EFFECT OF CaCl₂ COATING ON THE SENSORY QUALITY AND STORAGE DISORDERS OF APPLE CV. KINGSTAR STORED AT AMBIENT CONDITIONS

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ABSTRACT

Apple fruit were obtained from an orchard of Baghdere (Swat) in the first week of September 2002. Calcium chloride was applied to apple fruit (Cv. Kingstar) in four concentration levels i.e. 0, 2, 4 and 6% by the method of vacuum infiltration (270-300mmHg). The fruit were stored at ambient conditions (20-25°C and 70-75% RH) for five weeks. Fruit sensory quality was assessed on first day and after every week of storage. At the end of storage, physiological disorders (market losses) were recorded. Calcium Chloride significantly maintained the sensory quality of apple fruit by slowing down the metabolic changes. The 6% CaCl₂ treated fruit had most intense color and better texture. The results also showed that CaCl₂ treatment had significant effect (p<0.05) on Core rot (%), Cork spot (%) and Shrinkage (%). Cork spot (%) and Shrinkage (%) decreased significantly (p<0.05), while Rottening (%) and Core rot (%) increased significantly (p<0.05) with CaCl₂, which might be due to the possible injury exerted by high concentration (6%) of CaCl₂.

Key words: Apple storage, coatings of apples, sensory quality of apples

INTRODUCTION

Apple (Malus Sylvestris Borkh) fruit is well characterized for their taste, flavor and dietary values. Because of its short shelf life, it becomes spoiled and deteriorated. It has been reported that about 25-50% of fresh fruits and vegetables produced are lost after harvest (Wills and Scott, 1972). Early estimates of post-harvest losses in fresh fruits and vegetables have been reported as low as 12% and as high as 23% (Harvey, 1978). In Pakistan, total area under apple cultivation is 51.7 (000 hectares), which includes 0.3 in Punjab, 0.1 in Sindh, 9.3 in NWFP and 42.0 in Balochistan. While total production of apples in Pakistan is 377.3 (000 tones), which includes 2.7 in Punjab, 0.2 in Sindh, 101.7 in NWFP and 272.7 in Balochistan (MINFAL, 2000).

Calcium plays an important role in providing stability and mechanical strength to the cell structure of the fruit (Fry, 1988). Thus, the deficiency of calcium in the fruit leads to weakening of middle lamella due to which cells expand and burst. Consequently fruit softening and senescence sets in the storage, which shortens the post-harvest life of the produce. By increasing the calcium level in fruit tissues, the post-harvest life of apple fruit can be increased to a greater extent.

There are various methods of calcium application:

i. Pre-harvest application of calcium along with insecticides.
ii. Post-harvest
   a. Dip in calcium solution
   b. Spray of calcium
   c. Vacuum/Pressure infiltration.

Vacuum infiltration of calcium is being given to apple fruit on commercial scale in New Zealand. The only merit of this method is that it is more effective than dip or spray in controlling physiological or storage disorders such as bitter pit and storage break down. This technique can markedly retard the initiation of ripening in a number of climacteric fruits such as tomato, avocado, mango and pear, because it gives consistent quantitative delay in ripening. Most calcium entering the tissue accumulates in the cell walls and membranes that are thought to be the sites of its anti-senescence action (Glenn et al. 1988). There has been extensive research on the use of Calcium to retain quality of fruits during storage (Biggs et al. 1999; Dris et al. 1999; Carbo et al. 1998; Softner et al. 1998).

If we consider the role of Calcium, then there are a number of effects that calcium could have:

i. Ca strengthens cell wall, thereby delaying the senescence. Due to this effect, it delays the fruits softening which is associated with polygalacturonase activity.

ii. Reduces the weight loss (%) by controlling the transpiration rate.

iii. Maintenance of membrane function. It is an outside effect where calcium can affect phase transition and membrane fluidity.

Keeping in view the role of calcium in maintaining fruit quality, it is necessary to conduct research on this aspect of post-harvest management of fruit, which will help in extending storage life of apple fruit.

MATERIALS AND METHODS

This project was initiated at Post Production Technology Unit, Agricultural Research Station (North), Mingora, Swat on behalf of Department of Food Science and Technology, NWFP Agricultural University Peshawar. Apple fruit cv. Kingstar of uniform size were obtained from an apple orchard of Baghdere (Swat) in the first week of September 2002. The bruised and injured fruits were discarded. The fruit were washed in running tap water and dried. The fruit were then divided into four lots. Each lot

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was of about 15Kg. Calcium chloride solutions of 2%, 4% and 6% were prepared. The three calcium chloride solutions were applied to three lots one by one by the method of vacuum infiltration (270-300mmHg). The time for vacuum infiltration was 10 minutes. The fourth lot was taken as Control i.e. no calcium chloride was applied to it. All the four lots were packed separately in cardboards in three layers. The fruit were stored for five weeks at ordinary ambient conditions. Samples underwent sensory evaluation on zero days of storage and at the end of every week during storage. The samples were also analyzed for storage disorders (Market losses) at the end of storage period.

Sensory Evaluation

All the fruit samples were tested organoleptically for color, flavor and texture by trained judges using 9 points (1-9) hedonic scale as described by Larmond (1977).

Storage Disorders (Market losses)

Apples were analyzed for storage disorders (market losses) after 5 weeks of storage. The following disorders (losses) were observed after storage period in percentage.

- Shrinkage (%)
- Rottening (%)
- Cork Spot (%)
- Core Rot (%)

Statistical Analysis

The data for sensory quality were analyzed statistically by analysis of variance using Randomized Complete Block Design (RCBD). The data for storage disorders (Market losses) were analyzed statistically by simply one way analysis of variance. The means were separated by Least Significant Difference (LSD) Test as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Sensory Evaluation

Apples were analyzed for color, flavor and texture on zero days of storage and during ambient storage period of 5 weeks.

Color

Color of the fruit plays an important role towards consumer attraction. Results regarding the effect of treatments and storage intervals on the color of apple fruit are shown in the Table-I. The statistical analysis showed that different concentrations of CaCl₂ had a non-significant effect, while different storage intervals had a significant effect (P<0.05) on the mean score of color of the fruit. Maximum increase in the mean score was recorded in sample T6 (88.89 %) while minimum increase was recorded in sample T0 (77.78 %). Maximum mean values were recorded in sample T4 (6.0), while minimum mean values were recorded in sample T2 (5.9) (Table-I), in a similar study Bhartiya et al. (1998) also found such results.

Flavor

Flavor of a fruit is an important sensory factor for the acceptability of the product by the consumer. Results regarding the effect of CaCl₂ and storage intervals on the flavor of apple fruit are shown in the Table-II. The statistical analysis showed that different concentrations of CaCl₂ had non-significant effect (P<0.05) while different storage intervals had a significant effect (P<0.05) on flavor of the fruit. Maximum increase in the mean score was recorded in sample T4 and T6 (88.89 %), while minimum increase was recorded in sample T0 (77.78 %) (Table-II). Our results indicate a subsequent increase (from 4.5 to 8.3) in the mean score of flavor during storage period.

Texture

Texture of the apple fruit is an important factor for the acceptability of the product by the consumer. Results regarding the effect of CaCl₂ and storage intervals on the texture of apple fruit are shown in the Table-III. The statistical analysis showed that different concentrations of CaCl₂ and different storage intervals had a significant effect (P<0.05) on the mean score of texture of the fruit. Maximum increase in the mean score was recorded in sample T6 (72.22 %), while minimum increase was recorded in sample T0 and T2 (61.11 %). Minimum mean score of texture was obtained by T0 (6.16) while maximum score was obtained by T6 (6.62). In a similar study Raese and Drake (2000) found that CaCl₂ spray on ‘Red’ and ‘Golden Delicious’ apples improve the fruit quality as measured by improved texture.

Storage Disorders (Market Losses)

Shrinkage (%)

Table-IV revealed that the data pertaining to shrinkage (%) was statistically significant (P<0.05). Greater losses were recorded at T0 and T2, which were 66.81% and 63.12 % respectively. The data showed decreasing trend of shrinkage (%) with the increasing concentration of CaCl₂. The mean values of T0 and T2 were not statistically significant with one another. Badshah et al. (1994), treated apple cv. Red Delicious) with CaCl₂ at 0, 1, 2, 4 or 8 percent, then placed in cold storage at 38° F, 92% RH for 14 months. The results, they obtained showed a marked reduction in water loss with CaCl₂ (with the increasing concentration of CaCl₂). Pathmanaban et al. (1994) observed minimum water loss in Calcium treated fruits. The insufficient weight loss can lead to disorder such as mealiness (Hatfield and Knee, 1988) and low temperature breakdown (Wills and Scott, 1972). On the other hand, excessive weight loss and its associated disorders shrivel (visible wrinkling) cause loss in fruit value. Hatfield and Knee (1988) reported that as little as 5% loss in weight could cause shrivel in apples. Moreover, excessive shrinkages occur due to immaturity of the apple and days before storage.

Rottening (%)

Table-IV revealed that the data pertaining to rottening (%) was statistically significant (P<0.05) for replication as well as for treatment. Greater losses were recorded at T6, which
were 20.22. In case of T6 treatment, the rottening percentage was maximum. This should have been minimum of all the treatments, as CaCl$_2$ application reduces spoilage (Ahmad and Khajawall, 1999) and Calcium chloride used as a post-harvest treatment decreases the fungal decay (El et al. 1998). This may be due to the injury caused by high concentration of Ca. Conway et al. (1994) also obtained this result. They infiltrated apple fruits (cv. Golden Delicious) with CaCl$_2$ and stored at 0°C for 5-6 months. They observed increased fruit decay incidence in treated fruits. They stated that this could be possibly exacerbated by CaCl$_2$ injury. Similarly, Conway et al. (1995) pressure infiltrated apple fruits (cv. Golden Delicious) with 2% and 4% CaCl$_2$ at harvest. They stated that application of higher concentrations, although producing much lower increases cell wall bound Ca levels resulting in possible injury to the fruit. The variety Kingstar is an open calyx variety, thus calcium solution entered into the core of the fruit through calyx, which caused rottening in the treated fruit. Therefore, it can be concluded that this variety does not response positively against post-harvest calcium treatment.

Cork Spot

Table-IV revealed that the data pertaining to cork spot (%) was statistically significant (P<0.05). Greater losses were recorded at T0 and T2, which were 52.92 and 47.25 respectively. The data showed decreasing trend of cork spot (%) with the increasing concentration of CaCl$_2$. All the mean values were significant with each other. The data obviously indicated that delicious group of apple varieties are susceptible to this disorder (Harry, 1975). Cork spot is a physiological disorder of apple that can affect fruit quality and reduce visual appeal. It generally appears in the outer portion of fruit flesh as small green dimples or depression. The green spot eventually enlarges to corky, discolored areas $\frac{1}{4}$ to $\frac{1}{2}$ inch into the flesh of the apple. The corky spots may occur anywhere on the fruit flesh (Manson and Welsh 1970). This disorder has complex origin, but is associated with deficiency of calcium. Incidence of this disorder may be correlated with the low level of calcium in soil insufficient uptake by the tree, excessive uptake of potassium compound, water stress and the increased irrigation. All these factors probably have an indirect influence on the ultimate concentration of calcium in the fruit (Brun et al. 1985).

Core Rot (%)

Table-IV revealed that the data pertaining to core rot (%) was statistically significant (P<0.05). Greater losses were observed at T4 and T6, which were 15.99 and 24.02 respectively. The data showed increasing trend of core rot (%) with the increasing concentration of CaCl$_2$. Mean values of T0 and T2 were non-significant with one another. Fungal invasion of the core of the apple fruit were prevalent in some apple cultivars having open calyces such as Delicious, Golssters and Starking (Miller, 1959). Kingstar (a delicious) is one of the pre-dominant cultivars of Swat valley. Because of its open calyces, it comes under the susceptible group to moldy core (Miller, 1959). As Kingstar is an open calyx variety, thus calcium solution entered into the core of the fruit through calyx, which caused rottening of the core in the treated fruit.

CONCLUSION

From the data, it can be concluded that post-harvest CaCl$_2$ application to apple fruit by the method of vacuum infiltration retains its color, as the color has been found slight better in case of treated fruit. CaCl$_2$ has no effect on the flavor, but has some effect on the texture of apple fruit. The texture of the fruit improved as the concentration of the calcium chloride solution increased. Less shrinkage (%) and low incidence of cork spot has been observed in the treated fruit. The rottening percentage has been low in 2% and 4% CaCl$_2$ treated lots and high in 6% CaCl$_2$ treated lot than the control lot. The more rottening in 6% CaCl$_2$ solution treated lot may be due to the possible injury caused by high concentration of calcium chloride. The incidence of core rot has been less in the untreated fruit lot than the treated lots. This may be due to the open calyces of this fruit or the fruit may not be fully dried before packing. However, 6% calcium chloride application has given overall best performance. Therefore calcium chloride application at post harvest by the method of vacuum infiltration is recommended in order to maintain the quality and prolong the storage life of apple fruit and also to minimize the incidence of core rot in the treated fruit, the fruit should be dried before packing.
Table I  
Effect of various treatments and storage periods on color of apple fruit during storage at ambient conditions (20-25°C and 70-75% RH).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Storage (in weeks)</th>
<th>Means</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>T0</td>
<td>4.50</td>
<td>4.75</td>
<td>6.25</td>
</tr>
<tr>
<td>T2</td>
<td>4.50</td>
<td>7.75</td>
<td>6.25</td>
</tr>
<tr>
<td>T4</td>
<td>4.75</td>
<td>5.00</td>
<td>6.25</td>
</tr>
<tr>
<td>T6</td>
<td>4.75</td>
<td>4.75</td>
<td>6.25</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td>4.62e</td>
<td>4.81c</td>
<td>6.25b</td>
</tr>
</tbody>
</table>

Figures with similar letters are statistically not different from one another (p<0.05).

Table II  
Effect of various treatments and storage periods on flavor of apple fruit during storage at ambient conditions (20-25°C and 70-75% RH).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Storage (in weeks)</th>
<th>Means</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>T0</td>
<td>4.50</td>
<td>5.75</td>
<td>6.75</td>
</tr>
<tr>
<td>T2</td>
<td>4.50</td>
<td>5.75</td>
<td>6.75</td>
</tr>
<tr>
<td>T4</td>
<td>4.50</td>
<td>6.00</td>
<td>6.50</td>
</tr>
<tr>
<td>T6</td>
<td>4.50</td>
<td>6.00</td>
<td>6.75</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td>4.50e</td>
<td>5.87d</td>
<td>6.68c</td>
</tr>
</tbody>
</table>

Figures with similar letters are statistically not different from one another (p<0.05).

Table III  
Effect of various treatments and storage periods on texture of apple fruit during storage at ambient conditions (20-25°C and 70-75% RH).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Storage (in weeks)</th>
<th>Means</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>T0</td>
<td>4.50</td>
<td>5.50</td>
<td>6.00</td>
</tr>
<tr>
<td>T2</td>
<td>4.50</td>
<td>5.50</td>
<td>6.00</td>
</tr>
<tr>
<td>T4</td>
<td>4.50</td>
<td>6.00</td>
<td>6.25</td>
</tr>
<tr>
<td>T6</td>
<td>4.50</td>
<td>6.25</td>
<td>6.50</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td>4.50e</td>
<td>5.81d</td>
<td>6.18c</td>
</tr>
</tbody>
</table>
Table IV  Effect of Calcium Chloride Coatings on Shrinkage, Rottening, Cork spot and Core rot (mean values).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shrinkage (%)</th>
<th>Rottening (%)</th>
<th>Cork spot (%)</th>
<th>Core rot (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>66.81a</td>
<td>11.283c</td>
<td>52.92a</td>
<td>6.26c</td>
</tr>
<tr>
<td>T2</td>
<td>63.12a</td>
<td>14.010b</td>
<td>48.53b</td>
<td>7.45c</td>
</tr>
<tr>
<td>T4</td>
<td>50.39b</td>
<td>12.638bc</td>
<td>33.22c</td>
<td>15.99b</td>
</tr>
<tr>
<td>T6</td>
<td>37.82c</td>
<td>20.225a</td>
<td>17.47d</td>
<td>24.02a</td>
</tr>
</tbody>
</table>

Figures with similar letters are statistically not different from one another (p<0.05).

T0 = Control treatment (No Calcium Chloride solution applied).
T2 = 2% (20g/litre) Calcium Chloride solution applied.
T4 = 4% (40g/litre) Calcium Chloride applied.
T6 = 6% (60g/litre) Calcium Chloride applied.

REFERENCES


Miller, P.N. 1959. Open Calyx tubes as a factor contributing t carpel discoloration and decay of apples, Phytopath. 49, 520-523.


