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Research Article

PUTRESCINE IMPROVES SHELF LIFE AND QUALITY OF MANGO (*Mangifera indica* L.) FRUITS *CV.* KESAR

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Abstract- In a trial conducted at Navsari Agricultural University, Navsari putrescine was applied at three different levels (1, 2 and 3 mM) to mango *cv.* Kesar, as preharvest spray (10 days before harvesting), postharvest dip (5-6 min) and preharvest spray + postharvest dip treatment. Methods of application and levels of putrescine had a significant impact on all parameters included in the study except pulp: peel ratio. Preharvest spray +postharvest dip of putrescine @ 2mM emerged as the best treatment combination for mango fruits exposed to this treatment could be stored for 20 days at 11±1°C & 90-95% RH. Fruits thus treated had the lowest spoilage, maximum firmness and the highest organoleptic scores. These results throw light on the potential use of putrescine in prolonging the shelf life of mango without any detrimental effect on fruit quality. This technology can be put to use when transporting fruits to high end and distant markets

Keywords- Mango, Putrescine, Fruit firmness, Shelf life, Spoilage

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Introduction

Mango (*Mangifera indica* L.) occupies a pre-eminent place among fruit crops grown in India. It is favored by all sections of the society due to its delicious taste, unique flavor and nutritive value. Mango is closely associated with the culture, history and customs of the Indian subcontinent. Mango covers about 25.16 lakh hectares in India with a production of 184.31 lakh MT and a productivity of 7.3 MT/ha. The major mango growing states are Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar and Telangana. Gujarat contributes nearly 6.1% to the total mango production of the country [1]. Valsad, Navsari and Junagadh are the leading mango growing districts of Gujarat [2]. Kesar, Alphonso, Rajapuri and Totapuri are the most popular mango varieties of Gujarat amongst which Kesar and Alphonso have good export potential. In the past decade, area under Kesar has increased, owing to higher productivity and regularity in bearing. Indian consumers have shown a strong preference for its attractive shape, size, colour, exquisite flavor and pleasant aroma.

Polyamines are polycationic compounds of low molecular weight that are present in living organisms [3]. The term polyamines collectively applies to putrescine (PUT), spermidine (SPD) and spermine (SPM) along with few other related secondary conjugated products [4, 5]. Exogenous application of polyamines is reported to improve yield in strawberry [6], litchi [7] and mango [8]. Postharvest treatment with polyamines has helped maintain firmness in apple [9], plum [10] and apricot [11].

Although there is ample experimental evidence to indicate that polyamines can improve yield in a wide spectrum of fruit crops, there is a paucity of information regarding the effect of polyamines on post harvest quality of fruit crops in general and mango in particular. The current investigation is aimed at studying the effect of putrescine and its mode of application on the shelf life and quality of mango *cv.* Kesar.

Materials and Methods

This trial was conducted at Navinchandra Mafatlal College of Agriculture (NMCA) Farm, Navsari Agricultural University (NAU), Navsari during 2013-14. It is located on the coast of the Arabian sea at 20°-57'N latitude and 72°-54'E longitude at an altitude of about 10 metres above the mean sea level. Navsari campus falls under South Gujarat Heavy Rainfall Zone-I and is characterized by fairly hot summer, moderately cold winter, humid and warm monsoon with heavy rains. A maximum temperature of 38°C in the month of April and a minimum temperature of 10°C in the month of January was recorded. Monsoon generally starts from the second week of June and lasts up to the second week of September. Most of the rainfall is received from South West monsoon in the months of July and August and ranges between 1500 to 1800 mm. During the experimental period (May to June), average maximum temperature ranged from 27.6°C to 36.0°C, minimum temperature from 12.0°C to 28.1°C and relative humidity was in between 85-95%.

Seven years old mango trees of cultivar 'Kesar' planted at a distance of 5 x 5 m at NMCA Farm, NAU, Navsari were selected for experimentation. The selected trees were of uniform shape, size and growth. These trees were managed with uniform cultural practices as per the standard recommendations of NAU with respect to manures and fertilizers, irrigation and plant protection measures etc. Treatments consisted of preharvest spray, postharvest dip and preharvest spray + postharvest dip treatments of putrescine at three different levels (1, 2 and 3 mM). Mango trees of *cv.* Kesar were sprayed with putrescine solution of the desired concentration, 10 days before harvesting using battery operated knapsack sprayers. Fruits were sprayed till the surface was thoroughly wet. Tween-20 a stickler agent was mixed with solution before spraying. Fully mature fruits were harvested and immediately brought to the Centre of Excellence on Postharvest Harvest Technology, NAU, Navsari. Harvested fruits were subjected to postharvest dip treatments of putrescine solutions for 5-6 minutes followed by low temperature storage at 11±1°C & 90-95% RH. Five fruits were selected at random from each treatment

for recording observations at an interval of 5 days starting from the day of harvesting. Fruit firmness was determined with the help of penetrometer at room temperature and expressed in kg/cm^2. Fruits were cut vertically and the pulp was extracted which was expressed in grams. Similarly the peel was weighed and expressed in grams. The pulp peel ratio was calculated by dividing the pulp weight of five randomly selected mango fruits by their peel weight. The Physiological Loss in Weight (PLW) was determined by the following formula and expressed as percentage.

$$PLW\ (\%) = \frac{Initial\ weight\ of\ fruit - final\ weight\ of\ fruit}{Initial\ weight} x\ 100$$

Fruits were assessed for their colour, texture, taste, aroma and overall acceptability by a panel of five judges using a 9 point hedonic scale. The number of days taken from harvesting to optimum eating stage was regarded as the shelf life of fruits. The number of diseased, rotten and over ripened fruits were counted and expressed in percentage over the total number of fruits. Statistical analysis was carried out under the technical supervision of the Department of Agricultural Statistics, NMCA, NAU, Navsari as per the Factorial Completely Randomized Design (FCRD) for the first fifteen days of storage. Data recorded on the twentieth day of storage was analyzed as per Randomized Block Design. The standard method of analysis of variance technique as described by Panse and Sukhatme [12] was followed. Treatment means were compared by means of critical differences at 5 per cent level of probability.

Results and Discussion

Effect of method of application

All parameters chosen for this study were significantly altered by the method of application on the 15th day of storage [Table-1], [Table-2]. Between the three methods of application, preharvest spray recorded the maximum fruit firmness (7.33 kg cm^{-2}). This is in agreement with the findings of Malik et al. [13] in mango. The minimum peel weight (60.78g), PLW (13.45%) and the maximum pulp: peel ratio (5.40) were observed under postharvest treatment. Bhatt et al. [14] also noticed a reduction in PLW when putrescine was applied as a postharvest dip treatment in mango *cv.* Dashehari. However, preharvest spray + postharvest dip treatment resulted in the maximum pulp weight (345.33 g) and the minimum spoilage (20.74%). The authors have come across very few studies in which preharvest sprays + postharvest dip treatments were assessed for their impact on quality parameters of mango and therefore this is a matter which warrants further investigation.

Table-1 *Effect of method of application and levels of putrescine on fruit firmness and physiological loss in weight of mango cv. Kesar*

Treatments	Fruit firmness (kg cm^{-2})				Physiological loss in weight (%)			
	Storage Period (days)				Storage period (days)			
	0	5	10	15	0	5	10	15
Methods of Application								
Preharvest spray	12.79	11.40	9.40	7.33	0	3.72	9.81	14.48
Postharvest dip	13.40	10.58	8.91	6.78	0	3.79	9.45	13.45
Preharvest spray + Post harvest dip	13.13	9.71	7.71	5.86	0	3.55	9.18	13.73
S. Em.±	0.09	0.08	0.08	0.10	-	0.11	0.12	0.14
CD 5%	0.28	0.25	0.25	0.29	-	NS	0.37	0.42
Levels of Putrescine								
Put @ 1mM	13.94	10.71	9.04	6.89	0	3.69	9.82	13.48
Put @ 2mM	16.47	12.27	10.27	8.23	0	3.59	9.14	13.69
Put @ 3mM	13.23	10.61	8.61	6.52	0	3.78	9.48	14.48
S. Em.±	0.09	0.08	0.08	0.10	-	0.11	0.12	0.14
CD 5%	0.28	0.25	0.25	0.39	-	NS	0.37	0.42
CV %	2.15	2.37	2.88	4.34	-	8.56	3.94	3.03

Table-2 *Effect of method of application and levels of putrescine on pulp weight, peel weight, pulp peel ratio and spoilage in mango cv. Kesar*

Treatments	Storage period (15 days)			
	Pulp weight (g)	Peel weight (g)	Pulp peel ratio	Spoilage (%)
Methods of Application				
Preharvest spray	335.33	69.00	4.87	25.11 (18.32)
Postharvest dip	323.33	60.78	5.40	22.33 (14.79)
Preharvest spray + Post harvest dip	343.33	76.33	4.50	20.74 (12.74)
S. Em.±	1.52	1.14	0.10	0.41
CD 5%	4.52	3.40	0.28	1.21
Levels of Putrescine				
Put @ 1mM	315.33	64.33	5.03	20.11 (11.84)
Put @ 2mM	339.33	70.78	4.83	21.32 (13.68)
Put @ 3mM	347.33	71.00	4.91	26.75 (20.33)
S. Em.±	1.52	1.14	0.10	0.41
CD 5%	4.52	3.40	NS	1.21
CV %	1.37	5.00	5.83	5.36

Effect of levels of Putrescine

Putrescine had a significant influence on all traits considered in this trial except for pulp: peel ratio. A gradual decrease in fruit firmness was observed during the storage period across all Put treatments. The maximum fruit firmness (8.23 kg cm^{-2}) was recorded under putrescine @ 2mM treatment on the 15th day of storage. This can be attributed to the influence of putrescine on inhibiting ethylene biosynthesis [15] and the activity of cell wall degrading enzymes such as pectin esterase, pectin methyl esterase and polygalacturonase involved in fruit softening [16]. It also cross-links pectic substances in the cell wall, producing rigidification and increasing fruit firmness [17]. An increase in fruit firmness with the application of putrescine was earlier reported in mango [18], grape [19], ber [15] and date palm [20]. Physiological weight in loss showed a constant increase with enhancement of the storage period. Putrescine 1 mM resulted in the lowest physiological loss in weight (13.48%) on the 15th day of storage. The reduced weight loss due to putrescine treatments during storage may be due to comparatively lower rates of respiration and increased fruit firmness in treated fruits compared to control [21]. Putrescine may have modified the properties of cell wall and the permeability of tissues to water [22].The findings of Bhatt et al. [14]; Malik et al.[18] in mango, Mirdehghanet al.[23] in pistachio nut and Champa et al. [24] in grape are in confirmation with the present investigation.

Putrescine 3mM resulted in the maximum pulp weight (347.33g) on the 15th day of storage. Whereas, minimum peel weight (64.33g) and maximum pulp: peel ratio were observed under putrescine 1 mM treatment (5.03). Improvement in the physical attributes of the fruit as a result of putrescine treatments might be due to their influence in enlarging the cell size and enhancing the strength of carbohydrate sink, thus increasing pulp weight. Putrescine 1 mM resulted in the lowest spoilage (20.11%) on the 15th day of storage. Whereas, maximum spoilage was observed under putrescine 3 mM treatment (26.75%). Reduced spoilage can be attributed to a decrease in the microbial activity of fruits [25]. Polyamines conjugated to phenloic compounds and hydroxycinamic acid amides have been shown to accumulate in cells in interactions between plants and a variety of pathogens [26]. Thus, putrescine treated fruits had less fungal infection than untreated ones. Similar, findings were also observed by Bhattet al. [14] and Jawandha et al. [27] in mango.

There was a significant improvement in the shelf life of mango fruits due to the treatments imposed [Fig-1]. Putrescine @ 1 mM when applied as a preharvest spray or postharvest dip or preharvest spray + postharvest dip was able to extend the shelf life of mango fruits till 20 days. A shelf life of 20 days was also realized in mango fruits treated with putrescine @ 2 mM applied either as postharvest dip or as preharvest spray + postharvest dip. Untreated fruits could not be stored beyond 15 days [28], prevention of fungal infection [25] and retardation of fruit softening due to inhibition of polygalacturonase activities, presumably through binding to pectic substances [29]. Similar conclusions were reported in plum [10] and pistachio nut [23].

Interaction Effect

The interaction effect between method of application and levels of putrescine was significant for pulp weight, peel weight and pulp: peel ratio on the 20th day of storage [Table-3]. Mango fruits subjected to postharvest dip treatment of Putrescine had a significant influence on all traits considered in this trial except for putrescine @ 2mM (M_2P_2) had the maximum pulp weight (361.67 g). Whereas, postharvest dip treatment with putrescine @ 1mM (M_2P_1) resulted in the lowest peel weight (53.33 g) and the maximum pulp: peel ratio (5.72).Interaction between method of application and levels of putrescine was found significant for physiological loss in weight, fruit firmness and spoilage at the end of the experiment [Table-4]. The minimum PLW (19.23%) and spoilage (26.20%) was recorded when mango fruits were treated with preharvest spray + postharvest dip of 2mM putrescine (M_3P_2). The same treatment combination also resulted in maximum fruit firmness (3.83 kg cm^{-2}).

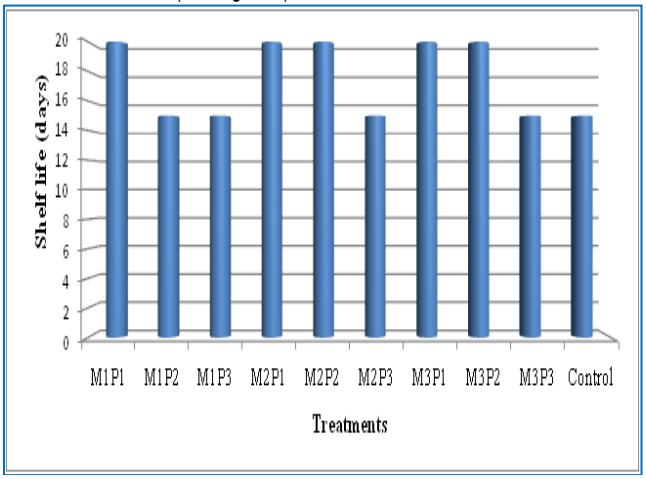

Fig-1 Effect of method of application and levels of putrescine on shelf life of mango *cv.* Kesar

Organoleptic Evaluation

Ripe treated fruits of mango *cv.* Kesar were subjected to organoleptic analysis after 20 days of storage and results indicated a significant influence of mode of application and levels of putrescine on all parameters chosen for this analysis [Table-5]. Putrescine@2mM when applied through preharvest spray + postharvest dip recorded the highest score for pulpcolour (8.16), fruit aroma (7.79), fruit taste (8.74), fruit texture (7.63) and overall acceptability (8.25). Better pulp colour is probably due to higher carotenoids synthesis in fruits with increased maturity [30]. Higher score for taste can be attributed to better accumulation of photosynthates in polyamine applied trees [15] which resulted in higher yield with improved quality in terms of TSS, total sugars and reducing sugars. Close association of aroma and taste of fruits with TSS and sugars is already well established. It may be possible that the fruits having higher TSS and sugars have higher levels of aroma containing molecules, which ultimately contribute to better taste of fruits obtained from putrescine treated trees. Superior overall acceptability was recorded in putrescine treatments over control, which might be due to better retention of fruit firmness for a long period of time and also due to higher scores for other organoleptic characters. These results are in agreement with those obtained by Malik and Singh [18] in mango, Marzouk and Kassem [19] in grape and Ali et al. [11] in apricot.

Table-3 *Interaction effect of method of application and levels of putrescine on pulp weight, peel weight and pulp:peel ratioin mango cv. Kesar*

Mean Values	Storage period (20 days)								
	Pulp weight (g)			Peel weight (g)			Pulp: peel ratio		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
P_1	304.33	303.00	347.00	68.00	53.33	79.00	4.48	5.72	4.40
P_2	-	361.67	330.00	-	73.33	70.33	-	4.94	4.70
P_3	-	-	-	-	-	-	-	-	-
S.Em±	3.10			1.73			0.13		
CD 5%	9.21			5.15			0.38		
CV %	1.63			4.36			4.57		

Table-4 *Interaction effect of method of application and levels of putrescine on physiological loss in weight,fruit firmness and spoilage in mango cv. Kesar*

Mean Values	Storage period (20 days)								
	Physiological loss in weight (%)			Fruit firmness (kg cm^{-2})			Spoilage (%)		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
P_1	19.55	19.47	19.43	3.53	3.33	2.80	27.46 (21.28)	26.81 (20.35)	27.49 (21.33)
P_2	-	19.47	19.23	-	2.80	3.83	-	27.27 (21.00)	26.20 (19.50)
P_3	-	-	-	-	-	-	-	-	-
S.Em±	0.19			0.15			0.37		
CD 5%	0.56			0.44			1.11		
CV %	1.67			7.85			1.18		

Table-5 *Interaction effect of method of application and levels of putrescine on organoleptic score of mango cv. Kesar*

Treatments	Storage period (20 days)				
	Colour	Aroma	Taste	Texture	Overall acceptability
M_1P_1	7.34	7.49	7.43	7.13	7.17
M_1P_2	-	-	-	-	-
M_1P_3	-	-	-	-	-
-M_2P_1	7.65	7.44	8.28	7.23	7.30
M_2P_2	7.26	7.53	7.61	7.07	7.75
M_2P_3	-	-	-	-	-
M_3P_1	7.00	7.08	7.46	6.67	6.80
M_3P_2	8.16	7.79	8.74	7.63	8.25
M_3P_3	-	-	-	-	-
Control	-	-	-	-	-
S.Em±	0.03	0.05	0.05	0.07	0.06
CD 5%	0.08	0.16	0.16	0.22	0.19
CV %	0.59	1.24	1.18	1.78	1.50

Conclusion

In conclusion, method of application and concentration of putrescine did have an important bearing on storability and quality of mango cultivar Kesar. Statistical scrutiny of experimental data revealed that for higher firmness and lower spoilage, fruits of mango cultivar Kesar should be sprayed once with putrescine (2mM) ten days before harvesting followed by postharvest dip for 5-6 minutes. Using putrescine (1 and 2 mM), treated mango fruits could be stored for up to 20 days with better palatability.

Conflict of Interest: None declared

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Abbreviations
PUT: Putrescine
SPD: Spermidine
SPM: Spermine
NMCA: Navinchandra Mafatlal College of Agriculture
NAU: Navsari Agricultural University
FCRD: Factorial Completely Randomized Design
PLW: Physiological Loss in Weight