairi' mangoes on day 9 (Krishnamurthy and Subramanyam, 1970). These differences are normal due to differences in location, climatic conditions, orchard and tree conditions and especially postharvest conditions used in the different studies. The rise in the climacteric respiration in 'Dashehari', 'Amarpali' and 'Rataul' mangoes coincide with the highest level of sucrose and polygalacturonase (PG) activity in ripening fruit (Kalra and Tandon, 1983). Further, with the rapid development of fruit trade, most of the fruit sellers are using ripening agents such as calcium carbide which is extremely hazardous to the human body as it contains traces of arsenic and phosphorus. Similarly, ethrel is another ripening agent used for fruits. On dipping the mature fruits in ethrel, it enters the fruits cell, releases ethylene and hastens the ripening process. However, use of such ripening agent(s) decrease on the nutritive value as well as have negative impact on food safety & health security and it has also been observed that these ripened fruit have shorter shelf life. Keeping in view, the above mentioned facts present study is proposed to assess whether the organic agents can also hasten the ripening of mango similar to the inorganic organic ripening agents and can be exploited as natural and safe mode of fruit ripening.

Materials and Methods

Mangoes were treated with different ripening agents such as (T_0) Control without treatment, (T_1) ethephon 1000ppm (10 ml in 1 litre water) was sprayed with pump pressure sprayer, (T_2) plash leaves harvested in morning and dried under shade for five days (800 gm), (T_3) wet kachnar leaves collected in morning (1.50 kg), (T_4) wet amaltas leaves were collected in morning (1.50 kg), (T_5) wheat straw (2.5 kg), (T_6) rice straw (700gm), (T_7) newspaper (250 gm), (T_8) white paper (160 gm), (T_9) tissue paper (110 gm), (T_{10}) brown paper bag (210 gm), (T_{11}) wheat grain (4kg), (T_{12}) jute bag (3.25 kg), and (T_{13}) Cardamom (4 in number) for 3kg mangoes having size approx 150 gm per replicae per treatment were layered alternately in a CFB Box. However, for four replications, 12 kg mangoes each having size approximately 150 gm were used per treatment. Therefore treated 168 kg mangoes fruits were packed in fifty six corrugated fibre boards. All boxes were tagged as per treatment and stored under ambient condition. Observations were recorded daily till fruit ripened upto 6 days by the following methods.

Physiological Loss In Weight (%) by measuring initial and final weight, Moisture (%)AOAC (1980), Firmness (Newton) by Texture Analyzer, Respiration Rate (ml $Co_2 kg^{-1} h^{-1}$) by Head Space Gas Analyzer, Ethylene Production (ppm) by Ethylene Analyzer, Ripening Index (%) Va'sqez-Caicedo *et al.*, (2005), Polygalacturonase (PG) (µgPGN min^{-1}) Zainon and Brady (1982), Pectin methyl esterase (PME) ($A_{620} min^{-1}$) Hagerman and Austin (1986)

Results and Discussion

Physiological loss of weight and Moisture content

It is evident from the data (Table 1) that physiological loss of weight of mangoes was increased with the advancement of ripening in all the treatments. The maximum physiological loss of weight recorded in the T_1 (27%) followed by T_{11} (25.12%) and

minimum in T_2 (10.12%) on 6th day of ripening period. Weight loss is mainly related to respiration through skin, transpiration and metabolic process in the fruit. The rate of water loss depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere in strawberry (Hernandez-Munoz *et al.,* 2008), in guava (Wijewardane, 2013) and in banana fruit (Rahaman and Bishop, 2013). Similarly, moisture content was increased with the advancement of ripening in all the treatments. The maximum moisture content recorded in the T_1 (Ethephon) (90.45**%**) and minimum in T_0 (69.25**%**) on 6th day of ripening period.

Firmness and ripening index

The results indicate that the Firmness of ripened mango was decreased with the advancement of ripening (Table 2). On 6th day minimum firmness (3.50 Newton) was recorded in the treatment T_1 (Ethephon) followed by 7.50 Newton in T_2 (Newspaper) and maximum (20.00 Newton) was in T_0 (without treatment). Fruit firmness was gradually decreased from the initial stage to the final stage of ripening. This decrease was more in the treated fruits than in the control fruits. Decreasing fruit firmness might be associated with fruit softening which in coincide with the report of (Gill *et al.,* 2015).

In ripening mango, sharp physio-chemical changes that occur are softening of the fruit, change in odour and flavour, increase in sugar content, reduction in organic acids, and formation of pigments, especially carotenoids and ripening index on 6th day was maximum 7.24 in T_2 (Dried plash leaves) and lowest 6.55 in T_1 (Ethephon). Increase in ripening index during post-harvest storage was mainly due to decrease in acidity and increase in TSS. Sugar: acid ratio serves as an index of degree of ripeness and hence determines the flavour of the fruit.

Table.1 Effect of ripening agent(s) on physiological loss of weight and moisture content of mango cv. Dhasheri during ripening time

Treatment	Ripening time (days)											
	Physiological loss of weight (%)						Moisture (%)					
	1	2	3	4	5	6	1	2	3	4	5	6
T_0 (Without treatment)	4.95	8.48	16.66	17.26	18.77	22.89	55.60	57.14	59.45	62.14	65.25	69.25
T_1 (Ethephon)	6.02	9.45	14.78	17.44	21.00	27.03	67.95	69.00	71.75	83.45	86.75	90.45
T_2(Dried plash leaves)	0.24	3.32	4.82	7.42	9.81	10.12	64.54	69.10	75.65	79.15	82.45	86.15
T_3(Wet kachnar leaves)	0.82	4.98	7.93	10.00	12.61	13.00	64.00	71.95	76.45	78.45	81.95	85.75
T_4(Wet Amaltas leaves)	0.96	5.41	9.10	10.24	12.62	12.95	64.00	71.00	77.00	77.94	80.14	85.01
T_5(Wheat straw)	5.24	8.49	10.24	14.66	15.12	18.75	57.45	61.00	65.45	76.12	70.45	73.45
T_6(Rice straw)	4.77	10.5	14.81	17.67	20.78	23.18	58.17	62.25	64.24	69.45	72.70	75.25
T_7(News paper)	4.24	9.02	16.59	18.02	19.09	22.85	61.75	67.45	72.45	78.25	82.14	88.14
T_8(White paper)	3.28	7.12	10.11	13.56	16.81	20.38	59.00	64.40	69.25	73.14	75.45	79.35
T_9(Tissue paper)	6.12	8.12	13.45	18.25	21.45	23.50	59.00	66.00	70.00	74.00	78.00	82.45
T_{10}(Brown paper bag)	5.38	11.21	14.51	17.46	18.18	23.65	60.00	65.50	71.00	76.45	81.70	85.80
T_{11}(Wheat grain)	4.98	10.12	11.56	17.45	20.12	25.12	57.12	62.50	64.00	68.00	71.90	77.75
T_{12} (Jute bag)	3.24	5.94	10.12	12.39	18.58	19.17	55.70	56.14	58.12	61.25	65.01	70.85
T_{13} (Cardamom)	5.23	9.45	14.22	17.55	20.81	24.62	63.21	67.45	72.75	79.45	82.45	84.15
SEm±	0.26	0.59	0.08	0.10	0.21	0.28	0.38	0.47	0.48	0.51	1.00	1.03
CD (P=0.01)	1.10	0.22	0.31	0.39	0.81	1.08	1.48	1.80	1.83	1.97	3.82	3.94

Table.2 Effect of ripening agent(s) on firmness and ripening index of mango cv. Dhasheri during ripening time

Treatment	Ripening time (days)											
	Firmness (Newton)						Ripening Index					
	1	2	3	4	5	6	1	2	3	4	5	6
T_0 (Without treatment)	36.00	32.50	28.00	25.00	22.00	20.00	6.42	6.49	6.70	6.74	6.77	6.78
T_1 (Ethephon)	24.00	18.00	13.00	10.00	7.00	3.50	6.60	6.83	7.10	7.41	7.14	6.55
T_2(Dried plash leaves)	34.00	29.00	23.00	17.00	12.00	8.50	6.42	6.49	6.70	6.84	7.17	7.24
T_3(Wet kachnar leaves)	33.00	30.00	24.00	19.00	13.50	9.00	6.44	6.49	6.66	6.83	7.12	7.16
T_4(Wet Amaltas leaves)	32.50	30.50	26.00	20.50	14.00	9.00	6.48	6.55	6.75	6.88	7.09	7.19
T_5(Wheat straw)	32.00	29.00	28.00	26.00	21.00	17.00	6.42	6.52	6.88	7.03	7.07	7.10
T_6(Rice straw)	31.00	27.00	25.50	23.50	22.50	18.00	6.34	6.43	6.60	6.80	7.05	7.07
T_7(News paper)	31.00	28.00	25.50	21.00	14.00	7.50	6.51	6.63	6.88	7.11	7.13	7.13
T_8(White paper)	33.00	30.00	27.50	23.00	19.00	16.00	6.49	6.54	6.84	6.91	7.01	7.02
T_9(Tissue paper)	34.00	32.00	28.00	24.00	18.00	13.00	6.39	6.40	6.69	6.85	6.93	6.97
T_{10}(Brown paper bag)	33.00	29.50	26.00	22.00	15.00	11.00	6.40	6.46	6.73	6.78	6.87	6.89
T_{11}(Wheat grain)	31.00	27.50	22.50	18.00	16.00	12.50	6.41	6.47	6.62	6.67	6.73	6.76
T_{12} (Jute bag)	36.00	34.00	27.00	23.50	22.00	18.00	6.43	6.45	6.53	6.65	6.69	6.70
T_{13} (Cardamom)	35.00	28.00	25.00	19.00	14.00	10.00	6.59	6.61	6.88	6.90	6.99	7.10
SEm±	0.21	0.25	0.17	0.14	0.20	0.16	0.03	0.04	0.04	0.06	0.10	0.08
CD (P=0.01)	0.80	0.85	0.65	0.53	0.79	0.61	0.12	0.18	0.17	0.22	0.39	0.33

Table.3 Effect of ripening agent(s) on ethylene and respiration rate of mango cv. Dhasheri during ripening time

Treatment	Ripening time (days)											
	Ethylene (ppm)						Respiration rate (ml $CO_2kg^{-1}h^{-1}$)					
	1	2	3	4	5	6	1	2	3	4	5	6
T_0 (Without treatment)	3	10	15	18	20	24	16.684	24.532	39.687	51.359	65.691	66.987
T_1 (Ethephon)	50	74	95	110	160	94	67.24	79.626	86.542	92.639	58.847	32.528
T_2(Dried plash leaves)	38	68	88	98	136	151	47.017	80.637	99.09	101.921	108.544	117.846
T_3(Wet kachnar leaves)	48	74	94	105	111	129	39.687	83.418	97.599	100.006	108.666	110.794
T_4(Wet Amaltas leaves)	36	69	74	80	102	134	39.813	68.365	94.888	102.803	108.729	113.752
T_5(Wheat straw)	6	19	36	49	59	62	20.602	32.356	47.321	60.263	64.156	74.521
T_6(Rice straw)	11	24	39	46	56	64	25.025	40.698	55.738	68.251	76.188	78.868
T_7(News paper)	19	37	52	87	102	128	52.578	69.767	76.795	82.912	88.727	95.551
T_8(White paper)	4	9	16	29	49	61	21.992	49.899	58.696	64.51	71.638	78.109
T_9(Tissue paper)	6	16	21	34	50	79	30.334	42.467	50.152	75.581	81.143	87.361
T_{10}(Brown paper bag)	12	23	42	54	79	85	51.314	59.151	71.587	84.226	89.788	90.053
T_{11}(Wheat grain)	8	12	37	59	71	83	41.709	62.69	79.803	84.454	85.996	90.887
T_{12} (Jute bag)	5	11	23	25	27	29	16.684	28.842	32.356	59.656	78.552	81.143
T_{13} (Cardamom)	24	41	78	98	115	132	32.963	54.853	71.79	94.843	99.482	102.661
SEm±	0.16	0.31	0.39	0.47	1.36	1.06	0.27	0.43	0.49	0.56	1.28	1.10
CD (P=0.01)	0.46	0.89	1.12	1.35	3.88	3.03	1.04	1.66	1.90	2.17	4.90	4.20

Table.4 Effect of ripening agent(s) on polygalacturonase (PG) and pectin methyl esterase (PME) content of mango cv. Dhasheri during ripening time

Treatment	Ripening time (days)											
	Polygalacturonase (PG) (µgPGN min^{-1})						Pectin methyl esterase (PME) ($A_{620}min^{-1}$)					
	1	2	3	4	5	6	1	2	3	4	5	6
T_0 (Without treatment)	2.50	2.90	3.45	4.00	4.60	4.82	0.19	0.25	0.31	0.39	0.41	0.55
T_1 (Ethephon)	4.45	5.12	6.65	8.82	6.45	4.58	0.39	0.45	0.55	0.76	0.43	0.39
T_2(Dried plash leaves)	3.60	4.24	5.48	6.24	7.90	9.10	0.28	0.37	0.40	0.56	0.62	0.81
T_3(Wet kachnar leaves)	3.34	4.02	5.14	6.19	7.75	8.76	0.26	0.28	0.35	0.44	0.56	0.79
T_4(Wet Amaltas leaves)	3.30	3.98	5.04	6.14	7.72	8.65	0.25	0.26	0.32	0.52	0.63	0.66
T_5(Wheat straw)	2.74	3.10	3.67	4.45	5.12	5.25	0.19	0.27	0.31	0.40	0.43	0.47
T_6(Rice straw)	2.78	3.19	3.78	4.60	5.13	5.30	0.19	0.26	0.30	0.37	0.43	0.44
T_7(News paper)	4.12	4.49	6.46	7.64	8.90	7.42	0.36	0.40	0.43	0.65	0.71	0.75
T_8(White paper)	3.05	3.98	4.12	5.14	5.67	6.12	0.30	0.35	0.39	0.49	0.58	0.60
T_9(Tissue paper)	3.15	4.11	4.25	5.34	5.70	6.23	0.34	0.36	0.40	0.40	0.53	0.57
T_{10}(Brown paper bag)	3.75	4.24	5.65	6.34	7.38	8.00	0.37	0.39	0.43	0.46	0.57	0.70
T_{11}(Wheat grain)	3.15	3.45	3.98	4.56	5.01	5.49	0.18	0.27	0.29	0.37	0.46	0.58
T_{12} (Jute bag)	2.52	2.91	3.44	4.01	4.71	4.84	0.17	0.24	0.30	0.35	0.43	0.57
T_{13} (Cardamom)	3.56	4.98	5.45	6.42	6.89	7.98	0.32	0.35	0.40	0.47	0.57	0.76
SEm±	0.06	0.09	0.12	0.13	0.14	0.13	0.01	0.02	0.02	0.03	0.07	0.08
CD (P=0.01)	0.08	0.11	0.13	0.15	0.36	0.34	0.06	0.09	.010	0.13	0.29	0.31

Ethylene and respiration rate

It is evident from the data (Table 3) that ethylene and respiration rate of ripened fruit increased with the advancement of ripening in all the treatments except T_1 (Ethephon) treatment where firmness and ripening increases upto 5th day and then decreases. On 6th day of ripening period, maximum ethylene and respiration rate recorded in the T_2 (dried plash leaves) (151 ppm and 117.846 ml $CO_2kg^{-1}h^{-1}$ respectively) and minimum in respiration rate in T_1 (Ethephon) (32.528 ml $CO_2kg^{-1}h^{-1}$) while, minimum ethylene evolution in T_0 (Control) treatment (24 ppm). In climacteric fruits sudden increase in respiration and the burst of ethylene production occurs, after which it declines which is the major cause of short shelf life. However, increase in respiration rate and ethylene increases the permeability of the external tissue and enzymatic activity for carotene synthesis and hence hastens the ripening and colour development. The present study was in agreement with (Cua and Lizada, 1990 and Reddy and Srivastava, 1999).

Polygalacturonase (PG) and Pectin methyl esterase (PME)

The results indicate that the PG and PME of ripened mango increased with the advancement of ripening (Table 4) except in T_1 (Ethephon) and T_7 (Newspaper). On 6th day maximum PG and PME (9.10 µgPGN min^{-1} and 0.81 $A_{620}min^{-1}$ respectively**)** was recorded in the treatment T_2 (Dried plash leaves) and minimum (4.58 µgPGN min^{-1} and 0.39 $A_{620}min^{-1}$) was recorded in T_1 (Ethephon).

In ripening process Polygalacturonan enzyme produced in plants is involved in hydrolysis of carbohydrates which is the component of the pectin network that comprises plant cell walls. The activity of the endogenous plant polygalacturonase is to soften and sweeten fruit during ripening process. Similarly Pectin methyl esterase is responsible for de-estrification of pectin and also to modify pH and cation exchange properties of wall which might, in turn, affect activity of other wall degrading enzymes. So, increase in PME

resulted in cell wall softening in mango fruit. The present study is in agreement with (Kalra and Tandon, 1983).

In conclusion, thus, dried plash leaves as ripening agent(s) influence the physico-enzymatic activity of Dashehari mango during ripening period of 6th day, was found best from health point of view and also increase the shelf life of mango during storage as compared other ripening agent(s).

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