EFFECT OF HEAT AND COLD TREATMENTS ON POST HARVEST QUALITY OF SWEET ORANGE CV. BLOOD RED

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ABSTRACT
The research work on effect of heat and cold treatments on post harvest quality of sweet orange Cv Blood Red was conducted at the Department of Horticulture, NWFP Agricultural University, Peshawar during 2002-2003. The post harvest quality of sweet orange was evaluated after 60 days storage at room temperature following different combinations heat and cold treatments. It was found that both heat and cold treatments and storage durations have significant effects on various parameters of citrus fruit. There was an initial increase in Total Soluble Solids (TSS) to the storage duration of 45 days but TSS then declined with 60 days storage. Total sugars and organic acids decreased continuously with increasing storage duration and reached the minimum value at day 60 of storage. The juice content increased with increasing storage duration up to 45 days but stated to decrease in some treatments after 60 days storage. Weight loss was maximum in heat treated fruit, while color development, total soluble solids and juice contents were maximum in cold treated fruits. Organic acids and percent sugars were maximum in control, which decreased with increasing duration of heat treatment (15 minutes at 50°C). Chilling injury increased with increased duration of cold treatment (72 hrs at 5°C).

INTRODUCTION
Sweet orange (Citrus sinensis) is an important fruit crop of Pakistan, which is 2nd only to apple in terms of area under cultivation. Citrus fruit (sweet orange) is among the major fruit crop grown in Pakistan over an area of 181,577 hectares with a total production of 1,702,347 tons. NWFP contributes 38,002 tons to the total national production with an area of 4,285 hectares under citrus fruits. (Pak. Agric. Stat. 2002-03). 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. The demand for sweet orange is very high both in domestic and international markets. However, citrus fruits could not be exploited to the full potentials for domestic markets and international trade. It continuous supply in domestic markets and as source of foreign exchange earning is limited due to the poor post harvest quality, variety of pathogens and cold temperature sensitivity.

The physiological problem (e.g. chilling injury) is a disorder caused by low temperature that results in of considerable post harvest losses both in quality and material. The symptoms of chilling injury in sweet orange include pitting, water soaked areas, brown stains and enhanced disease susceptibility etc develop after the fruit is removed from cold storages. This problem is rarely observed by the storage people which is never taken into account in storing the produce. 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. Due to chilling sensitivity, sweet orange can not be stored at low temperatures (0-10°C) for extended period of time (Couey 1986). Exposure of sweet orange to chilling temperatures result in surface pitting and abnormal ripening increased susceptibility to decay and enhanced senescence. Thus the citrus fruit offers a double trouble to the marketing personals. Since, it has to be stored at relatively higher temperatures, pathogens and insects can fully exploit the situation and degrade the quality of the produce. It will be of great significance if chilling sensitivity of the fruit of sweet orange is decreased so that the fruit is not seriously damaged by chilling temperatures. If the same treatments can also be used to decrease the incidence of insects and diseases on sweet orange, it will be achieving a
double benefit of a single treatment. The present project seeks to utilize heat treatment for this purpose.

Heat treatment has been shown to induce tolerance to chilling in seedling radicles (Rab and Saltveit 1996), mungbean hypocotyls (Grahm et al 1991). Such treatments are shown to induce heat shock proteins (Lauri and Klein 1991) and seems like an inbuilt system of acquiring tolerance against abiotic stresses.

The present project, therefore, was initiated to evaluate the effects of short durations of heat and cold treatments on the postharvest quality of sweet orange after 60 days storage at room temperature.

**MATERIALS AND METHODS**

The effects of heat and cold treatments were evaluated in two factorial randomized complete block design with three replications during June, 2004. The sweet orange fruit Cv. Bood Red was harvested in an orchard at Dargai, Malakund Division. The fruits were divided into 16 groups for various treatments of heat cold treatments combinations. The heat treatments were minutes in water heated 50°C while the cold treatments were in hours at 5°C. The control group was left untreated. Data on Weight loss, color development, pH, disease incidence and salable fruits were estimated at time zero and after 60 days storage. Total soluble solids, organic acids, Total sugars and Juice content of the fruit was determined at 15 days intervals from time zero to storage after 60 days.

Total soluble solids were determined using hand refractometer (Kernco Instruments Co. Texas). Acidity was determined by neutralization reaction as described in AOAC 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. Total sugars were determined according to AOAC 1990 by conversion of copper present in Fehling’s solution to insoluble cuprous oxide by sugars. The volume of unknown sugar solution required to completely reduce a measured volume of Fehling’s solution was determined by titration, using methylene blue as an indicator.

**RESULTS AND DISCUSSION**

The data recorded on the effect of heat and cold treatments and storage duration on different parameters related to the postharvest quality of citrus fruit is presented in Table I and figure 1-5.

**Total Soluble Solids:**

The data pertaining to total soluble solids as affected by heat and cold treatments and storage duration is shown in Fig.1. It is clear from the table that both heat and cold treatments significantly affected the total soluble contents of the fruit. Total soluble solids, at time zero ranged from 5.08-5.66 and 5.33 and 5.66% in heat and cold treatments respectively. With the difference being non-significant. It indicates that the fruits were harvested at uniform developmental stage. When total soluble solids are analyzed as a function of heat or cold treatments and storage duration, it increased with increase in storage duration up to 45 days but significantly decreased when storage duration was extended to 60 day (Park and Jung 1996). The heat treatments resulted in a decrease in total soluble solids so that the minimum value (5.83%) was observed in fruit heat treated for 15 at 50°C minutes, while the maximum value was observed in control. The total soluble solids percentage increased with increasing storage duration to 60 days where the maximum value (8.66%) was observed in control while the minimum was in fruit treated for 15 minutes at 50°C. This tendency clearly reveals that heat treatment seems to slow down the ripening process and hence delay the increase in soluble solids.

In cold treatments total soluble solids after 30 days storage increased from 5.33 to 6.16 while the maximum TSS (6.83) at this stage was found in fruit held at 5°C for 24 or 48 hours. When storage duration was extended 60 days the TSS percentage was the lowest in control (7.25) while the highest percentage was found in fruits held at 5°C for 24 or 48 hours. The data presented in fig. 1 suggest that a mild cold treatment e.g. 24 or 48 hours at 5°C help in enhancing the ripening process and the development of total soluble solids.

A comparative analysis of heat and cold treatments suggest that whereas heat treatment seems to delay the development of TSS, cold treatments upto 48 hours may enhance it. Since heat treatments slow
down the ripening process, the slow increase in total soluble solids in heat treated fruit can be attributed to this slowing down of the ripening process.

**Organic Acids**

Total organic acids were determined at various storage intervals e.g. after 0, 15, 30 and 60 days. The data was analyzed for organic acids values in relation to storage duration, heat and cold treatments. Fig. 2 indicate that organic acids decreased with increase in storage duration. At time zero there were only non-significant differences in organic acid contents of the fruits, an indicator of uniform fruit maturity at the time of harvest.

Organic acid in various treatment at time zero ranged from the minimum of 1.87 to the maximum of 2.05, with the difference being nonsignificant. Organic acid values showed a continuous decline with increasing storage durations. It decreased to the range of 1-1.54 after 15 days storage. The minimum value of organic acids observed after 30 days storage was 0.91% while the maximum at this point was 1.27%. When storage duration was increased to 60 days the minimum value of organic acids decreased to 0.81% while the maximum dropped to 0.88%. The decrease at each storage was interval was significant but the difference among various heat and cold treatments at a given storage duration was nonsignificant. These results are in conformity with the findings of Teruel et al (2000) who reported that ascorbic acid content of the fruit decreases with increasing cold storage duration.

A comparison of heat and cold treatments revealed that heat treated fruits were generally having lower values for organic acids as compared the cold treatments. These observation suggest that cold treatments promote maturation and subsequent synthesis of organic acids in sweet orange while the heat treatments delay the ripening process.

**Total Sugars**

Total sugars were highest at time zero and decreased with increasing storage duration. At time zero the total sugars in both heat and cold treatment ranged from 4.55-5.47%. The minimum and maximum total sugars after 15 days storage decreased to 3.37 and 4.67%. Further increase resulted in further decrease in total sugars to the range of 3.09 – 4.3% after 30 days. There was additional decrease in total sugars after 45 days storage and decrease further with additional 15 days increment (Day 60) of storage duration (Fig. 3). Since sugars are the substrate for respiration they are continuously burned in the process of respiration, it is expected to see a decrease in total sugars with increasing storage duration (Moazong et al. 1997).

Heat and cold treatment affected the total sugars of the fruit in opposite directions. In heat treatments, total sugars were significantly higher in control, indicating that heat treatment delays the development of sugars. This is an attribute that could be due to a delaying effect of heat treatments on citrus fruit (Aung et al.1998). By contrast, cold treatments showed relatively higher values for total sugars at each storage interval. While the decrease as a function of storage duration was significant the difference in various cold treatment was, however, nonsignificant.

**Juice Content**

The juice content of the fruit increased significantly with increasing storage duration for 45 days. The minimum and maximum percentage of juice content at time zero ranges from 32.69 – 38.83%. The juice content increased significantly after 15 days storage where it ranged from the minimum of 43.42% to the maximum of 47.17%. There was significant increase in juice content with further increase in storage duration to 30 days and 45 days. After 45 five days storage, the juice contents attained its maximum values. At this storage interval, the minimum and maximum juice
content ranged from 50.84 to 52.80%. There was no significant increase in juice content of cold treated fruits, when storage duration was increased to 60 days. By contrast, juice content decreased in heat treated tissue (Fig. 4).

An analysis of juice content as a function of heat and cold treatments indicate that the increase in juice content was relatively rapid in heat treated fruits as compared to cold treatments. Juice content increased from 38.83% to 52.8% in control thus resulting in a net increase of 13.77%. By contrast heat treatments for 5 and 10 minutes at 50°C resulted in increased juice content of 14.84 and 15.93% respectively. Increasing the heat treatments to 15 minutes resulted in further increase (19.21%) in juice content of sweet orange fruit (Teruel et al. 2000).

When cold treatments are analyzed for its effects on juice contents, it is clear from Fig.4 that cold treatments up 48 hours resulted in only slight increase in juice content. Whereas the net increase in juice content in control was 15.85%, it increased to 17.40% with 24 hours exposure to 5°C. Increasing cold exposure to 48 and 72 hours decreased juice content to 16.72 and 12.38%. The increase with 24 hours cold treatments confirm our previous findings of the beneficial effects of this treatment. The decrease in juice content with 72 hours cold treatment also confirm our conclusion that exposure to 5°C for 72 hours have undesirable effects on the fruit (Teruel et al. 2000).

Weight Loss
The data on weight loss after 60 days storage at room temperature is presented in Table 1. It is evident that both heat and cold treatments affect weight loss of the fruit. Weight loss of the fruit increased with increasing heat treatment duration. It increased from 9.51 in control to 10.25% when fruit were heat treated for 15 minutes. These results confirm the findings of Park and Jung (1996) and Schirra et al (1997) who repoted rapid weight loss in citrus fruit exposed to heat treatments. By contrast, the cold treatment decreased weight loss from 10.27% in control to 9.64 and 9.32% when cold treatment was extended to 24 and 48 hours. However, extension of cold storage treatments to 72 hours reversed this trend and weight loss increased to 10.16%, which was only nonsignificantly lower than control.

Colour Development
The data on color development was recorded after 60 days storage at room temperature. The fruits were visually evaluated by panel of 10 persons and color ranking was given and converted to percent. Most of the fruits developed good color after 60 days storage. However, increasing heat treatment duration resulted in significant decrease in color. Since heat treatments slow down the ripening process, it is reasonable to see a delay in full color development with increasing heat treatments duration. By contrast cold treatment upto 48 hours improved color but when applied for 72 hours resulted in a decrease in color development. The decrease in colour development with 72 hours exposure indicate that the fruit might have injured by chilling (Shahbake 1994) and hence the failure to develop full colour (Schirra et al. 1997).

Fruit pH
Both heat and cold treatments did not caused significant changes in the pH of the fruit. The minimum and maximum pH values in heat treatments were 3.46 and 3.52. The pH values of the fruit ranged from 3.53-3.45 in cold treatments and after 60 days storage at room temperature. Disease incidence

When fruits were analyzed after 60 days storage for diseases incidence. All treatments showed disease incidence, but difference in various heat and cold treatments was not significant. In heat treatments the minimum disease incidence of 5% was recorded in when fruits were heat treated for 10 minutes at 50°C while in the best cold treatment that showed minimum disease incidence (3.33%) was in fruits held ay 5°C for 48 hours before storage at room temperature (Table I). Generally citrus fruits are highly sensitive to various diseases, but the low disease incidence in this experiment could by due to the application of chemicals before harvest.

Salable Fruits
Salable fruits represent an overall picture of visual quality and is complexion of various quality attributes. Salable fruits for each treatment were approximated after 60 days storage at room temperature. The heat treatments resulted in
significant decrease in salable fruits after 60 days storage. The maximum salable fruits (82.5%) was in control treatment which significantly decreased to 65.83 and 70% with increasing heat treatment duration to 5 and 10 minutes. The difference in 5 and 10 minutes, however, was not significant. But when heat treatment was increased to 15 minutes, it significantly decreased the salable fruits to 59.17%. It has been reported by Schirra et al. (1997) that heat treatments may result in peel injury and this could be a reason for a decrease in salable fruits in heat treatments.

Cold treatment upto 48 hours caused nonsignificant increase in salable fruits, where it increased from 68.33% to 71.67 and 72.50% respectively. But increasing cold treatment up to 72 hours reversed the increase in salable fruits to values nonsignificantly lower than control (65.00%). These observations suggest that citrus fruits are not injured by low temperature for 48 hours but further expansion to fruit may initiate the cold injury to the fruit (Adsules et al. 1984) and subsequently decrease its market value.

CONCLUSION
An analysis of total soluble solids as a function of heat or cold treatments and storage duration revealed that TSS increased with increase in storage duration up to 45 days but significantly decreased when storage duration was extended to 60 days. A comparative analysis of heat and cold treatments suggest that whereas heat treatment seems to delay the development of TSS, cold treatments up to 48 hours may enhance it. Total sugars decreased with increasing storage duration and thus reached the minimum values after 60 days storage. Heat and cold treatment affected the total sugars of the fruit in opposite directions. In heat treatments, total sugars were significantly higher in control, indicating that heat treatment delays the development of sugars. The juice content of the fruit increased significantly with increasing storage duration of 45 days. An analysis of juice content as affected by heat and cold treatments indicate that the increase in juice content was relatively rapid in heat treated fruits as compared to cold treatments. Weight loss increased with increasing storage duration. Heat cold treatments have the opposite effect on weight loss. Whereas, weight loss of fruit increased with increasing heat treatment duration, cold treatment (upto 48 hours) decreased weight loss but 72 hours reversed this trend and weight loss increased was more and only nonsignificantly lower than control. The total storage time e.g. 60 days resulted in maximum color development in all treatments but cold treated fruit developed color more than heat treated fruits.

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<tr>
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<th>Effect of heat and cold treatments on weight loss, colour development, pH, disease incidence and salable fruits after 60 days storage at room temperature in citrus fruit</th>
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<td><strong>Heat Treatments</strong> (Minutes at 50°C)</td>
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</tr>
<tr>
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<td>LSD at 5%</td>
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<td><strong>Cold Treatments</strong> (Hours at 5°C)</td>
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REFERENCES


Fig. 1. Effect of Heat and cold treatments and storage duration on total soluble solids content of citrus fruit

Fig. 2. Effect of heat and cold treatments and storage duration on total organic acids of citrus fruit

Fig. 3. Effect of heat and cold treatments and storage duration on total sugars in citrus fruit

Fig. 4. Effect of heat and cold treatments and storage duration on juice content of citrus fruit