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EFFECT OF VARIOUS CALCIUM SALTS ON RIPENING OF MANGO FRUITS

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Abstract: Green mature fruits of mango cv. SS-1 (Kala Chaunsa) were immersed for 10 minutes in 2.5, 5.0 or 7.5% calcium chloride ($CaCl_2.2H_2O$), calcium sulphate ($CaSO_4.2H_2O$) or calcium ammonium nitrate $\{Ca(NH_4NO_3)_2\}$ solutions. A control was also included in which fruits were dipped in fresh water for 10 minutes. The fruits were ripened at ambient temperature (25 ± 3 ^oC) in boxes lined and covered with newspaper. Calcium chloride delayed the fruit ripening about 3 days as compared to control and resulted in better aroma of the fruits, however, it induced skin shrivelling. Calcium sulphate treatments resulted in improved pulp colour. The increase in concentration of calcium salts resulted in delayed ripening but had negative effect on fruit quality by increasing skin shrivelling and lowering flavour and taste of the fruits. Calcium chloride at 5.0% delayed the ripening for 4 days and resulted in better skin and pulp colour but with increased skin shrivelling and poor flavour and taste, indicating poor eating quality.

Keywords: Calcium ammonium nitrate, calcium chloride, calcium sulphate, eating quality, fruit colour, *Mangifera indica*, mango, ripening.

INTRODUCTION

Mango is well established as an item of international trade. Because of its superb quality, Pakistani mango sells at good prices in Europe, Canada, Gulf and Far Eastern countries. The export market for mango has become highly lucrative. Domestic and international trade of fresh mango has seen limited by the highly perishable nature and its susceptibility to post-harvest diseases and physical injury. The fruit may require 3–9 days to ripen and this short period seriously limits its commercialisation in distant markets. A major and often neglected problem to greater volume of nutritious food is to prevent the losses between the time of harvesting and consumption. Mango fruit has poor storage qualities and technologies for long term storage such as controlled or modified atmosphere have not been applied successfully to this fruit. Fruits stored in modified atmosphere often show undesirable characteristics, i.e. poor colour, poor eating quality and presence of undesirable flavours. So, to solve the problem of short shelf-life of mango fruits, different chemicals are used to delay the ripening [Suhardi 1992]. Although calcium carbide has been frequently used since long times to enhance ripening process of mango fruits [Srivastava 1967, Nagarag *et al*. 1984, Paj 1998], however, some other calcium salts especially calcium chloride and calcium nitrate have been reported in literature to delay the ripening and senescence in fruits by lowering the respiration rate [Singh *et al.* 1993]. The calcium salts in

different concentrations have either been used as pre-harvest sprays or infiltrated into harvested fruits, while some workers treated the harvested fruits by immersing in calcium solution for varying times. Three fortnightly sprays of 1% calcium nitrate, commencing 6 – 8 weeks before harvesting, delayed colour change and ripening in storage [Sive and Resnizky 1985]. Application of calcium ammonium nitrate (0.6 or 1.2%) to Tommy Atkins mangoes before harvest did not resulted in increase Ca content of fruit pulp or fruit loss. However, total soluble solids, total titratable acidity and pulp firmness were affected by the treatments [Kluge *et al*. 1999].

Wills *et al*. [1988] dipped mature fruits of 3 mango cultivars in 4% (w/v) Ca solution under sub-atmospheric pressure ranging from 20 – 80 kPa (cv. Cengkir) or 20–100 kPa (cvs. Arumanis and Gedong) for 4.5 min. and stored at 23 ^{o}C. Colour changes were delayed by 1 – 2 days in fruits dipped in Ca at 20 and 40 kPa. In another study, mature green mango cv. Kensington Pride fruits were infiltrated with 2, 4, 6 and 8% calcium chloride solution under a positive pressure of 115 kPa for 2 min or in an artificial vacuum of 32 kPa. After treatment, fruits were stored at 20 ^{o}C in boxes lined and covered with polyethylene film. Pressure and vacuum infiltration with $CaCl_2$ delayed fruit ripening by approximately 12 and 8 days respectively, compared with fruits infiltrated with water. Few differences in the effects of different $CaCl_2$ concentrations on ripening were also observed [Yuen *et al*. 1993]. Mango (cvs. Manila and Tommy Atkins) fruits were stored at 4 or 8 ^{o}C, 85% RH for 7 or 25 days. Half of the fruits were dipped in 5% $CaCl_2$ for 10 min prior to storage. The fruits were ripened at ambient temperature (20 ^{o}C) after storage. Calcium treatment delayed softening in Tommy Atkins fruits but not in Manila fruits [Corrales-Garcia and Lakshminarayana 1991]. $CaCl_2$ at 2% in the fungicide dip raised the Ca level and delayed ripening [Sive and Resnizky 1985]. Hot water treatment containing 1% $CaCl_2$ has been found the most effective treatment to retard ripening and spoilage of mango fruits (cvs. Fazli and Ashwina). Ripening was delayed by 5 – 8 days [Gofure *et al*. 1997]. Calcium ammonium nitrate application did not increase shelf-life of mango fruits when immersed for 90 min in 0.2 or 4% solution. However, the external appearance of the fruits was better at a concentration of 4% but this did not guarantee export quality [Freire and Chitarra 1999]. These results seem to be quite confusing. Therefore, in the present study different concentration of various calcium salts (i.e. calcium chloride, calcium sulphate and calcium ammonium nitrate) were used to ascertain their effects on delaying the ripening and eating quality of mango fruits.

MATERIALS AND METHODS

The present study was conducted to see the effect of different types of calcium salts on ripening of mango (*Mangifera indica* L.) cv. SS-1 (Kala Chaunsa) fruits at University College of Agriculture, Bahauddin Zakariya University, Multan during August 2002. Green mature fruits were

harvested in the evening and next morning these were cleaned with a cloth. The fruits were treated with 2.5, 5.0 or 7.5 % calcium chloride ($CaCl_2.2H_2O$), calcium sulphate ($CaSO_4.2H_2O$) or calcium ammonium nitrate $\{Ca(NH_4NO_3)_2\}$ solutions by dipping for 10 minutes. A control was also included in which fruits were immersed in fresh water for 10 minutes. The fruits were stored for ripening at ambient temperature (25 ± 3 ^oC) in wooden boxes lined and covered with newspaper.

The experiment was laid out as factorial with completely randomised design, having two factors (salts and concentrations) and three replications. The data were recorded on; time required for ripening (days), skin colour of the fruits at ripening, skin shrivelling of the fruits at ripening, aroma of the fruits at ripening, pulp colour of the fruits at ripening and flavour and taste of the fruits at ripening.

SENSORY EVALUATION

Organoleptic evaluation of the fruits for skin colour, shrivelling, aroma, pulp colour, flavour and taste was done using the Hedonic scale method of Peryam and Pilgrim [1957]. Five judges were employed in the panel who were asked to score the above mentioned parameters using the 10 point Hedonic scale, 10 being the most acceptable and zero the least. The SD (standard deviation) for each parameter was computed by the method of Steel and Torrie [1980].

RESULTS AND DISCUSSION

TIME REQUIRED FOR RIPENING

The calcium salts used differed for the time required for ripening of the fruits. Calcium chloride was more effective in delaying the ripening as compared to other salts and fruits treated with this salt ripened about 3.33 days later than the untreated (control) fruits. The ripening in the fruits treated with calcium sulphate was delayed only for 2.67 days. Calcium ammonium nitrate was not so effective but it was almost at par with control (Table 1). The delay in ripening by calcium chloride treatments has already been reported by several workers [Sive and Resnizky 1985, Corrales-Garcia and Lakshminarayana 1991, Yuen *et al*. 1993, Gofure *et al*. 1997]. Although the concentrations of the calcium salts used resulted in about 2 – 3 days in delaying the ripening than control, however, the concentrations did not differ with each other significantly (Table 2).

Calcium chloride at the concentrations of 2.5% and calcium sulphate at 5.0 and 7.5% behaved alike and delayed ripening for about 2 days. However, calcium chloride at the concentrations of 5.0 and 7.5% and calcium sulphate at 7.5% were the most effective and fruits in these treatments ripened 4 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 3). Sive and 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 $CaCl_2$ concentrations have also been observed by Yuen *et al.* [1993].

Table 1: Effect of various calcium salts on ripening and fruit quality.

Parameters	Control	$CaCl_2.2H_2O$	$CaSO_4.2H_2O$	$Ca(NH_4NO_3)_2$
Time required for ripening (days)	8.00 ± 0.00*	11.33 ±1.15	10.67 ± 1.15	8.67 ± 1.15
Skin colour of the fruits at ripening	8.35 ± 0.04	8.33 ± 0.57	8.22 ± 0.19	8.08 ± 0.51
Skin shrivelling of the fruits at ripening	0.00 ± 0.00	3.33 ± 1.77	2.22 ± 1.54	0.22 ± 0.39
Aroma of the fruits at ripening	4.00 ± 0.00	4.56 ± 1.50	1.89 ± 1.89	3.22 ± 1.35
Pulp colour of the fruits at ripening	7.50 ± 0.00	7.61 ± 0.42	8.06 ± 0.34	5.11 ± 0.59
Flavour and taste of the fruits at ripening	6.17 ± 00	5.67 ± 1.53	5.61 ± 0.85	5.45 ± 0.86

* Data represent means ±SD of 3 replicates.

Table 2: Effect of different concentrations of calcium salts on ripening and fruit quality

Parameters	Concentration			
	0% (cont.)	2.5%	5.0%	7.5%
Time required for ripening (days)	8.00 ± 0.00*	10.00 ± 0.00	10.00 ± 2.00	10.67 ± 2.31
Skin colour of the fruits at ripening	8.35 ± 0.04	8.25 ± 0.22	7.94 ± 0.42	8.44 ± 0.51
Skin shrivelling of the fruits at ripening	0.00 ± 0.00	1.11 ± 0.38	2.00 ± 2.40	2.67 ± 2.30
Aroma of the fruits at ripening	4.00 ± 0.00	2.00 ± 0.88	3.44 ± 2.88	4.22 ± 0.39
Pulp colour of the fruits at ripening	7.50 ± 0.00	6.83 ± 2.05	6.67 ± 1.32	7.28 ± 1.40
Flavour and taste of the fruits at ripening	6.17 ± 00	5.95 ± 1.18	5.61 ± 0.98	5.17 ± 1.01

* Data represent means ±SD of 3 replicates.

SKIN COLOUR OF THE FRUITS AT RIPENING

Skin colour of the mango fruits is an important character in marketing as it makes the commodity more attractive. Colour of the fruits at ripening was almost same in all the fruits treated with calcium salts showing no significant differences. However, the fruits treated with calcium ammonium nitrate were slightly inferior in colour than untreated fruits (control) and those treated with other two salts (Table 1). The concentrations of these salts used to treat the fruits also behaved alike and stood at par with control except the concentration of 5.0%, in which colour development was less as compared to the others (Table 2). Regarding the combined effect of calcium salts and concentrations, maximum colour development was noted in the fruits treated with calcium chloride at a concentration of 7.5%, while the minimum was in those treated with calcium ammonium nitrate at a concentration of 5% (Table 3). In all other treatment, colour development was equal or slightly less than those kept as control (untreated). The possible reason for poor colour development could be reduced rate of respiration of the treated fruits.

SKIN SHRIVELLING OF THE FRUITS AT RIPENING

Shrivelled skin gives bad appearance and mango fruits with smooth skin and no shrivelling fetch better price in the market. At ripening when fruit were observed, apparently no shrivelling was noted in untreated (control) fruits, closely followed by those treated with calcium ammonium nitrate.

Table 3: Effect of different concentrations of various calcium salts on ripening and fruit quality.

	$CaCl_2.2H_2O$				$CaSO_4.2H_2O$				$Ca(NH_4NO_3)_2$			
Parameters	0%	2.5%	5.0%	7.5%	0%	2.5%	5.0%	7.5%	0%	2.5%	5.0%	7.5%
Time required for ripening (days)	8.00 ± 0.81*	10.00 ± 0.81	12.00 ± 1.63	12.00 ± 0.81	8.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.81	12.00 ± 1.41	8.00 ± 0.00	10.00 ± 0.81	8.00 ± 1.41	8.00 ± 0.00
Skin colour of the fruits at ripening	8.40 ± 0.94	8.00 ± 0.41	8.00 ± 0.82	9.00 ± 0.41	8.33 ± 0.85	8.33 ± 0.24	8.33 ± 0.62	8.00 ± 0.41	8.33 ± 0.85	8.42 ± 0.66	7.50 ± 1.47	8.33 ± 0.85
Skin shrivelling of the fruits at ripening	0.00 ± 0.00	1.33 ± 0.94	4.67 ± 0.94	4.00 ± 0.00	0.00 ± 0.00	1.33 ± 0.94	1.33 ± 0.94	4.00 ± 0.00	0.00 ± 0.00	0.67 ± 0.94	0.00 ± 0.00	0.00 ± 0.00
Aroma of the fruits at ripening	4.00 ± 1.63	3.00 ± 0.82	6.00 ± 0.82	4.67 ± 0.94	4.00 ± 1.63	1.33 ± 0.94	0.33 ± 0.47	4.00 ± 2.45	4.00 ± 1.63	1.67 ± 1.25	4.00 ± 0.00	4.00 ± 1.63
Pulp colour of the fruits at ripening	7.50 ± 0.41	7.67 ± 0.47	7.17 ± 0.85	8.00 ± 0.41	7.50 ± 0.41	8.33 ± 0.94	7.67 ± 0.94	8.17 ± 0.24	7.50 ± 0.41	4.50 ±1.08	5.17 ± 1.31	5.67 ± 0.94
Flavour and taste of the fruits at ripening	6.17 ± 1.03	7.00 ± 0.41	6.00 ± 1.41	4.00 ± 0.41	6.17 ± 1.03	4.67 ± 0.62	6.33 ± 1.25	5.83 ± 1.89	6.17 ± 1.03	6.17 ± 0.85	4.50 ± 1.08	5.67 ± 1.25

*Data represent means ±SD of 3 replicates.

Few fruits treated with either calcium chloride or calcium sulphate showed symptom of shrivelling (Table 1). The concentrations of the calcium salts used also had a very slight effect on shrivelling of the fruits. As the concentration increased, chances of shrivelling also increased (Table 2). Maximum fruit shrivelling was noted when the fruits were treated with calcium chloride at a concentration of 5%, followed by those treated with either calcium chloride or calcium sulphate at 7.5% (Table 3). The calcium salts delay ripening and senescence in fruits by lowering the rate of respiration [Singh *et al*.1993]. What causes skin shrivelling is unknown.

AROMA OF THE FRUITS AT RIPENING

Although aroma is a characteristic of the cultivars but the ripening conditions and ripening state also affects the aroma of fruits. Calcium chloride treatment slightly increased the aroma of the fruits, while the fruits treated with calcium sulphate and calcium ammonium nitrate had fewer aromas than the untreated fruits (Table 1). As concentrations of calcium salts are concerned, lower concentrations 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% (Table 2). Regarding the combined effect of salts and their concentrations, fruits treated with calcium chloride at a concentration of 5.0% had the maximum aroma, followed by those treated at 7.5%. All other treatments resulted in aroma either lower or similar to the untreated fruits (Table 3). These results indicate that fruit treatment with calcium salts not only affects the ripening process but also influences the aroma of the fruits.

PULP COLOUR OF THE FRUITS AT RIPENING

The edible portion of the mango fruits is the pulp; therefore pulp colour is also important as it relates to the fruit quality. Pulp colour 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 colour as untreated fruits (Table 1). Pulp colour was also affected by the concentrations of the salts used and was decreased till 5.0% and then recovered (Table 2). As the combined effect of calcium salts and concentrations is concerned, calcium sulphate treatment at 2.5 and 7.5% and calcium chloride treatment at 7.5% resulted in better pulp colour as compared to the untreated fruits. The pulp colour was deteriorated when fruits were treated with calcium ammonium nitrate at all the concentrations (Table 3) indicating that the calcium ammonium nitrate treatment had negative effect on pulp colour.

FLAVOUR AND TASTE OF FRUITS AT RIPENING

Flavour and taste of the mango fruits is an important quality parameter. Treatments of the fruits with the all the three calcium salts resulted in reduced flavour and taste (Table 1). Similarly, flavour and taste of the

fruits was also reduced at all the concentrations used (Table 2). As combined effect of the salts and concentrations is concerned, only calcium chloride at 2.5% resulted in better flavour and taste of the fruits than the untreated control, while calcium ammonium nitrate at the concentration of 2.5% stood at par with the control. All other treatment combinations had negative effect on flavour and taste of the fruits. However, calcium chloride at 7.5%, calcium ammonium nitrate at 5.0% and calcium sulphate at 2.5% had badly affected the flavour and taste of the fruits (Table 3). This indicates that the delay in ripening of mango fruits due to calcium salts may affect the fruit quality.

CONCLUSION

Although the fruits treated with 5% calcium chloride solution resulted in delay in ripening for 4 days and had better skin and pulp colour but the eating quality of the fruits was poor.

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