MANGO SOFT NOSE DISORDER AND FRUIT QUALITY IN RELATION TO PRE-AND POST HARVEST TREATMENTS

BY

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ABSTRACT
Soft nose has proved to be a very serious threat to mango industry all over the world causing unbearable economic losses. Being the victims of this disorder, numerous mango varieties having great export potential are not able to enter into the international markets. Its actual cause is yet to be explored. This study aimed to investigate the effect of pre and post harvest application of different calcium (Ca) and magnesium (Mg) salts on post harvest soft nose disorder in mango (Mangifera indica L.) cv. Samar Bahisht Chaunsa. For pre harvest treatment, aqueous solutions of different concentrations of Ca and Mg were sprayed on the mango trees in an orchard 15 days prior to harvest. For post harvest application, fruits were dipped for 10 minutes in various concentrations of Ca and Mg. The fruits were harvested at the mature green stage and stored (12±1°C and 85% RH) for 15 days. At the end of storage, fruits were ripened at ambient temperature (25±1°C, 75-80% RH). Incidence of soft nose along with other physico-chemical parameters was assessed at ripe stage. All the pre and post harvest treatments (except pre harvest treatment of 1% CaSO₄) were found to suppress the soft nose incidence as compared to control. Lowest soft nose development was exhibited by both pre and post harvest treatments of 4% CaCl₂ and pre harvest treatment of 1% MgCl₂. This paper reports the effects of calcium and magnesium salts on soft nose incidence and quality of mango.

KEYWORDS: Mangifera indica; internal breakdown; calcium; magnesium; fruit quality

INTRODUCTION
Mango has a prominent position among the commercial fruits of Pakistan, having large potential market for export. A world-wide increase in the demand of mango has been observed over the last few years (FAO, 2006) extending the prospects for the producing countries. But like all other commodities, the potential market of mango is directly correlated with the quality of the fruits. It is well-known that the quality of fruits is deteriorated by several factors like nutritional illnesses, plagues and deficiencies, variations in the function of cultivation, the degree of maturation and the treatments used before harvest, at harvest and after-harvest. Numerous problems are observed at all the phases of development of the fruits. Apart from quick decline (Mahmood and Gill, 2002) and malformation (Iqbal et al., 2004) of trees, internal breakdown of fruit is also regarded as the most serious threat to mango industry of Pakistan. It results in the loss of cellular organization, and is characterized by the degradation of the pulp. Remarked confusion is found in literature about the nature of this threat. According to Mead and Winston (1991), internal breakdown seems to be a complex of three disorders known as soft nose, stem end cavity and jelly seed.
Raymond et al. (1998) concluded on the basis of temporal and spatial differences in symptom development within the fruit that soft nose, jelly seed and stem end cavity may be classified as separate disorders. Soft nose disorder has resulted in great economic losses. The actual cause of this disorder is still un-identified. In past, many pre and post harvest treatments have been evaluated and variations among the finding have been observed. Most of the researchers correlate it with low calcium contents in the fruits (Young and Miner, 1961; Gunjate et al., 1979; Burdon et al., 1991; Singh et al., 1993; Thorp et al., 1997; Murillo and Adimilson, 1999; Chitarra et al., 2001; Assis et al., 2004; Torres and Saúco, 2004; Torres et al., 2004). However, there are reports which do not support the above hypothesis (Sampaio et al., 1999). Hence the enigma remains as such.

Regarding the effects on fruit quality, calcium compounds have shown promise in the quality retention of fruits and vegetables through maintaining firmness, reducing respiratory rate and ethylene evolution (Poovaiah, 1986) and reducing storage disorders (Conway and Sams, 1984). The tissues high in calcium have been found to possess strong cell walls, high firmness and great infection resistance (Kirkby and Pilbeam, 1984; Poovaiah et al., 1988). Shelf life also, has been found to be increased by calcium application. Mootto (1991) reported increased shelf life in Julie mangoes following post harvest CaCl2 dips. Likewise, Mg has also been found to be involved in improving storage life. Whangchai et al. (2001) found that Ca and (Ca+Mg)/K ratio in mango fruits had high positive correlation with storage life.

In Pakistan, detailed study on the effect of Ca and Mg salts on soft nose incidence and fruit quality is yet to be done. Further a comparison of pre and post harvest application of these potential chemicals has also not been made for their effects on mango soft nose. This preliminary study was undertaken to test the response of soft nose towards pre and post harvest application of different calcium and magnesium salts in mango cultivar Samar Bahisht Chaunsa in order to develop a comprehensive plan for future studies in commercial mango varieties of Pakistan. The effects of these chemicals on fruit quality were also determined.

MATERIALS AND METHODS
Two experiments were included in the study. In the first experiment, pre harvest treatments were applied as exogenous sprays while, in the second experiment, same chemicals were tested as post harvest dip application. Each experiment constituted six treatments and three replications of 14 fruits each.

**Experiment No. 1. Pre harvest application of calcium and magnesium**
Six healthy, full-bearing mango trees (25 years old) were selected at a commercial orchard in district Multan (30.15°N; 71.36°E) Punjab Province. The experiment was laid out according to Randomized Complete Block Design (RCBD). Foliar application of following treatments was made 15 days prior to harvest, keeping single tree as treatment unit.

\[
\begin{align*}
T_0 &= \text{control} \\
T_1 &= 1\% \text{ CaCl}_2 \\
T_3 &= 1\% \text{ CaSO}_4 \\
T_4 &= 1\% \text{ Ca(OH)}_2 \\
T_5 &= 1\% \text{ MgCl}_2 \\
T_2 &= 4\% \text{ CaCl}_2 \\
T_3 &= 4\% \text{ CaCl}_2 \\
T_4 &= 1\% \text{ CaSO}_4 \\
T_5 &= 1\% \text{ Ca(OH)}_2 \\
T_9 &= 1\% \text{ MgCl}_2
\end{align*}
\]

**Experiment No. 2. Post harvest application of calcium and magnesium**
On harvesting day of pre harvest treated fruits, additional 252 fruits fulfilling the selection criteria were selected from an untreated tree at the same orchard. These selected fruits were divided into six individual lots each comprising of 42 fruits. Each lot was divided into 3 replications of 14 fruits each. The fruits of each replication were subjected to following post harvest treatments (10 minutes dip) at the same orchard just after harvesting.

\[
\begin{align*}
T_0 &= \text{Water dip} \\
T_1 &= 1\% \text{ CaCl}_2 \\
T_2 &= 4\% \text{ CaCl}_2 \\
T_4 &= 1\% \text{ Ca(OH)}_2 \\
T_3 &= 1\% \text{ CaSO}_4 \\
T_5 &= 1\% \text{ MgCl}_2
\end{align*}
\]

The experiment followed Completely Randomized Design (CRD).
Packing, Transport and Storage
The fruits were packed in the corrugated fiberboard boxes, transported to Faisalabad and were stored \((12\pm1^\circ C, 85-90\% \text{ RH})\) for 15 days.

Determination of Soft Nose Incidence
During storage, the data on soft nose development was recorded weekly by using following rating scale of 0-3: 0 = Nil; 1 = 5-10% affected area; 2 = 10-25% affected area; 3 = >25% affected area.

Post harvest Quality Assessment
After 15 days of storage, fruits were ripened at ambient temperature and were analyzed for different physiological, organoleptic and bio-chemical parameters.

Skin Colour: Skin colour development was scored according to the following scale: 0=100% Green & 0% Yellow; 1=75% Green & 25%Yellow 2= 50% Green & 50% Yellow 3= 25% Green &75% Yellow; 4= 0% Green & 100% Yellow.

Textural Softness: Textural softening was scored using the following scale: 0= Hard; 1= Sprung; 2= Slightly Soft; 3= Eating Soft; 4= Over Ripe

Weight Loss: Fresh weight loss was calculated on the basis of initial weight (before storage) and final weight (at the end of storage period).

Weight Loss (%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100

Biochemical Characteristics
Biochemical composition was assessed in fruit pulp to study the different components of fruit quality i.e. TSS, titratable acidity, ascorbic acid etc. For the determination of biochemical components, all the fruits of each replication were peeled off with a stainless steel knife. The juice was extracted from each sample and homogenized to study the biochemical parameters.

Total Soluble Solids (TSS)
Digital Refractometer (RX 5000, Atago, Japan) was used for the determination of total soluble solids (TSS). A drop of juice was placed on the prism of refractometer, the lid was closed and TSS \(^\circ\text{Brix}\) was noted directly from the digital scale of refractometer at room temperature \((30^\circ C \pm 1)\).

Ascorbic acid
For the estimation of ascorbic acid in the pulp, the method described by Ruck (1969) was used. For this purpose extracted juice from each sample was filtered through Whatman\textsuperscript{®} filter paper. 10 ml of filtered aliquot was taken in 100 ml round bottom flask, then volume was made up to the mark by adding 0.4% oxalic acid. Out of 100 ml aliquot, 5 ml was taken in a beaker and titrated against freshly prepared dye (2, 6-dichlorophenol indophenol) till light pink end point appeared which persisted for 10-15 seconds. For the preparation of dye, 42 mg baking soda (NaHCO\textsubscript{3}) and 52 mg 2, 6-dichlorophenol indophenol were taken in a 200 ml volumetric flask and volume was made up to the mark by adding distilled water. Ascorbic acid was calculated by using following formula:

\[
\text{Ascorbic Acid (mg/100 ml) = } \frac{R_1 \times V \times 100}{R \times W \times V_1}
\]

Where
\[
R_1 = \text{ml dye used in titration of aliquot}
\]
\[
R = \text{ml of dye used in titration of 1ml standard ascorbic acid solution prepared by adding 1ml of 0.1% ascorbic acid + 1.5 ml of 0.4% oxalic acid}
\]
\[
V_1 = \text{ml of juice used}
\]
\[
V = \text{volume of aliquot made by addition of 0.4% oxalic acid}
\]
\[
W = \text{ml of aliquot used for titration}
\]
Titratable acidity
Fruit acidity is primarily due to the presence of malic and citric acids. In addition, oxalic, malonic, succinic, pyruvic, adipic, galacturonic, tartaric, glycolic and mucic acids are also present (Jain et al., 1959; Fang, 1965). It decreases with the fruit growth (Léchaudel et al., 2004). For the determination of total titratable acidity, method given by Hortwitz (1960) was used. 10 ml fruit juice was taken from each sample in a beaker, diluted (1:4) with distilled water and titrated against N/10 NaOH solution by adding 2-3 drops of phenolphthalein (C₂₀H₁₄O₄) as an indicator. The results were expressed as % citric acid. Following formula was used for the determination of total titratable acidity.

\[
\text{Titratable acidity (\%) = \frac{N/10 \text{ NaOH used} \times 0.0064 \times 100}{\text{Volume of sample used}}
\]

Organoleptic Characteristics
The treatments were evaluated at ripe stage (on 15th day of storage) for organoleptic acceptability on the basis of taste, flavor, pulp color, texture and aroma using the 9 point hedonic scale method (Peryam and Pilgrim, 1957). Ten judges were called in the panel for organoleptic evaluation of treatments.

Statistical Analysis of Data
Data were subjected to analysis of variance using SPSS® Software (SPSS, Illinois, and USA) and treatment means were compared with the help of Duncan’s New Multiple Range Test (Steel et al., 1997).

RESULTS AND DISCUSSION
Effects of treatments on soft nose
Results regarding effect of pre- and post harvest treatments of calcium and magnesium on soft nose disorder are shown in Fig. 1 (a, b). In pre harvest treatments, minimum soft nose incidence (13.3%) was observed in the fruits treated with 4% CaCl₂ followed by pre harvest treatment of 1% MgCl₂ (16.6%) compared with control (33.3%). Pre harvest treatment of 1% CaCl₂ and 1% Ca (OH)₂ were at par with 23.3%, and showed non-significant differences with control. In post harvest treatments 4% CaCl₂ (16.7%) again performed significantly better compared to control (36.7%). All other post harvest treatments exhibited similar level (20%) of soft nose incidence.

Analysis of soft nose incidence at different intervals during storage is shown in Fig. 2. (a, b). Pre harvest application of 1% CaSO₄ was found to suppress the soft nose disorder for the first 12 days of storage. Afterwards sudden increase was observed in the fruits subjected to pre harvest treatment of 1% CaSO₄ as maximum number of fruits was found to be victim of soft nose disorder at the end of storage. The reduced incidence of soft nose as a result of calcium (Ca) application particularly at pre harvest stage implicates its role in tissues firmness and stability. Pre harvest method could be more effective as plants were actively absorbing nutrients compared to post harvest stage. Previously studies shows that Ca is an essential plant nutrient involved in a number of physiological processes concerning membrane structure and function, and enzyme activities (Jones and Lunt, 1967).

Effects of treatments on quality parameters
Highly significant effects of pre and post harvest treatments were observed on peel colour and weight loss percentage (Table 1 & 2). Application of 4% CaCl₂ produced significantly higher (2.1), while 1% MgCl₂ lowered colour (1.3) score as compared with control (1.6). External appearance has been found to be improved by calcium treatment (Murillo and Adimilson, 1999). In case of physiological parameters of weight loss, minimum weight loss (2.8%) was observed in the fruits subjected to pre harvest treatment of 1% MgCl₂ followed by post harvest treatment of 1% Ca (OH)₂. Highest weight loss (31.89%) was observed in the fruits included in post harvest treatment of 1% CaSO₄ (Table 1 & 2). As far as the fruit textural softness is concerned, the pre harvest treatments showed no significant effect whereas post harvest treatments were found to affect the pulp softness significantly. The analysis of variance of the both pre and post harvest treatments showed no significant effect on the biochemical characteristics of the fruits.
Organoleptic evaluation showed significant differences in aroma score in pre harvest treatments, while post harvest treatments affected taste along with aroma. Fruits treated with 4% CaCl₂ at pre harvest and Post harvest stages had significantly higher (5.2, 6.0) aroma score compared with control (3.9, 3.4). Post harvest treatment of 1% MgCl₂ followed by 4% CaCl₂ produced significantly better taste compared with control (4.8). Whangchai et al. (2001) found that Ca and (Ca+ Mg)/K ratio in mango fruits had high positive correlation with storage life.

CONCLUSION
The significant reduction in soft nose indicates that calcium and magnesium may prove to be good control measure for mango soft nose in future. So it is suggested that in future, a series of higher concentrations of calcium and magnesium salts (particularly chlorides of Ca and Mg) should be evaluated in relation to different times of applications. As pre and post harvest treatment of calcium and magnesium did not show any negative effects on the quality parameters (Table 1 and 2) of fruits and soft nose was found to be reduced in most of the treatments, so including calcium and magnesium in the orchard nutrition program will help to improve fruit quality.

ACKNOWLEDGEMENTS
We acknowledge Pakistan Horticulture Development & Export Board (PHDEB) for financial support and Post harvest Research Centre, Ayub Agricultural Research Institute (AARI), Faisalabad for provision of cold storage facility.

Table-1: Effect of pre harvest Ca and Mg treatment on soft nose and other quality traits

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Soft Nose (%)</th>
<th>Peel Color score</th>
<th>Textural Softness score</th>
<th>Weight Loss (%)</th>
<th>TSS (°brix)</th>
<th>Titratable Acidity (%)</th>
<th>Ascorbic Acid (mg/100ml)</th>
<th>Taste score</th>
<th>Aroma score</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>33.3abc</td>
<td>1.6bc</td>
<td>4.0</td>
<td>10.3c</td>
<td>30.1</td>
<td>0.51</td>
<td>56.6</td>
<td>3.0</td>
<td>3.9c</td>
</tr>
<tr>
<td>T₁</td>
<td>23.3bc</td>
<td>1.7abc</td>
<td>4.1</td>
<td>12.2b</td>
<td>29.9</td>
<td>0.53</td>
<td>58.8</td>
<td>3.0</td>
<td>3.5c</td>
</tr>
<tr>
<td>T₂</td>
<td>13.3c</td>
<td>2.1a</td>
<td>4.0</td>
<td>6.9d</td>
<td>29.4</td>
<td>0.49</td>
<td>53.3</td>
<td>3.0</td>
<td>5.2a</td>
</tr>
<tr>
<td>T₃</td>
<td>43.3a</td>
<td>1.9ab</td>
<td>4.0</td>
<td>6.4d</td>
<td>31.1</td>
<td>0.46</td>
<td>63.3</td>
<td>3.0</td>
<td>4.2bc</td>
</tr>
<tr>
<td>T₄</td>
<td>23.3bc</td>
<td>1.5cd</td>
<td>4.0</td>
<td>15.9a</td>
<td>30.2</td>
<td>0.53</td>
<td>60.0</td>
<td>4.0</td>
<td>4.6bc</td>
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<tr>
<td>T₅</td>
<td>16.6c</td>
<td>1.3d</td>
<td>4.1</td>
<td>2.8e</td>
<td>30.5</td>
<td>0.47</td>
<td>68.8</td>
<td>4.0</td>
<td>4.1bc</td>
</tr>
</tbody>
</table>

Any two means not sharing same letter differ significantly at 5% level of probability.

Table-2: Effect of post harvest Ca and Mg treatment on soft nose and other quality traits

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Soft Nose (%)</th>
<th>Peel Color score</th>
<th>Textural Softness score</th>
<th>Weight Loss (%)</th>
<th>TSS (°brix)</th>
<th>Titratable Acidity (%)</th>
<th>Ascorbic Acid (mg/100ml)</th>
<th>Taste score</th>
<th>Aroma score</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>36.7a</td>
<td>1.3b</td>
<td>4.0</td>
<td>11.6d</td>
<td>29.6</td>
<td>0.57</td>
<td>56.7</td>
<td>4.8bc</td>
<td>3.4e</td>
</tr>
<tr>
<td>T₁</td>
<td>20.0ab</td>
<td>1.4b</td>
<td>4.0</td>
<td>11.6d</td>
<td>30.1</td>
<td>0.59</td>
<td>81.1</td>
<td>5.2b</td>
<td>4.8c</td>
</tr>
<tr>
<td>T₂</td>
<td>16.7b</td>
<td>1.3b</td>
<td>4.0</td>
<td>25.9b</td>
<td>31.2</td>
<td>0.53</td>
<td>70.0</td>
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<tr>
<td>T₃</td>
<td>20.0ab</td>
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<td>4.0</td>
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<td>31.3</td>
<td>0.47</td>
<td>67.8</td>
<td>4.8bc</td>
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<tr>
<td>T₄</td>
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<tr>
<td>T₅</td>
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<td>27.1</td>
<td>0.49</td>
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<td>6.3a</td>
<td>3.9d</td>
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</table>

Any two means not sharing same letter differ significantly at 5% level of probability.

** = Highly significant, * = Significant, ns = non significant (p=<0.05)
Fig. 1: Effects of pre (a) and post harvest (b) treatments on soft nose disorder

Fig. 2: Graphical representation of soft nose incidence from the day of harvesting to the end of storage in the fruits of pre (a) and post harvest (b) treatments

Fig. 3. Fruit showing symptoms of Soft Nose
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