Research Article

# Influence of Hot Water Treatments on the Storage Life of Sweet Orange Cv. Sherkhana-I

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**Abstract** | The experiment "Influence of hot water treatments on the storage life of sweet orange (Citrus sinensis) cv. Sherkhana-I" was carried out at Post harvest Laboratory, Department of Horticulture, The University of Agriculture, Peshawar, Pakistan. The research was conducted in completely randomized design (CRD) with two factors i.e. hot water dipping times (0, 5, 10, and 15 Minutes) and storage durations (0, 15, 30, 45 and 60 Days). Hot water dipping times significantly affected the quality parameters of Sherkhana-I sweet orange fruits. The fruits of sweet orange having hot water dipping time of 15 minutes showed the maximum fruit juice content (51.07%), volume (141.94 ml), firmness (2.41 Kg.cm-2), acidity (1.50%) and ascorbic acid (34.50%). The storage durations also had significant effects on the quality attributes of sweet orange. However the maximum fruit volume (160.25 ml), juice content (57.00%), firmness (2.89 kg cm-2), ascorbic acid (40.96%) and acidity (1.64%) were noted in fresh fruits. The HWDT of 15 minutes was found to be the most suitable treatment for preserving the postharvest quality of sweet orange. From the above findings, it can be concluded that hot water treated (Hot water temperature: 45 ˚C) sweet orange fruits can be stored commercially up to 60 days at room storage conditions (Storage Temperature: 12 ± 2 ˚C and RH: 70 - 80%). HWT can serve as a dynamic means of maintaining the postharvest quality of sweet orange fruits during long term storage with economic benefits.

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**Keywords** | Completely Randomized Design (CRD), Hot Water (HW), Hot Water Dipping Time (HWDT), Hot Water Treatments (HWT), Relative Humidity (RH)

## Introduction

Sweet orange (*Citrus sinensis*) is a member of Rutaceae family and subfamily Aurantioideae. It ranked 2nd after apple in the world business and largely produced in Pakistan. Allspecies of citrus aresubtropical fruitsprimarily, but are suitable for a wideclimaterange, 28-124 ˚F. Sweet Orange is an important member of genus "*citrus*" (Nicolosi et al., 2000). In Pakistan, citrus fruits are cultivated on 194.5 thousand hectaresarea, with a production of 1982.25 thousand tons per year, while citrus is grown on 4.0 thousand hectares in KPK is with 32.3 thousand tons per year production (MINFA, 2010).

Technique of hot water treatment is applied to many fruit types to prevent insect and fungal attack in the post-harvest management (Lurie, 1998). Hot water (HW) and steam or hot air is applied commercially for increasing storage life of fruits. Heat treatment methods and duration of fruit exposure to heat may affect fruit quality. Hot water treatment is more effective than the hot air and is a heat transfer medium

(Shellie and Mangan, 1994). Hot water dipping of fruits controls fungal pathogens effectively even dipping only for a few minutes (Paull and Chen, 2004). Hot water effects post harvest physiology of fruits, including reduced ethylene production (Paull and McDonald, 1994), the process of delayed maturation (Woolf et al., 1995), decrease flesh softening and pectin solubalization (Klein et al., 1990). The application of hot water treatment induced chilling tolerance in seedling radicals. These treatments have shown to induce heat shock proteins and appeared as an integrated acquisition of tolerance against abiotic stresses (Lauri and Klein, 1991).

Due to importance of post harvest fruit treatments a research was conducted to evaluate the impacts of short-term hot water treatments on the post-harvest life of sweet orange fruits cultivar Sherkhana-I stored at room conditions.

## Materials and Methods

### *Site of experiment*

The experiment "Influence of hot water treatments on the storage life of sweet orange (Citrus Sinensis) cv. Sherkhana-I fruits" was conducted at Post harvest laboratory, Department of Horticulture, The University of Agriculture, Peshawar, Pakistan.

### *Fruit materials*

The fruits of sweet orange cv. Sherkhana-I of about similar maturity and size were collected from Citrus Research Institute Sargoda and then carried to the Post harvest Laboratory of department of Horticulture, The University of Agriculture, Peshawar, Pakistan. Before dipping in hot water, the fruits were washed with distilled water carefully.

### *Application of hot water*

The fruits were then dipped in hot water with a temperature of 45 ± 2 °C. The temperature of water was maintained through water bath.

### *Design of experiment*

The research was designed in Completely Randomized Design (CRD) with two factors. Hot water dipping Time (0, 5, 10, 15 Minutes) and Storage durations (0, 15, 30, 45, 60 Days).

### *Studied parameters*

Data were recorded after 0, 15, 30, 45 and 60 days on fruit volume, firmness, juice content, acidity and ascorbic acid.

$$\text{Percent junice content} = \frac{\text{Average juice weight}}{\text{Average fruit weight}} \times 100$$

### *Ascorbic acid (mg. 100 g$^{-1}$)*

Ascorbic acid was observed by dye method as prescribed in AOAC (1990) of randomly selected fruits in each replication for all treatments.

$$\text{Ascorbic acid content} = \frac{F \times T \times 100}{D \times S} \times 100$$

Where:

F= Dye Factor
T= ml dye solution used from the burette
D= ml diluted sample taken for titration
S= g sweet orange juice taken for dilution

$$\text{Dye factor (F)} = \frac{\text{ml ascorbic acid solution}}{\text{ml dye solution used}} \times 100$$

### *Percent acidity*

Acidity was observed by neutralization reaction as described in AOAC (1990). The sample of unknown acidity was titrated with a standard 0.1N sodium hydro oxide (NaOH) solution. The completion of the reaction was established using phenolphthalein as an indicator.

$$\text{Percent titratable content} = \frac{F \times T \times N \times 100}{D \times S} \times 100$$

Where:
T = ml of NaOH used from the burette
N= NaOH normality
D = ml sample taken for dilution
S = ml diluted sample taken for titration
F = Constant acid factor (for primary acid in the fruit) = 0.0067 (citric acid in sweet orange)

### *Statistical analysis*

The data were statistically subjected to analysis of variance (ANOVA) technique through STATISTIX (version 8.1) software. The means were further assessed in such cases where the differences were significant through least significant difference (LSD) test (Jan et al., 2009).

## Results and Discussion

### *Fruit volume (ml)*

The effects of both hot water treatments and storage

durations on fruit volume were found statistically significant at room storage conditions, while its interaction was not significant. Fruit volume of sweet orange exhibited a decrease by prolonging the storage period. The volume at harvest was 160.25 ml which decreased to 150.34, 140.08, 129.00 and 118.75 ml in 15, 30, 45, and 60 days respectively, but the decrease was lower in HW treated fruits compared to control group. The maximum fruit volume (141.94 ml) after 60 days of storage was noted in fruits dipped in hot water for 15 minutes, followed by volume (140.54 ml) of fruits dipped in hot water for 10 minutes, whereas the minimum fruit volume (137.54 ml) was observed in control fruits (Table 1).

Fungal and microbial attacks reduce the storage life of sweet orange. Hot water dipping is one of the postharvest methods that can enhance shelf life of fruits by decreasing postharvest respiration and other metabolic activities in fruits (Ansari and Hossain, 2007). There is a very high correlation between fruit volume and fruit weight and so as when there is a significant weight loss during storage then there will be a significant change in fruit volume (Lurie, 1998). Water loss leads to weight loss because water loss influences the texture and visual appearance of the fruits and hence causes a reduction in weight so when weight is reduced volume of the fruit is also reduced (Kader, 2002). It is possible to assume that shrinkage values will rise and weight values will decrease after long-term storage in response to dehydration process. The magnitude of the values will depend on the postharvest management of the fruit (Maria et al., 2008).

*Fruit firmness (kg cm$^{-2}$)*

The fruit firmness of the sweet orange generally decreased in all treatment groups during the storage period, but hot water treatments delayed the fruit softening. The highest fruit firmness (2.41 kg.cm-2) after storage of 60 days was found in fruits having HWDT of 15 minutes followed by (2.31 kg.cm-2) firmness of fruits having hot water dipping time of 10 minutes, while the lowest (2.10 kg.cm-2) was recorded in control fruits (Table 1). A Decreasing trend in fruit firmness was determined during the whole storage period. The fruit firmness was 2.89 kg cm-2 at harvest, but decreased to 1.78 kg cm-2 in 60 days (Table 1).

The decrease in fruit firmness is related to weight and moisture loss (Laurie et al., 1998). With the decrease in weight and moisture content, fruit firmness was decreased but hot water treatments delayed this decrease because it deactivated the respiratory enzymes (Desmolases, Dehydrogenases, Carboxylases) so the breakdown of starch to glucose and fructose was inhibited (Laurie et al., 1998). Ansari and Hossain (2007) also claimed that the fruit firmness of sweet orange was decreased with increasing storage duration, but hot water, thiabendazol and wax treated fruits showed higher fruit firmness as compared to untreated fruits.

*Percent fruit juice content*

Means pertaining to fruit juice content in Table 1 indicating that storage durations and hot water dipping time had significant effect on the fruit juice content

**Table 1:** *Fruit volume, firmness, juice content, percent acidity, and ascorbic acid content of sweet orange cv. Sherkhana1 as affected by hot water dippings.*

| Treatment | Treatment Levels | Fruit volume (ml) | Fruit firmness (kg.cm$^{-2}$) | Fruit juice content (%) | Percent acidity | Ascorbic acid (mg/100g) |
|---|---|---|---|---|---|---|
| Storage Days(D) | Fresh | 160.25 a | 2.89 a | 57.00 a | 1.64 a | 40.96 a |
| | 15 | 150.34 b | 2.43 b | 51.83 b | 1.61 b | 36.47 b |
| | 30 | 140.08 c | 2.09 b | 43.00 c | 1.51 c | 34.91 c |
| | 45 | 129.00 d | 2.00 c | 40.75 cd | 1.42 d | 31.36 d |
| | 60 | 118.75 e | 1.78 d | 39.50 d | 1.23 e | 25.12 e |
| LSD at 5% | | 0.9286 | 0.1216 | 2.4776 | 0.0166 | 0.6729 |
| Hot water dipping time (T) | 0 | 137.54 d | 2.10 b | 43.00 c | 1.46 b | 33.04 c |
| | 5 | 138.74 c | 2.13 b | 44.80 bc | 1.47 b | 33.76 b |
| | 10 | 140.54 b | 2.31 a | 46.80 b | 1.49 a | 33.75 b |
| | 15 | 141.94 a | 2.41 a | 51.07 a | 1.50 a | 34.50 a |
| LSD at 5% | | 0.8306 | 0.1088 | 2.216 | 0.0149 | 0.6018 |
| S × T | | NS | NS | NS | NS | NS |

of sweet orange (cv. Sherkhana-I). The maximum juice content (51.07%) after 60 days of storage was noted in fruits having hot water dipping time of 15 minutes followed by juice content (46.80%) of fruits dipped in HW for 10 minutes. The minimum (43.00%) juice content was found in control fruits. With regard to storage durations, the highest (57.00%) juice content was recorded in fresh fruits followed by (51.83%) juice content of fruits having storage period of 15 days, while the lowest juice content (39.50%) was observed in fruits having storage period of 60 days.

The juice content of sweet orange fruits decreased with the increase in storage duration, because of moisture loss and postharvest respiration (Khan et al., 2007). The present findings are in line with Ansari and Hossain (2007). During their study on the effect of hot water, fungicide and waxing on the storage life of Valencia and local oranges of Siavarz, they reported that, by increasing the storage period, juice content was also decreased but hot water treated and waxed fruits showed relatively high juice contents as compared to control fruits.

*Percent acidity*

Acidity of sweet orange continuously decreased in all groups during storage, but this decrease was slower in HW dipped fruits compared to control fruits (Table 1). At harvest the acidity of sweet orange was 1.64%, which decreased to 1.61%, 1.51%, 1.42% and 1.23% in 15, 30, 45 and 60 days respectively. At the end of 60 days storage period, acidity of control fruits was 1.46%, while in hot water dipped fruits having dipping time of 15 minutes the acidity was 1.50% which was high compared to control fruits.

The cause of reduction in acidity might be the postharvest metabolic activities in fruits. The decrease in acidity might be due to the breakdown of pectin into pectic acid during storage. With the increase in storage duration, acidity was decreased but the use of postharvest treatments like hot water, wax and fungicide application reduced the postharvest decrease in acidity of sweet orange as compared to control group because these treatments decreased the postharvest metabolic activities (Rab et al., 2011).

*Percent ascorbic acid*

Table 1 shows changes in ascorbic acid content of "Sherkhana-I" sweet orange during 60 days of room storage conditions. During the storage period, ascorbic acid content of fruits continuously decreased in all treatment groups but this decrease was slower in hot water treated fruits compared to the control fruits. After 60 days of storage, the maximum percent ascorbic acid (34.50%) was noted in fruits having hot water dipping time of 15 minutes followed by ascorbic acid (33.75%) of fruits treated in hot water for 10 minutes, whereas the lowest ascorbic acid (33.04%) was noted in control group. As concerned to storage intervals the ascorbic acid was 40.96% at harvest and decreased to 36.47%, 34.91%, 31.36 and 25.12% in 15, 30, 45 and 60 storage days respectively.

Ascorbic acid is a relatively less stable compound and normally decreases with increase in storage duration (Kaul and Saini, 2000). It is interesting to observe that while other ripening associated changes were inhibited by modest heat treatment in diverse types of fruits such as banana (Blackbourn et al., 1989; Jiang et al., 2002), avocado (Eaks, 1978) and tomato (Lauri, 1998), the decline in ascorbic acid was further enhanced by wet heat treatment (WHT). The WHT seems to enhance the decline in ascorbic acid content of the citrus. But the application of hot water significantly retarded the ascorbic acid decline of sweet orange.

## Conclusions

According to the experimental results, it can be concluded that hot water treatments significantly retarded the decrease in fruit volume, firmness, ascorbic acid, acidity and juice content of sweet orange. As a result, Sherkhana-I sweet orange can be stored commercially up to 30 days at room storage conditions (12 ± 2 °C temperature and 70 - 80% RH) with cost-effective benefits. The hot water dipping time of 15 minutes was determined to be the most appropriate treatment for maintaining the postharvest quality of Sherkhana-I sweet orange.

## Author's Contribution

Fazal Ullah & Muhammad Sajid conceived and designed the experiments, Fazal Ullah & Syeda Leeda Gul performed the experiments, Fazal Ullah & Syeda Leeda Gul analyzed the data. Fazal Ullah, Bibi Zainub and Maaz Khan contributed reagents/ materials/ analysis tools. Fazal Ullah wrote the article.

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