ISSN: 2617 - 8338

EBAUB Journal
An Academic Journal of
EXIM Bank Agricultural University Bangladesh

Effect of Various Calcium Salts on the Post-harvest Quality of Mango (*Mangifera indica* L.)

Mujibur Rahman Khan[1]*, Md. Rifat Alam[2], Md. Tajul Islam[3]

[1]Department of Horticulture, EXIM Bank Agricultural University Bangladesh, Chapainawabganj-6300, Bangladesh
[2]Department of Entomology, EXIM Bank Agricultural University Bangladesh, Chapainawabganj-6300, Bangladesh
[3]Department of Genetics and Plant Breeding, EXIM Bank Agricultural University Bangladesh, Chapainawabganj-6300, Bangladesh

ARTICLE INFO

Received date: October 06, 2020
Accepted date: Dec. 20, 2020

ABSTRACT

The effect of several calcium salts is differing on the ripening of the mango fruits in Bangladesh, which is frequently found. This study was conducted to discuss how different calcium salt concentrations affected mango ripening, export quality, and eating quality. Three different varieties of mango (Gopalvog, Langra, Himsagor) were taken. After harvesting, the fruits were immersed for l0 minutes in different calcium salt concentrations. Three calcium salts were taken in four concentrations 2.5, 5.0, 7.5 and 10 %. The salts were calcium chloride ($CaCl_2.2H_2O$), calcium sulphate ($CaSO_4.2H_2O$) and calcium ammonium nitrate, $Ca(NH_4NO_3)_2$. For the accuracy of the result, a control for every concentration was also included in which fruits were dipped in fresh water for 10 minutes. The mango fruits were ripened at ambient temperature (27±4 ^{0}c) in the paper carton-boxes lined and covered with newspapers. Calcium salts delayed the fruits ripening about 3 days as compared to the control fruits, however, it induced skin shriveling. $CaSO_4.2H_2O$ also delayed fruits ripening but improved the pulp color. The gradual increase in concentration of calcium salts delayed the fruits ripening, but had negative effects on fruit quality by increasing skin shriveling and lowering flavor and taste of the mango fruits. On the other hand, the calcium ammonium nitrate had a poor influence in the mango fruits ripening. Although calcium salts delayed the ripening for some days, but it as well as decreased the fruits quality, thus, responsible for poor eating quality.

Key words: Calcium salts, Eating quality, Mango, Organoleptic evaluation, Post-harvest, Ripening

CORRESPONDENCE
* mujiburkhan.bd@gmail.com
Lecturer, Department of Horticulture, EXIM Bank Agricultural University Bangladesh, Chapainawabganj 6300, Bangladesh

1. INTRODUCTION

Mango (*Mangifera indica* L.) is regarded as the king of fruits from tropical areas of the world. In Bangladesh the total production of Mango is about 12, 88,000 tons (BBS, 2017). The production of mango in the year of 2016-17 was covered 1,03,000 acres area which is 25.22% of the total fruit production. The average yield of 92 kg/acre was recorded during the year 2016-17 (BBS, 2017). National and international trade of fresh mango has seen limited by the highly perishable nature and susceptibility to the post-harvest diseases and physical injury. The short period of ripening also limits its commercialization in distant markets. For solving this problem various calcium salts

especially calcium chloride and calcium nitrate have been reported in literature to delay the ripening by lowering respiration rate (Singh et al., 1993). Three fortnightly sprays of 1 % calcium nitrate delayed ripening (Sive & Resnizky, 1985). Calcium spraying increased the productivity of mango due to the reduction of abscission (Kumar et al., 2006). The pre-harvest and post-harvest application of chemicals like calcium chloride and calcium nitrate are known to influence the quality and self-life of fruits during storage (Gill et al., 2005).

Gofure et al. (1997) studied on extension of post-harvest storage life of mango and they reported that the increase in calcium salts level leads to delayed hastening but had bad effect on fruit quality by enhancing skin shriveling and reducing flavor and taste of the fruits. Therefore, the present study is focused to determine the effect of different concentration of various calcium salts (i.e. calcium chloride, calcium sulphate and calcium ammonium nitrate) on delaying the ripening, export quality and eating quality of mango fruits.

2. MATERIALS AND METHODS

This study was conducted to discern the many biological and morphological effects of the calcium salts on ripening of mango fruits (*Mangifera indica* L.) at EXIM Bank Agricultural University Bangladesh, Chapainawabganj during September 2018 to June 2019. Three different varieties of mango (Gopalvog, Langra, Himsagor), which were fresh and mature, were harvested in the evening from the largest mango garden was situated in the different upazilas of Chapainawabganj. In next morning, these fruits were cleaned with the cloth. Mangoes were separately treated with four concentrations (2.5, 5.0 7.5 and 10%) of $CaCl_2.2H_2O$, $CaSO_4.2H_2O$ and $Ca(NH_4NO_3)_2$ solutions by dipping for 10 minutes. A control was received immersing in fresh water only for 10 minutes. Sixteen controls were maintained against 64 samples of calcium salts. The fruits were stored accurately for ripening at ambient temperature ($27\pm4\ ^0$c) in boxed lined and covered with newspaper.

The experiment was laid out as factorial with completely randomized design, having two factors, (salts and concentrations) and four replications. The data were recorded on color of the fruits at ripening; skin shriveling of the fruits at ripening, aroma of the fruits at ripening, pulp color of the fruits at ripening, flavor and taste of the fruits at ripening and many other morphological and physiological properties and changes (Anjum et al., 2004).

The physiological and morphological change of the fruits before and after ripening, with or without any chemicals, was observed very carefully and regularly. The organoleptic evaluation of fruits for skin color shriveling, aroma, pulp color, flavor and taste were done using the hedonic scale method of (Peryam & pilgrim, 1957). Ten qualified judges were employed in the panel who were asked to score the above-mentioned parameters using the 10 points hedonic scale, 10 being the highest score indicating most acceptable and zero the least. For proper evaluation and better accuracy, the standard deviation (SD) for each parameter was computed by the method of Steel & Torrie (1980). All parameters were checked daily and, in every case, the fraction of the day was also calculated and their changes were also well established by proper judgment.

3. RESULTS AND DISCUSSION

3.1. Time Required for Ripening

The time required for the ripening of the fruits was influenced by different concentrations of calcium salts. Calcium chloride was more effective in delaying the ripening of fruits as compared to other salts treated and fruits treated with this salt ripened about 3.5 days later than the untreated (control) fruits. The ripening in the fruits treated with calcium sulphate was delayed only for 3.00 days. Calcium ammonium nitrate was not so effective but it was almost at par with control (Table 2). The delay in ripening by calcium chloride treatments has already been reported by several workers (Sive & Resnizky, 1985; Corrales-Garcia & Lakshminarayana, 1991; Yuen et al., 1993; Gofure et al., 1997). Although the concentrations of the calcium salts used resulted in about 2 - 3.5 days in delaying the ripening than control, however, the concentrations did not differ with each other significantly (Table 3). Calcium chloride at the concentrations of 2.5%, calcium sulphate at 2.5% and 5.00% and calcium ammonium nitrate at 2.5% and 5.00% behaved alike and delayed ripening for about 2 days. However, calcium chloride at the concentrations of 7.5% and 10%, and calcium sulphate at 7.5% and 10% were the most effective and fruits in these treatments ripened 4 days or 5 days later than those kept as control. Calcium ammonium nitrate was only effective at lower concentration of 2.5% and delayed ripening for only 2 days. However, at higher concentrations it stood at par with untreated (control) fruits (Table 4). Sive & Resnizky (1985) have already reported that calcium chloride at 2% in fungicide dip delayed the ripening of fruits. The differences in the effects of different $CaCl_2.2H_2O$ concentrations have also been observed by (Yuen et al., 1993).

3.2. Skin Color of the Fruits at Ripening

Among the physiological properties, the skin color of the mango fruits is a vital characteristic for marketing as it makes the commodity more attractive. Color of the fruits at ripening, was significantly different from the control fruits and the fruits treated with calcium salts. The fruits treated with $Ca(NH_4NO_3)_2$ were slightly inferior in color than the untreated fruits and fruits treated with other two salts. The fruits treated with $CaCl_2.2H_2O$ and $CaSO_4.2H_2O$ were not also in accurate desired color. In the both cases, at least 25% parts of the mango fruits was greenish, except the Himsagor. All the Himsagor mangoes were yellowish in color in the both case of $CaCl_2.2H_2O$, $CaSO_4.2H_2O$ treatment. The concentration of these salts used to treat the fruits also behaved alike and stood at par with control except the concentration of 5% and 10%, in which color development was less as compared to the other. Regarding the combined

Table 1 Effects of various calcium salts and $CaCl_2$ on ripening and fruit quality

Name of the parameters	Name of the salts		
	$CaCl_2.2H_2O$	$CaSO_4.2H_2O$	$Ca(NH_4NO_3)_2$
Days tale to ripe	9 days	8 days	7 days
Color of the fruits	95% yellowish + 5% greens	95% yellowish + 5% greens	30% yellowish + 70% greens
Taste	Satisfactory	Satisfactory	Satisfactory
Spoilage of mango fruits	25% of fruits were spoiled after	25% of fruits were spoiled after	25%of fruits were spoiled
Black spots on the skin	No	Low quantity/number	Very Low quantity/number
Color of the nipple	Light black	Greenish + yellowish	Light black
Aroma, flavor, texture	Good but not better	Better	Good but not better
Overall appearance	Normal but so attractive as	Normal but so attractive as	Normal and attractive
Hardness and softness	Like as control	Like as control	Like as control

Table 2 Effects of different concentrations of various calcium salts on ripening and fruit quality

Name of the parameters	Name of the salts			
	Control	$CaCl_2.2H_2O$	$CaSO_4.2H_2O$	$\{Ca(NH_4NO_3)_2\}$
Time required for ripening (days)	6.00 ± 0.00*	9.50 ± 1.29	9.00 ± 1.15	7.00 ± 1.15
Skin Color of the fruits at ripening	6.52 ± 0.29	6.56 ± 0.52	6.38 ± 1.44	6.44 ± 0.52
Skin shriveling of the fruits at ripening	0.00±0.00	4.25 ± 1.72	4.06 ± 1.52	0.63 ± 0.10
Aroma of the fruits at ripening	4.00 ± 0.00	4.00 ± 0.84	2.63 ± 1.20	3.31 ± 0.67
Pulp color of the fruits at ripening	5.50 ± 0.00	5.75 ± 0.35	6.01 ± 0.41	4.47 ± 0.48
Flavor and taste of the fruits at ripening	4.50 ± 0.00	3.94 ± 0.78	4.03 ± 0.68	4.38 ± 0.37

* Data represent means ± SD of 4 replicates

effect of calcium salts and concentrations, maximum color development was noted in the fruits treated with calcium chloride at a concentration of 7.5% and 10% while the minimum was in these treated with $Ca(NH_4NO_3)_2$ at a concentration of 5% (Table 4). In all the treatments, color development was slightly different than those kept as control (untreated). The possible reason for poor color development could be the reduced rate of respiration of the treated fruits. It was also mention that all the controls fruits were also not in its exact ripened color and the color was not also uniform in all cases.

3.3. Skin Shriveling of the Fruits at Ripening

The first and most attractive feature of the ripped mango is the appearance and smoothness of the skin of the fruits. The mangoes that contain smooth skin and no shriveling fetch better price. In our study, it was seen that, there were no shriveling was noted in the controls fruits and those treated with $Ca(NH_4NO_3)_2$ salts. With some presence of the shriveling were found in the fruits those were treated either by $CaCl_2.2H_2O$ or by $Ca(NH_4NO_3)_2$ (Table 2). The shriveling was depending on the concentration of the salts and which was directly proportional to the salt concentration.

As the concentration of $CaCl_2.2H_2O$ and $CaSO_4.2H_2O$ salts were increased, the shriveling of the skin was also increased (Table 3). Minimum skin shriveling was noticed when the fruits were treated with the 10% $CaSO_4.2H_2O$ followed by those treated with both $CaCl_2.2H_2O$ and $CaSO_4.2H_2O$ at the concentration of the 7.5 % (Table 4). The calcium salts delay ripening and senescence in fruits by lowering the rate of respiration (Singh et al., 1993). But the causes of the skin shriveling are still now unknown.

3.4. Aroma of the Fruits at Ripening

The aroma of the mango fruits is varied within the subspecies of the mango and it is a characteristic of the cultivars. In another study, it was proven that the ripening condition, ripening state and environmental stress also affects the aroma of the fruits. Calcium chloride slightly increased the aroma of the fruits then the controls ones, but fewer aroma was observed in these fruits treated with $CaSO_4.2H_2O$ and $\{Ca(NH_4NO_3)_2\}$ (Table 2). In the case of the $CaSO_4.2H_2O$ and $\{Ca(NH_4NO_3)_2\}$ at the 10% concentration, the aroma is very mild but nearest as the control fruits.

As concentration of calcium salts was concerned, lower concentration of 2.5% and 5.0% reduced the aroma of treated fruits; however, it improved when fruits were treated at the higher concentration of 7.5% and 10% (Table 3). Regarding the combined effects of salts and their concentration, fruits treated with $CaCl_2.2H_2O$ at concentration of 7.5% had the maximum aroma, followed by those treated at 10%. All other treatments resulted in aroma either lower or similar to the untreated fruits (Table 4). Those results indicate that fruits treatment with calcium salts not only affects the ripening process but also influences the aroma of the fruits.

Table 3 Effects of different concentrations of various calcium salts on ripening and fruit quality

Name of the parameter	Concentration				
	0%	2.5%	5%	7.5%	10%
Time required for ripening (days)	6.00 ± 0.00*	8.00 ± 0.00	8.00 ± 0.56	8.67 ± 2.11	9.00 ± 2.65
Skin Color of the fruits at ripening	6.42 ± 0.29	6.42 ± 0.14	6.00 ± 0.25	6.58 ± 0.38	6.83 ± 0.29
Skin shriveling of the fruits at ripening	0.00 ± 0.00	0.92 ± 0.88	2.92 ± 2.00	4.00 ± 2.17	4.00 ± 1.98
Aroma of the fruits at ripening	3.00 ± 0.00	2.42 ± 0.52	2.83 ± 1.98	4.08 ± 0.80	3.92 ± 0.29
Pulp color of the fruits at ripening	5.50 ± 0.00	3.33 ± 1.18	5.04 ± 0.83	5.62 ± 0.76	5.75 ± 0.66
Flavor and taste of the fruits at ripening	4.50 ± 0.00	4.21 ± 0.97	4.17 ± 0.52	4.00 ± 0.50	3.42 ± 1.12

* Data represent means ±SD of 4 replicates

Table 4 Effects of different concentrations of various salts on ripening and fruit

Parameters	$CaCl_2.2H_2O$					$CaSO_4.2H_2O$						$\{Ca(NH_4NO_3)_2\}$			
	0%	2.5%	5.0%	7.5%	10%	0%	2.5%	5.0%	7.5%	10%	0%	2.5%	5.0%	7.5%	10%
Time required for ripening (days)	5.00 ± 0.61	7.00 ± 0.77	8.00 ± 0.82	9.00 ± 0.64	10.00 ± 0.84	5.00 ± 0.61	7.00 ± 0.76	7.00 ± 0.62	9.00 ± 1.02	9.00 ± 1.17	5.00 ± 0.61	7.00 ± 0.67	7.00 ± 0.63	5.00 ± 0.46	5.00 ± 0.63
Skin colors of the fruits at ripening	5.75 ± 0.89	5.25 ± 0.20	5.00 ± 0.61	6.00 ± 0.74	6.00 ± 0.46	5.25 ± 0.61	5.50 ± 0.16	5.25 ± 0.50	5.25 ± 0.75	5.50 ± 0.16	5.25 ± 0.61	5.50 ± 0.58	4.75 ± 0.31	5.50 ± 0.16	6.00 ± 0.22
Skin shriveling of the fruits at ripening	0.00 ± 0.00	1.00 ± 0.35	4.00 ± 0.79	4.25 ± 0.46	3.75 ± 0.56	0.00 ± 0.00	1.75 ± 0.46	1.75 ± 0.54	4.25 ± 0.21	4.50 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.00	0.75 ± 0.73
Aroma of the fruits at ripening	3.00 ± 1.53	2.00 ± 1.37	2.75 ± 0.00	4.00 ± 0.09	3.25 ± 0.00	3.00 ± 1.53	1.00 ± 0.35	0.25 ± 0.00	2.50 ± 0.36	2.75 ± 0.00	3.00 ± 0.65	1.25 ± 0.85	2.50 ± 0.36	2.75 ± 0.00	2.75 ± 0.00
Pulp colors of the fruits at ripening	4.50 ± 0.63	4.75 ± 0.31	4.25 ± 0.46	5.00 ± 0.61	5.00 ± 0.00	4.50 ± 0.63	5.25 ± 0.61	4.75 ± 0.31	5.13 ± 0.00	5.25 ± 0.00	4.50 ± 0.63	3.00 ± 0.32	3.13 ± 1.30	3.75 ± 0.00	4.00 ± 0.79
Flavors and taste of the fruits at ripening	3.50 ± 1.07	4.00 ± 0.09	3.00 ± 0.32	2.50 ± 0.36	2.25 ± 0.00	3.50 ± 1.07	2.13 ± 0.51	3.75 ± 0.13	3.00 ± 0.00	3.25 ± 0.00	3.50 ± 1.07	3.50 ± 0.29	2.75 ± 0.94	3.50 ± 0.31	3.75 ± 0.00

3.5. Pulp Color of the Fruits at Ripening

The edible portion of the mango fruits is the pulp; therefore, pulp color is also important as it related to the fruit quality. Pulp color was significantly improved with the calcium sulphate treatment and deteriorated with calcium ammonium nitrate treatment. However, the fruits treated with calcium chloride had almost same color as untreated fruits (Table 2). Pulp color was also affected by the concentrations of the salts used and decreased randomly and then recovered (Table 3). As the combined effect of calcium salts and concentrations is concerned, calcium sulphate treatment at 2.5 and 10 % and then 7.5%, calcium chloride treatment at 7.5% and 10% resulted in better pulp color as compared to the untreated fruits. The pulp color was deteriorated when fruits were treated with calcium ammonium nitrate at all the concentrations (Table 4) indicating that the calcium ammonium nitrate treatment had negative effect on pulp color.

3.6. Flavor and Taste of the Fruits at Ripening

Flavor and taste are the important quality parameter to measure the mango quality for the Bangladeshi population. As all the fruits were treated in different concentration of the calcium salts, but was clear that in all the concentration, the flavor and taste of the fruits were also reduced similarly. As the combined effect of the calcium salts and concentrations was a major concern in our study, it was seen that only $CaCl_2.2H_2O$ at 2.5% resulted in better flavor and taste of the fruits than the untreated control. On the other hand, $\{Ca(NH_4NO_3)_2\}$ treated fruit's flavor and taste were same as like as the control one, as in the concentration of the 2.5% and 7.5%. It is a matter of the great concern that, all others treatment of the fruits combined had a negative effect on the flavor and taste of the fruits. The overall condition of the fruits flavor and taste were the worst in the 2.5% of $CaSO_4.2H_2O$ (Table 4). So, it is clear that, delay ripening of the fruits with calcium salts also have some negative effects on the fruit quality.

4. CONCLUSION

The findings of the study revealed that, the calcium salts delayed ripening for a few days, but they also reduced fruit quality, resulting in poor eating quality. Calcium salts, such as calcium ammonium nitrate, calcium chloride, and calcium sulphate, can be used to prolong fruit ripening instead of extremely toxic chemicals.

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