ABSTRACT

The research work on fruit quality and senescence related changes in sweet orange (Citrus sinensis) cv. Blood Red was conducted at Nuclear Institute for Food and Agriculture (NIFA), Peshawar during 2003-2004. The fruits of sweet orange were stored for 75 days at room temperature in different uni-packing materials i.e. polyethylene, cellophane, polyethylene green, wax paper, kraft paper and news paper. It was found that taste and visual quality significantly decreased with 45 days storage at room temperature. Increasing storage duration resulted in significant increase in weight loss, total soluble solids and TSS/Acid ratio, while Ascorbic acid content and percent acidity decreased with extension in storage duration. Cellophane and polyethylene uni-packing resulted in significant retention of taste and visual quality over 45 days storage, with minimum weight loss of 1.18% and 1.33% respectively, and high ascorbic acid content (60.45 mg/100 ml as compared to 44.86 mg/100 ml) in control over 75 days storage at room temperature. There was a slight decrease in percent acidity in polyethylene (1.34%) and cellophane (1.31%) uni-packing as compared to 1.68% in control. Total soluble solids increased with increase in storage duration with maximum increase in control and news paper uni-packing (12.73% each), which was significantly higher than Cellophane (11.60%) and polyethylene (11.73%) after 75 days. Similarly TSS/acid ratio also increased with increasing storage with maximum increase in control (12.18) but was significantly lower in polyethylene green (7.61), cellophane (7.64) and polyethylene (8.95) after 75 days storage.

Key Word: Sweet Orange, Red Blood, Uni-packing, storage, TSS, Acid, Ascorbic Acid.

INTRODUCTION

Sweet orange (Citrus sinensis L.) is an important member of citrus group of fruits. In Pakistan citrus fruits are grown over an area of 183.8 thousand hectares with a total production of 1,943.7 thousand tons (Agric. Statistics Pakistan, 2004-2005). Citrus fruits are not only important for domestic consumption but also can serve as a source of foreign exchange. Currently Pakistan exports 94,806 tons of citrus (Kinnow and others) fruit to different countries (PHDEB Board 2006). The demand for sweet orange is very high both in domestic and international markets. The fruits are harvested during November-December and stored in cold storages. The demand for the fruit increases from January onward but the quality of the fruits can not be retained. Improper storage results in rapid loss of sugars, ascorbic acid (Maleki and Sarkissian, 1967) and enhanced weight loss (McGornack, 1975). Low temperature storage is generally used to slow down the deterioration of citrus fruits during storage but citrus fruits are chilling sensitive and hence may be injured by chilling temperatures (Purvis 1985). Since most of the prevailing cold storages in Pakistan operate at 0-5°C, cold storage of citrus fruit may deteriorate the quality due to chilling sensitivity. Thus, sweet orange can not be stored at low temperatures (0-5°C) for extended period of time (Couey, 1986).

Exposure of sweet orange to chilling temperatures results in surface pitting, abnormal ripening, increased susceptibility to decay and enhanced senescence (Purvis 1985). Improper post harvest management and subsequent deterioration is a serious concern in citrus industry. Optimum post harvest management is crucial for extending supply of citrus fruits in domestic market as well as export purposes.
Chemical treatments e.g. thiabendazol (Farooqi et al. 1975), proper storage conditions (McGornack 1975) and packaging materials (BenYahoshia et al. 1979, Kwada and Albergo 1979) and waxing the fruits (Petracek et al. 1998), have been intensively investigated to enhance the storage life of citrus fruits. Citrus fruits are also uni-packed in different materials such as paper wraps, polyethylene, cellophane, wax paper and kraft paper etc. (BenYahoshia et al. 1981, Pervis 1984 and Pervis 1985). The present project was, therefore, initiated to evaluate the effects of different uni-packing materials used in citrus industry on the postharvest life and quality of citrus fruits stored for various durations to the maximum of 75 days.

MATERIALS AND METHODS

The effects of uni-packing materials and storage duration on postharvest quality of sweet orange was evaluated in two factorial randomized complete block (RCB) design with three replications. The sweet orange fruits Cv Blood Red, with about similar size and maturity stage were harvested from an orchard in District Dargai, Malakand Division and brought to Nuclear Institute for Food and Agriculture (NIFA), Peshawar. Fruits were washed with clean tap water and dried with a blower before uni-packing in different materials. Data on fruit taste, visual quality, weight loss, ascorbic acid content, TSS, percent acidity and TSS/acid ratio were recorded at 15 days interval for 75 days.

Taste and visual quality was estimated according to 10 points hedonic scale with 10 being the best (Larmond 1977) for fruit taste, texture and physical appearance. Weight loss was approximated as percent of original weight with the help of an electronic balance measuring weight to third decimal. Total soluble solids, ascorbic acid and percent acidity of the fruit was determined at 15 days intervals from time zero to storage after 75 days. TSS was measured with a hand refractometer (Kernco Instruments Co. Texas). Acidity was determined by neutralization reaction as described in Association of Official Analytical Chemists A.O.A.C. (1990). The sample of unknown acidity was titrated with a standard 0.1N NaOH solution. The completion of the reaction was established using phenolphthalein as an indicator.

Ascorbic acid content was determined by titration. For this purpose 1ml of juice was diluted with 1N oxalic acid solution and percent vitamin C content was approximated by the following formula.

\[
\text{Ascorbic acid content} = \frac{FxT \times 100}{D \times S} \times 100
\]

where:

- \( F \) = Factor for standardization = ml ascorbic acid/ ml of dye
- \( T \) = ml of dye used in sample – ml of dye used in blank
- \( D \) = ml of sample taken for titration
- \( S \) = ml of dilute solution taken for titration.

RESULTS AND DISCUSSION

Taste and Visual Quality

Both taste and visual quality decreased with increasing storage duration. The data presented in Table I reveals that maximum base line taste score (9.16) was recorded in fresh fruit, which decreased significantly after 30 days storage. Increasing storage duration to 45 days caused significant decrease in taste score of the fruits and reached unacceptable values. Thus, data for these parameters is not shown after 45 days storage at room temperature. The taste of the fruits in all treatments was very poor after 45 days except cellophane in which the unacceptable value was reached after 60 days storage (data not shown). Among the different uni-packing materials, the maximum retention of taste was found in Cellophane (8.34), followed by polyethylene (8.27). The lowest taste score was in News paper packing (6.79), followed by kraft paper (6.99) and wax paper with 7.06 as compared to taste score of 7.67 in control. The visual quality of the fruit decreased in comparable fashion to the taste of fruits. There was non significant decrease in visual quality during the first 15 days of storage, but the mean score for visual quality decreased significantly to 7.40 and 6.31 after 30 and 45 days respectively. Fruits uni-packed in polyethylene and cellophane showed the maximum visual quality with Hedonic Score 8.13 and 8.08 respectively. The minimum mean visual quality score over 45 days storage was in wax paper (6.88) and news paper packing (6.94).

Polyethylene and cellophane retained the visual quality with 45 days storage with the score being non-significantly lower than time zero, but both uni-packing material showed significant decrease in visual quality with further extension in storage to 60 days (Data not shown). The visual quality score of polyethylene (5.86) and cellophane (6.56) was significantly higher than all other uni-packing materials
included in the study. Despite good visual quality, fruit uni-packed in polyethylene or cellophane showed fermented taste that may be due to decreased O₂ and alcoholic fermentation in these packing materials (Ahmad et al. 1979), despite having relatively better visual quality (Table I). Thus, cellophane, polyethylene and polyethylene green seem to maintain quality and retard the senescence initially (Ben-Yehoshua et al. 1981) but extend storage enhanced anaerobic respiration, resulting in the synthesis of ethanol and acetaldehyde (Geravetova and Astabasvan 1976) that might decrease the taste of fruits (Ben-Yehoshua et al. 1979 and Coulomb 1984).

**Table I**  
Effect of storage and unipacking material on taste and visual quality of sweet orange fruits

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Storage Duration (Days)</th>
<th>Taste</th>
<th>Visual Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Control</td>
<td>9.16 A</td>
<td>9.00 A</td>
<td>7.64 B</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>9.16 A</td>
<td>9.03 A</td>
<td>7.91 B</td>
</tr>
<tr>
<td>Polyethylene Green</td>
<td>9.16 A</td>
<td>8.95 A</td>
<td>7.29 B</td>
</tr>
<tr>
<td>Kraft Paper</td>
<td>9.16 A</td>
<td>9.00 A</td>
<td>5.87 C</td>
</tr>
<tr>
<td>Celluphane</td>
<td>9.16 A</td>
<td>9.08 A</td>
<td>7.83 B</td>
</tr>
<tr>
<td>Mean</td>
<td>9.16 A</td>
<td>8.98 A</td>
<td>6.75 B</td>
</tr>
</tbody>
</table>

LSD for Storage Intervals at alpha 0.01 = 0.477  
LSD Uni-Packing Materials at alpha 0.01 = 0.442  
LSD for interaction at alpha 0.01 = 1.16

**Weight Loss**

There was significant increase in weight loss with increasing storage duration (Fig. 1). The average weight loss as function of storage interval was 1.38% after 15 days storage that increased to the maximum of 27.55% with 75 days storage. Among the different uni-packing materials, maximum percent weight loss was recorded in control which increased from 2.21% at day 15 to 52.74%, when storage was extended to 75 days, followed by News Paper and Kraft Paper in which weight loss increased from 2.07% and 1.92% to 44.52 and 43.29% after 75 days storage. Percent weight loss was significantly lower with cellophane, polyethylene green and polyethylene (Fig. 1) at all storage intervals. In these uni-packing materials, percent weight loss was 0.93, 1.28 and 1.33% respectively after 15 days storage which increased to 2.86, 1.93 and 2.25% accordingly after 60 days storage.

![Fig. 1](image-url)  
**Fig. 1**  
Effect of Storage interval and uni-packing materials on percent weight loss in sweet orange fruit
Weight loss of perishables is a serious concern in its storage because loss of moisture decreases visual quality, salable weight and may result in physiological dysfunctions. The sweet orange fruit continued to lose water after harvest but uni-packing materials contribute significantly toward retarding moisture loss. Since cellophane, polyethylene and polyethylene green are impermeable to water, unipacking in such materials raises the humidity around the commodity and decrease moisture loss (Faroogi et al. 1975). The permeability of uni-packing materials is, thus, important characteristic for retention of quality because sealed polyethylene film (Purvis 1985) or polyethylene bags (Kwada and Albrigo, 1979) are reported to retain the kinnow fruit weight and other phsio-chemical properties better than tissue paper or wax paper. Polyethylene uni-packing thus seems to offer an economical measure of decreasing weight loss because it may drastically decrease weight loss (1-2%) as compared to 13.29% in unwrapped fruits over 60 days refrigerated storage (Sonkar and Ladaniya, 1999). This might help in decreasing the cost involved in waxing of fruits, used as measure of decreasing weight loss (Ahmad, 1979).

**Total Soluble Solids (TSS)**

Total soluble solids content is an important aspect of fruits quality of which 75-80% is sucrose. There was a general tendency of increased total soluble solids with increasing storage duration. Total soluble solids, at time zero was 10.47%, which significantly increased to 10.74 and 11.11% with 15 and 30 days storage. Increasing storage duration to 45 and 60 and 75 days resulted in increased TSS to 11.41, 11.89 and 12.24% respectively (Fig. 2). Uni-packing materials also significantly affected the changes in TSS content. The maximum TSS percentage was recorded in control (11.68%) followed by 11.48% in Wax Paper with the difference being nonsignificant (Fig. 2). Significantly lower TSS than the rest of uni-packing materials was observed in cellophane (10.92%) and polyethylene (11.04%). It appears that increase in total soluble solids is a built in proess in aging sweet orange fruits and may be due to the breakdown of complex carbohydrates. The analysis of total soluble solids as a function of storage duration reveals a general tendency of increase in soluble solids as the fruits advance in ripening and senescence (Nawaz 1971). The uni-packing materials also significantly affected the total soluble contents of the fruit. At each storage interval, the maximum TSS percentage was recorded in control with the maximum value of 12.73% after 75 days storage. The mean TSS values of all storage interval in control (11.68%) was significantly higher than polyethylene, polyethylene green and cellophane which were non significant among themselves. Although Gupta et al. (2000) have reported a decrease in TSS with extended storage duration, the opposite trend was observed in this experiment which showed conformity with the results obtained by Nawaz (1971). Since, TSS percentage is a function of total dissolved solids and moisture content of the fruit, the increase in TSS may be due to low moisture content of the fruit. It may explain the relatively smaller increase in polyethylene, polyethylene green and cellophane uni-packing which also showed the least weight during storage (Fig. 2).
Percent Acidity

The percent acidity of the fruit was significantly affected by both storage duration and uni-packing materials. There was a decrease in percent acidity with increasing storage duration. The mean percent acidity for all treatments decreased from 1.68 at time zero to 1.024 after 75 days storage (Table II). Percent acidity was significantly affected by different uni-packing materials. It decreased from the base levels of 1.68 to 0.75 in control. Decrease in percent acidity was minimum in Cellophane (1.44), Polyethylene (1.46) and Polyethylene Green (1.43), with the difference being nonsignificant. Other treatments e.g. Wax Paper and News paper wrap also retained percent acidity over the storage duration (Table II).

The acidity of citrus fruit is due to various organic acids e.g. citric acid, malic acid, benzoic acid, tartaric acid and oxalic acid. The taste and flavor of the fruit is a function of sugars and organic acids present in the fruits. Since most of the organic acids are intermediate metabolites of the citric acid cycles, they are consumed during the respiration and therefore, the acidity decreased with increasing storage duration (Min and Or 1977, Sheikh et al. 1979). Thus, the decrease in percent acidity may be regarded as a pattern of senescence. The decrease in percent acidity in cellophane, polyethylene and polyethylene green can be due to the fact that these uni-packing result in higher CO2 concentration in the packages (Vines and Obserbacher 1961) which decrease the rate of respiration (Peteracek et al. 1998) and subsequently retain organic acids in the fruits.

Table II  Effect of storage duration and uni-packing material on percent acidity of sweet orange fruits

<table>
<thead>
<tr>
<th>Treatments</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.68 A</td>
<td>1.20 FG</td>
<td>0.94 HI</td>
<td>0.87 H-K</td>
<td>0.80 I-K</td>
<td>0.75 K</td>
<td>1.04 C</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>1.68 A</td>
<td>1.55 AB</td>
<td>1.44 B-E</td>
<td>1.40 C-E</td>
<td>1.35 E</td>
<td>1.31 EF</td>
<td>1.46 A</td>
</tr>
<tr>
<td>Polyethylene Green</td>
<td>1.68 A</td>
<td>1.49 B-D</td>
<td>1.32 EF</td>
<td>1.40 C-E</td>
<td>1.37 C-E</td>
<td>1.32 EF</td>
<td>1.43 A</td>
</tr>
<tr>
<td>Wax Paper</td>
<td>1.68 A</td>
<td>1.33 EF</td>
<td>1.19 FG</td>
<td>1.00 H</td>
<td>0.87 H-K</td>
<td>0.81 I-K</td>
<td>1.15 B</td>
</tr>
<tr>
<td>News Paper</td>
<td>1.68 A</td>
<td>1.36 DE</td>
<td>1.15 G</td>
<td>0.90 H-J</td>
<td>0.84 I-K</td>
<td>0.81 I-K</td>
<td>1.13 B</td>
</tr>
<tr>
<td>Kraft Paper</td>
<td>1.68 A</td>
<td>1.33 EF</td>
<td>1.15 G</td>
<td>0.93 H-J</td>
<td>0.88 H-K</td>
<td>0.80 JK</td>
<td>1.13 B</td>
</tr>
<tr>
<td>Celluphane</td>
<td>1.68 A</td>
<td>1.50 BC</td>
<td>1.32 EF</td>
<td>1.37 C-E</td>
<td>1.39 C-E</td>
<td>1.34 E</td>
<td>1.44 A</td>
</tr>
<tr>
<td>Mean</td>
<td>1.68 A</td>
<td>1.39B</td>
<td>1.21 C</td>
<td>1.12 D</td>
<td>1.07 E</td>
<td>1.02 E</td>
<td></td>
</tr>
</tbody>
</table>

LSD Storage Intervals at alpha 0.01= 0.051
LSD Uni-Packing Materials at alpha 0.01= 0.055
LSD for interaction at alpha 0.01= 0.136

TSS Acid Ratio

It is evident from the data in Table III that both storage duration and uni-packing materials significantly affected the TSS/ Acid ratio of citrus fruits. The TSS acid ratio increased significantly with increasing storage duration. TSS/Acid ratio increased significantly from the base value of 6.02 to 7.73 and 9.31 with 15 and 30 days storage respectively. With further extension in storage duration it increased to 10.60 and 11.78 with 45 and 60 days storage and finally reached 12.83 after 75 days. The minimum increase from the time zero base value (6.02) was recorded in Polyethylene, cellophane and polyethylene green with 7.61, 7.64 and 7.67 respectively, while the maximum increase (12.18) was recorded in control followed by News Paper and wax paper with 11.24 and 10.74 with the difference being significant.

Both storage duration and uni-packing materials significantly affected the TSS/ Acid ratio of citrus fruits. The TSS acid ratio increased significantly with increasing storage duration. It increased from the base value of 6.02 to 7.73 and 9.31 with 15 and 30 days storage respectively. With further extension in storage duration to 45 and 60 days, TSS/Acid ratio increased to 10.60 and 11.78 and finally reached 12.83 after 75 days. Since TSS increased (Fig 2) while percent acidity decreased (Table II) with increasing storage duration, increased TSS/Acid ratio is the result on increased TSS content of the fruit. The increase in TSS Acid ratio over 75 days storage was significantly lower in Polyethylene, cellophane and polyethylene green with 7.61, 7.64 and 7.7.67 respectively, while the maximum increase (12.18) was recorded in control followed by News Paper and wax paper with 11.24 and 10.74 with the difference being significant. It is indicative of the fact that Polyethylene, cellophane and polyethylene green inhibit the senescence process and hence can be used as measure of extending the storage period.
Table III  

Effect of storage duration and uni-packing material on TSS:Acid ratio of sweet orange fruits

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Days in Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>6.02</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>6.02</td>
</tr>
<tr>
<td>Kraft Paper</td>
<td>6.02</td>
</tr>
<tr>
<td>Celluphane</td>
<td>6.02</td>
</tr>
<tr>
<td>Mean</td>
<td>6.02F</td>
</tr>
</tbody>
</table>

LSD Storage Intervals at alpha 0.01 = 0.458
LSD Uni-Packing Materials at alpha 0.01 = 0.495
LSD for interaction at alpha 0.01 = 1.214

**Ascorbic Acid Content**

Ascorbic acid content is an important constituent of citrus fruits (Gupta et al., 2000) for both taste and nutritional value (Khan, 1964). Since Vitamin C is rapidly lost during extended storage of citrus fruits (Ben-Yehoshua et al., 1979; Coulomb, 1984), its retention is of prime importance in postharvest handling of citrus fruits. The data pertaining to ascorbic acid content of the fruit as affected by storage duration and packing materials is shown in Fig. 3. The data reveals that both storage duration and packing materials significantly affected the ascorbic acid content of the fruit. Ascorbic acid decreased significantly with increasing storage duration. The highest values of ascorbic acid (73.83 mg/100 ml) at time zero decreased to 50.35 in control which was non-significantly different from news paper and kraft paper. The mean values showed that polyethylene, cellophane and polyethylene green resulted in significantly lower loss of ascorbic acid, which decreased to 68.53, 67.55 and 66.56 accordingly. The retention of ascorbic acid content in Uni-packing with polyethylene, cellophane and polyethylene green can be attributed to moisture retention and higher CO₂ concentration in the packages (Vines and Obserbacher, 1961) which may have decreased the rate of respiration (Peteracek et al., 1998) and subsequently slowing down the overall senescence in citrus fruits (Min et al., 1977).

![Figure 3: Decrease in ascorbic acid content with storage duration](image)

**Fig. 3**  Decrease in ascorbic acid content with storage duration
CONCLUSION

It is found that citrus fruits continue to decline in taste and visual quality during storage. The decline in taste and visual quality is accompanied by a decrease in ascorbic acid and percent acidity. Total soluble solids and TSS/Acid ratio increase during storage. Among the different uni-packing materials polyethylene and cellophane uni-packing retained the taste and visual quality of the fruit longer than the rest of the uni-packing materials. The maintenance of taste and quality was also accompanied by less weight loss, retention of total solids, ascorbic acid and percent acidity which resulted in lower TSS/Acid ratio. Thus both polyethylene and cellophane can be recommended as uni-packing materials for sweet oranges. Since the fruit lost its taste and visual quality value greatly after 45 days storage, polyethylene and cellophane, uni-packaging can only be recommended as short term storage or low temperature storage to retain the taste as well as chemical quality attributes.

REFERENCES


