PHYSICO-CHEMICAL CHANGES AND SHELF LIFE OF MANGO AS AFFECTED BY DIFFERENT CONCENTRATION LEVELS OF CALCIUM CHLORIDE

BY

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ABSTRACT
The effects of post harvest application of calcium chloride at 2.5%, 5.0%, 7.5% and 10.0% concentration on physico-chemical properties, physiological weight loss and shelf life of mango were determined at Sindh Agriculture University Tandojam and stored after treatment with calcium salts for ripening. The results showed that the post harvest treatment of CaCl₂ significantly (P<0.01) affected the moisture, protein, total sugars and sucrose contents, while, non-significantly (P>0.05) to fat, ash and T.S.S. contents. The average physiological weight loss was 4.84, 3.88, 3.10 and 4.61% in CaCl₂ treated mangoes against 5.58% weight loss in control. The shelf life of fruits under room temperature treated with post harvest application of CaCl₂ at 0, 2.5, 5.0, 7.50 and 10.0 % concentration showed that the shelf life range was 2-3, 3-4, 3-4, 5-6 and 3-4 days, respectively over control (2-3 days). The shelf life in cold storage was 4-5, 6-7, 7-8, 10-11 and 9-10 days when fruits received CaCl₂ at 0, 2.5, 5.0, 7.50 and 10.0 % concentration, respectively under cold storage conditions.

Keywords: Mango, sodium chloride, physico-chemical properties, physiological weight, shelf life

INTRODUCTION
Pakistan is one of the top five mango producing countries of the world (Iqbal, 2005). India lead with 44 percent of the total world production, China 13 percent, Thailand 6 percent, Mexico 5 percent, and Pakistan 4 percent. Philippines, Indonesia, Nigeria, Brazil and Egypt share 3, 3, 3, 2 and 1 percent of the total world production, respectively and are in the leading ten mango producing countries (Sussser, 2004). A 100 g edible portion of mango contains 66 calories, 0.6 g protein, 17g total carbohydrates, 0.27g fat, zero cholesterol, 2mg sodium, 156mg potassium, 3890 IU vitamin A and 27 mg vitamin C. The fruit flesh of a ripe mango contains about 15% sugar, up to 1% protein, and significant amounts of vitamins A, B and C (Ltz, 1997 and Schaffer, 1993). The taste of the fruit is very sweet, with some cultivars having a slight acidic tang. The texture of the flesh varies markedly between different cultivars; some have quite a soft and pulpy texture similar to an over-ripe plum, while others have a firmer flesh much like that of a cantaloupe or avocado, and in some cultivars the flesh can contain fibrous material. Mangoes are very juicy; the sweet taste and high water content make them refreshing to eat, though somewhat messy (Stewart and Strauss, 2002).

Mangoes are generally harvested at physiological mature stage and ripened for optimum quality. Fruits are hand-picked or plucked with a harvester. During harvesting, the latex trickles down the fruit surface from the point of detachment imparting a shabby appearance to it upon storage. After harvest the fruits are usually heaped under a tree on the ground. Bruised and injured fruits develop brown to black spots during storage making the fruits unattractive. Moreover, injuries to the peel or to the stalk end serve as avenues
for invasion of microorganism and lead to rotting of the fruits. The post harvest losses in mangoes have been estimated in the range of 25-40 percent from harvesting to consumption stage. If proper methods of harvesting, handling, transportation and storage are adopted, such losses could be minimized. The mango fruits should be harvested at green mature stage. The harvest maturity in Dashehari and Langra cultivars reaches 12 weeks after fruit set, while in Chausa and Mallika it takes about 15 weeks. The best way to observe maturity in mango is the colour of the pulp which turns cream to light yellow on maturity and hardening of the stone (Anonymous, 2005). Storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distances. The mature green fruits can be kept at room temperature for about 4-10 days depending upon the variety. Shelf life of fruits could be extended by pre cooling, chemical treatments, low temperature, etc. The harvested fruits are pre cooled to 10-12°C and then stored at an appropriate temperature. The fruits of Dashehari, Mallika and Amrapali should be stored at 12°C, Langra at 14°C and Chausa at 8°C with 85-90 per cent Relative Humidity. The fruits could be stored for 3-4 weeks in good condition at low temperature (Iqbal, 2005).

Calcium infiltration is an improved technique of extending the storage life of mango fruits, especially for Dashahri variety. The fruits are kept in calcium chloride solution (4%) at sub-atmospheric pressure of 500 mm Hg for 5 minutes. The treated fruits can be stored at low temperature (12°C) for 27 days. It is a general practice to harvest fruits early in the season (premature stage) to capture early market. These fruits do not ripe uniformly without any ripening aid. Such fruits could be ripened uniformly by dipping in 750 ppm ethrel (1.8 ml/litre) in hot water at 52±2°C for 5 minutes within 4-8 days under ambient conditions. Mature fruits can similarly be ripened with lower doses of ethrel for uniform colour development (Sussser, 2004). Scientists from the world’s largest mango producing country, Mexico, have developed a treatment using hot air which could boost mango shelf-life by 50 percent. They claim that the treatment delays the fruit’s ripening process through inhibiting the synthesis of enzymes (Trejo, 2005). Considering the above points in view, an investigation was performed to examine the effects of calcium chloride (CaCl₂) at different concentration levels on the quality and shelf life of mango.

MATERIAL AND METHODS
The fruit samples were initially washed with tap water and dried with muslin cloth. All the mangoes were weighed and divided into various groups and dipped in CaCl₂ with various concentrations (i.e 2.5%, 5.0%, 7.5% and 10.0%) for 10 minutes and kept out for drying. All the mangoes (treated and untreated) were put in the paper made boxes and stored at 20°C. The fruits were examined on alternate day till ripening (18 days). However, the ripening effect on some physico-chemical qualities were evaluated by analyzing the mangoes on day 1, day 6, day 12 and on day 18. The formulae applied for various determinations are described below:

**Total Sugars**

\[
\text{Reducing sugar} \% = \frac{\text{Factor} \times \text{Dilution} \times 100}{\text{Titre}} \\
\text{Total sugar} \% = \frac{\text{Factor (From Table # 01)} \times 50}{\text{Titre}}
\]

**Sucrose**

\[
\text{Formula Sucrose} \% = \frac{132.56}{(D-I)} \\
(D-I) = (D-x2 - D-I) \\
100 \times 132.56
\]

**T.S.S**

The total soluble solids (T.S.S) were determined by the means of hand refractometer. A certain quantity of prepared solution of mango pulp was dropped on the sample point of the refractometer and after adjustment of the equipment; the reading for total soluble solids was recorded.

**Protein (following BSI, 1990)**

\[
1.4 (V_1 - V_2) \times \text{normality}
\]
Shaheen, et al. (2007). Effect of calcium chloride on mango

Protein% = ---------------------------------------

Sample weight taken
Fat
The fat content in the mango samples was determined following Rose Gettolub Method. Blended (mango) sample (2 g) was taken in conical flask, and 15 ml HCl was added, then hydrolyzed for 30 minutes and then cooled. The in the cooled sample, 10 ml Ethanol, 25 ml diethyl was added, then 35 ml petroleum ether was added and left for 30 minutes. This method is further described by the method of international Dairy Federation (IDF, 1987) using Rose-Gottolub method.

Ash
Ash percentage was determined by Gravimetric method as described by AOAC (2000) using muffle furnace at 550°C.

pH
pH values were determine using with pH meter (Hana Instrument, HI8417, Italy).

Total solids
Total solids contents were observed according to the method of AOAC (1990d). The prepared mango sample was thoroughly mixed, and sample (2-3d) was transferred in pre-weighed flat bottom dish. After evaporation on steam bath, it was transferred to hot air oven (Memmert 854, Sehwa batch, West Germany) at 101± 1°C. Dried sample was transferred to a desicator, having a silica gel as desicant. After 1h, the dish was weighed and returned to the hot air oven for further drying (30 minutes). It was again transferred to desicator, cooled and weighed as before. The heating, cooling and weighing processes were repeated until constant weight. Total solids content was calculated according to the following formula.

\[
T.S\% = \frac{\text{Weight of dried sample}}{\text{Weight of sample taken}} \times 100
\]

The data thus collected were subjected to statistical analysis for analysis of variance and other comparison following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

RESULTS

1. Moisture
The moisture content before treatment (at day-1) was 86, 86, 85 and 85 % in fruits treated with CaCl₂ concentrations of 0, 2.5, 5.0, 7.5 and 10.0 %, respectively. The moisture content was significantly (P<0.01) reduced to 82, 84, 82, 83 and 82 % at ripening (day 18) in fruits treated with post harvest CaCl₂ concentrations of 0, 2.5, 5.0, 7.5 and 10.0 %, respectively (Table-1).

2. Protein
The fruits received post harvest treatment of CaCl₂ at various levels before treatment (at day-1) had protein content of 0.8, 0.6, 0.6, 0.6 and 0.6 % in fruits treated with CaCl₂ concentrations of 0, 2.5, 5.0, 7.5 and 10.0 %, respectively. The protein content was significantly (P<0.01) reduced to 0.2, 0.5, 0.5, 0.5 and 0.5 % at ripening (day 18) with post harvest application of CaCl₂ at 0, 2.5, 5.0, 7.5 and 10.0 % concentration, respectively (Table-1).

3. Fat
Fat content in fruits before post harvest treatment of CaCl₂ at various levels (at day-1) was 0.07, 0.08, 0.07, 0.10 and 0.06 %, respectively. The fat content was significantly (P<0.01) increased to 0.2, 0.5, 0.5, 0.4 and 0.3 % in ripe fruits (at day 18) with post harvest application of CaCl₂ at 0, 2.5, 5.0, 7.5 and 10.0 % concentration, respectively (Table-1).

4. Ash
Ash content in mango fruits before post harvest treatment of CaCl₂ at various levels (day-1) was 0.33, 0.33, 0.31, 0.34 and 0.33 %, respectively. The ash content had mixed trend of variation and at ripening (day-18) the ash content was 0.34, 0.33, 0.32, 0.33 and 0.32 % with post harvest application of CaCl₂ at 0, 2.5, 5.0, 7.5 and 10.0 %, respectively. Statistically the differences between overall results for ash content were non-significant (P>0.05).
5. **Total soluble solids (T.S.S)**

Total soluble solids content in mango fruits before post harvest treatment of CaCl$_2$ at various levels at 0, 2.5, 5.0, 7.5 and 10.0 % was 16.17, 15.60, 15.30, 10.13 and 10.16 %, respectively. The total soluble solids content had increasing trend and at ripening (day-18) the total soluble solids contents increased to the level of 17.4, 17.76, 17.80, 17.56 and 17.53 % with post harvest application of CaCl$_2$ at 0, 2.5, 5.0, 7.5 and 10.0 %, respectively (Table-1).

6. **Total sugars**

Total sugars content before treatment (at day-1) was 10.16, 10.13, 10.13 and 10.16 % in fruits treated with CaCl$_2$ at 0, 2.5, 5.0, 7.5 and 10.0 % concentrations, respectively. The total sugar contents increased significantly (P<0.01) to the level of 14.17, 16.56, 16.57, 16.57 and 16.16 % at ripening (day 18) in fruits treated with post harvest CaCl$_2$ concentrations of 0, 2.5, 5.0, 7.5 and 10.0 %, respectively (Table-1).

7. **Sucrose**

Sucrose content in mango fruits before post harvest treatment of CaCl$_2$ at various levels (day-1) was 0.88, 0.74, 0.75, 0.75 and 0.76 %, respectively. The sucrose content was remarkably increased during ripening period (day-1 to day 18) and it was 1.02, 1.60, 1.46, 1.46 and 1.43 % with post harvest application of CaCl$_2$ at 0, 2.5, 5.0, 7.5 and 10.0 %, respectively (Table-1).

**Physiological weight loss (%)**

Table-2 revealed that the weight loss at day-1 in fruits treated with 0, 2.5, 5.0, 7.50 and 10.0 % calcium chloride (CaCl$_2$) was 1.15, 1.15, 0.84, 1.05 and 1.28 %, at day-4, 2.30, 2.00, 1.94, 2.10 % and 2.24, at day-6, 3.44, 2.29, 2.78, 3.15 % and 3.83, at day-8, 4.3, 3.15, 3.33, 3.94 and 4.80 %, at day-10, 5.16, 4.29, 4.71, 4.73 and 5.76 %, at day-12, 5.74, 4.58, 4.99, 5.52 and 6.39 %, at day-14, 6.60, 4.86, 5.82, 6.30 and 7.99 %, at day-16, 7.17, 6.00, 5.82, 7.09 and 8.63 %, and at day-18 (complete ripening), the weight loss was 7.74, 6.58, 6.65, 7.62 and 9.27 %, in fruits receiving post harvest treatment with 0, 2.5, 5.00, 7.50 and 10.0 % CaCl$_2$ concentration, respectively and hence, the mean weight loss was 4.84, 3.88, 4.10, 4.61 and 5.58 %, respectively. Comparing the weight loss of fruits in treated samples with control, it was noted that there was 1.28, 2.24, 3.84, 4.80, 5.76, 6.39, 7.99, 8.63 and 9.27 % weight loss at day 1, 4, 6, 8, 10, 12, 14, 16 and 18 %, respectively. Relatively, greater weight loss was recorded in fruits kept under control and fruits treated with calcium chloride at 5.00% concentration recorded lowest weight loss of 3.88 %, while maximum weight loss (4.84 %) was recorded in fruits treated with 2.5 % CaCl$_2$ concentration. However, the mean weight loss was higher 5.58 % in fruits kept under control (Table-2).

**SHELF LIFE**

**Under room temperature**

Mango fruits stored under room temperature and received post harvest treatment of CaCl$_2$ 0, 2.5, 5.0, 7.50 and 10.0 % concentration had shelf life range of 2-3, 3-4, 3-4, 5-6 and 3-4 days, respectively over control (2-3 days). It was observed that the maximum shelf life on average was recorded (10-11 days) when the fruits were treated with 7.5 % CaCl$_2$ concentration (Table-3).

**Under cold storage**

The shelf life of the fruits was considerably increased when ripe mangoes of variety Sindhri were stored in cold storage and the shelf life was 4-5, 6-7, 7-8, 10-11 and 9-10 days when fruits received post harvest treatment of CaCl$_2$ at 0, 2.5, 5.0, 7.50 and 10.0 % concentration, respectively (Table-3).

**DISCUSSION**

In the present investigation, post harvest treatment of CaCl$_2$ significantly (P<0.01) affected the moisture, protein, total sugars and sucrose contents, while non-significantly (P>0.05) to fat, ash and T.S.S. contents. The results of the present study are fully supported by the findings of Waskar and Masalkar (1997) who treated mango fruits with CaCl$_2$ solutions of 2, 4 or 6 % and found significant effects on moisture, protein, fat, ash, total sugars and sucrose contents. Chitarra et al. (1999) reported that mango fruits treated for ripening with calcium chloride at 0.0, 2.5 or 5.0% resulted declined cell wall of cellulose significantly during storage and the total uronide contents increased as the storage period was prolonged, xylose, mannose and galactose were the predominant sugars. Russián and Manzano (2003) reported that lower temperatures delayed the increase in the level of TSS and reduction in titratable acidity; such delays were greater in fruits stored at 10 plus or minus 2°C. The average physiological weight loss in the present study was 4.84, 3.88, 3.10 and 4.61% in CaCl$_2$ fruits against 5.58% weight loss in control samples.
The shelf life of fruits under room temperature treated with post harvest application of CaCl₂ 0, 2.5, 5.0, 7.50 and 10.0 % concentration showed the shelf life range of 2-3, 3-4, 3-4, 5-6 and 3-4 days, respectively over control (2-3 days). The shelf life in cold storage was 4-5, 6-7, 7-8, 10-11 and 9-10 days when fruits received post harvest treatment of CaCl₂ at 0, 2.5, 5.0, 7.50 and 10.0 % concentration, respectively. Moreover, the effect of storage condition was also prominent and the shelf life of ripe mangos was prolonged well enough when stored in cold storage as compared to the shelf life obtained under room temperature. The results regarding the shelf life are partially supported by Srinivasa et al. (2002) who reported that cold solutions containing up to 8% CaCl₂ fruits dipped in 6% CaCl₂ showed lower weight loss than those dipped in 8% solution under both storage conditions. Concentrations of 4 and 6% extended shelf life to 9 days under ambient conditions and to 14 days under cold storage compared with 4 and 7 days, respectively, for the controls. In a similar study, Galvis et al. (2003) treated mangoes in 0, 10, 15 and 20% calcium chloride solution and found that 10% CaCl₂ extended the shelf-life of the fruit, allowing fruits to ripen after storage. CaCl₂ at 15 and 20% were harmful, since they impeded maturation.

CONCLUSION

The comparative analysis regarding the physico-chemical properties, physiological weight loss, sensory analysis and shelf life of fruits of mango variety Sindhri indicated that CaCl₂ as ripening agent at 7.5 % concentration was quite better to maintain the ripe fruit quality. Moreover, the effect of storage condition was also prominent and the shelf life of ripe mangos was prolonged well enough when stored in cold storage as compared to the shelf life obtained under room temperature.

Table-1: Effect of post harvest application of CaCl₂ (Calcium chloride) to various proportions on physico-chemical properties of ripe mango variety Sindhri

<table>
<thead>
<tr>
<th>Treatment (CaCl₂)</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>T.S.S</th>
<th>Total sugar</th>
<th>Sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
<td>D18</td>
<td>D1</td>
<td>D18</td>
<td>D1</td>
<td>D18</td>
<td>D1</td>
</tr>
<tr>
<td>Control</td>
<td>86</td>
<td>82</td>
<td>0.8</td>
<td>0.2</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>2.5%</td>
<td>86</td>
<td>84</td>
<td>0.6</td>
<td>0.5</td>
<td>0.0</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>5.0%</td>
<td>86</td>
<td>82</td>
<td>0.6</td>
<td>0.5</td>
<td>0.0</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>7.5%</td>
<td>85</td>
<td>83</td>
<td>0.6</td>
<td>0.5</td>
<td>0.1</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>10.0%</td>
<td>85</td>
<td>82</td>
<td>0.6</td>
<td>0.5</td>
<td>0.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>S E</td>
<td>0.2</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Significance</td>
<td>***</td>
<td>***</td>
<td>***</td>
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<td>***</td>
<td>ns</td>
<td>***</td>
</tr>
</tbody>
</table>

Table-2: Average loss of physiological weight of mango (%) as affected by post harvest application of calcium chloride (CaCl₂) at different levels (variety Sindhri)

<table>
<thead>
<tr>
<th>Treat. Initial</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td>T1 2.5%</td>
<td>1.15</td>
</tr>
<tr>
<td>T2 5.0%</td>
<td>1.15</td>
</tr>
<tr>
<td>T3 7.5%</td>
<td>0.84</td>
</tr>
<tr>
<td>T4 10.0%</td>
<td>1.05</td>
</tr>
<tr>
<td>T5 Control</td>
<td>1.28</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 3: Effect of different concentrations of calcium chloride on shelf life of mango variety Sindhri.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Maximum Shelf Life (days)</th>
<th>At room temperature</th>
<th>In cold storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2-3</td>
<td>4-5</td>
<td></td>
</tr>
<tr>
<td>2.5%</td>
<td>2-3</td>
<td>6-7</td>
<td></td>
</tr>
<tr>
<td>5.0%</td>
<td>2-3</td>
<td>7-8</td>
<td></td>
</tr>
<tr>
<td>7.5%</td>
<td>4-5</td>
<td>9-10</td>
<td></td>
</tr>
<tr>
<td>10.0%</td>
<td>3-4</td>
<td>7-8</td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES


