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ORIGINAL ARTICLE

Effect of Post-Harvest Treatments on Quality Characteristics of Carrots During Storage

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ABSTRACT

Background: Carrot due to its versatility in culinary uses is considered to be one of the most preferred vegetable. The carrot in Pakistan ranks third among winter vegetables, but due to adoption of improper postharvest techniques and storage, it leads to a great reduction in its quality.

Objective: The study was carried out to assess the effect of different treatments on quality characteristics of carrot.

Methodology: The study was carried out at the Laboratory of Farm Structures, Sindh Agriculture University Tandojam, Pakistan. Freshly harvested mature carrots free from damage and fungal attack were obtained from field. The carrot samples were subjected to different post-harvest treatments i.e. 40 ºC hot water dip for 2 minutes, 50 ºC hot water dip for 2 minutes, 0.4% concentration of calcium chloride ($CaCl_2$) dip for 2 minutes and tap water.

Results: The results revealed that moisture content and firmness decreased with increasing storage duration, whereas weight loss, fungal incidence and total soluble solids increased with increasing storage duration. The carrots treated with 0.4% concentration of $CaCl_2$ dip for 2 minutes had maximum moisture content (78.32%) and firmness (4.12 lbs), with minimum weight loss (41.33%), fungal incidence (38.14%) and total soluble solids (10.43%), followed by 40 ºC hot water dip for 2 minutes, 50 ºC hot water dip for 2 minutes and tap water.

Conclusion: The carrots treated with 0.4% concentration of $CaCl_2$ dip for 2 minutes showed better quality characteristics at the end of storage. The adoption of this treatment should therefore be encouraged in the developing countries for extending the quality characteristics of carrots.

Keywords	*Address of Correspondence	Article info.
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INTRODUCTION

The carrot due to its versatility in culinary uses and its enriched healthy composition, such as protein, carbohydrate, fibre, vitamin A, potassium, and sodium is considered to be the most preferred vegetable[1]. The carrot in Pakistan ranks third among winter vegetables[2]. To meet the increasing demand in future, researches are being carried to increase the quantity produced and to improve post-harvest preservation[3]. The quality and acceptance of carrots at sale is affected at all the stages of the supply chain i.e. growing, harvesting, storage, cleaning, grading, packaging and distribution. In recent years, the black root rot caused by the fungi has become a key problem for the carrot production[4]. The disease symptoms, gray black lesions on the carrot surface, usually develop after storage during retailing when carrots are held at room temperature under moist condition[5].After harvesting the carrot leads weight loss, discoloration, textural changing and structural break down which ultimately decrease shelf life of the carrots[6]. Several chemical changes occur during the storage of carrots, including the conversion of polysaccharides to simple sugars and sucrose for reducing sugars, resulting in the release of off tastes, textural alterations, structural breakdown and colour change[7]. Refrigeration with or without regulation of atmospheric composition is commonly practiced to maintain the quality of fruits and vegetables during storage; whereas it is not economically practical to apply such technologies[8]. Fungicides prevent whole fruits from rotting after harvest, but they leave residues that can harm humans and the environment[9]. Sulfites are an efficient chemical preservative, as they are both antibacterial and inhibited enzymatic browning. However, due to negative customer reactions, their use has been prohibited[10]. Plastic sheets can also help to prevent moisture loss, although they are prone to microbial growth and disposal issues[11].

Studies have shown that by employing a simple and ecologically friendly methods, ripening and colour can be delayed, water loss and decay can be reduced, and attractiveness can be improved[12]. Edible films and coatings improves the shelf life of products, limit oxidation and respiration processes, maintain texture and sensory features, and are eco-friendly[13]. To increase the firmness and to extend the shelf life, calcium dips have been used as firming agents for a variety of fruits and vegetables after they have been harvested. Pathogen germination, speculation and growth, as well as significant colour change, textural breakdown, and ripening and degradation, are all reduced by calcium treatments[14]. Hot water immersion can also be used a heat treatment technique to control pests and diseases after harvest in fresh perishable commodities[15]. The overall quality of products when treated with hot aqueous solution and hot water treatment resulted better, when compared without hot treatment[16]. Similar results for hot water treatment at different temperature has also been reported by Hu et al.[17]. Keeping in view the importance and necessity of the problem, and to provide a desired environment for maintaining the quality of carrot, the present study was carried out to determine the effect of post-harvest treatments on the quality of the carrot.

MATERIALS AND METHODS

The study aiming to assess the effects of treatments on the quality of carrots was carried at Laboratory of Farm Structures, Sindh Agriculture University Tandojam. The carrot samples were collected from field at the time of maturity and transported to the laboratory. The sample of carrots were divided into four lots and treated according to the treatments i.e 40ºC hot water dip for 2 minutes (T_1), 50 ºC hot water dip for 2 minutes (T_2), 0.4% concentration of $CaCl_2$ dip for 2 minutes (T_3) and control with tap water (T_4).The treated samples were then placed at room temperature in the laboratory, and following observations were recorded (replicated thrice) at an interval of three days.

Ambient temperature and relative humidity

The temperature and relative humidity were determined by using dry and wet bulb thermometers during the entire storage period. The ambient temperature was directly calculated from dry bulb, whereas relative humidity was determined by Psychrometric chart using dry and wet bulb data.

Moisture content (%)

A sample of 10g was taken and oven dried at 105ºC for 24 hours[18]. Moisture content was then determined using the following equation.

$$\text{Moisture content} = \frac{\text{Weight of wet sample - dry matter of sample}}{\text{Weight of wet sample}} \times 100$$

Weight loss (%)

An electronic weight balance was used for evaluating the weight loss of carrot for all treatments. Weight loss was determined according to the following formula[19].

$$\text{Weight loss} = \frac{\text{Wight of fresh carrot - Weight after storage}}{\text{Wight of fresh carrot}} \times 100$$

Firmness (lbs)

A fruit penetrometer with a probe of 15mm was used to measure the firmness of the carrot sample. The carrot was placed on a hard surface. The probe of the penetrometer penetrated the carrot tissue after a force was applied to the surface of the carrot. As a measure of carrot firmness, the force required to enter each tissue was measured[20].

Fungal incidence (%)

Carrot samples were monitored daily at room temperature for signs of degradation. The amount of rotted roots as a percentage of the total number of carrots was then calculated[21].

Total soluble solids (%)

ATC-1E hand-held Refractometer (ATAGO, Japan) was used for determining the total soluble solids at a temperature of 20 ºC. Two drops of carrot juice were placed on the Refractometer plate, recording the TSS percent on the scale accordingly[22].

Statistical analysis

The analysis of variance by statistics software (Statistix Ver. 8.1) was carried out using 2-factorial completely randomized design to examine the effect of treatments on quality of carrots.

RESULTS AND DISCUSSION

Temperature and relative humidity of the experimental site

The ambient temperature ranged between 27.5 to 32.4ºC throughout the storage period, with an average value of 29.45ºC, whereas the relative humidity ranged from 52.4 to 68.5% (Figure **1**). Storage conditions such as temperature and relative humidity are the main factors influencing degradation of carrots during post-harvest preservation[23]. The temperature and humidity ranging between 0 to 1 ºC and RH of 95- 98% accordingly has been reported to be suitable by various researchers[24]. Low relative humidity during storage and loss in weight of carrots resulted in deterioration of quality. In the present study, it was observed that the temperature and humidity conditions were not suitable for storage causing maximum damage and contamination.

Moisture content

Mean squares showed significant differences in moisture content for carrot under different treatments, duration and the interaction of treatment × duration (Table **1**). Moisture content of carrot decreased with increasing days of storage. The maximum moisture content with 78.32% after 15 days of storage was observed in carrots treated with0.4% $CaCl_2$ dip for 2 minutes, followed by 40 ºC hot water dip for 2 minutes, 50 ºC hot water dip for 2 minutes and then with control throughout the storage duration (Figure **2a**). The decrease in moisture content may be due to high rate of respiration of carrots and low humidity. Several methods have been used to reduce moisture loss from fruits and vegetables during storage i.e. refrigeration[25], high humidity stores[26], air tight storages[27].Mostofi et al.[28]reported that various chemical treatment have been used to slow down physiological changes and moisture loss. Bahri & Rashidi[29] found a decrease in moisture level of carrot during 14 days storage after post-harvest treatment.

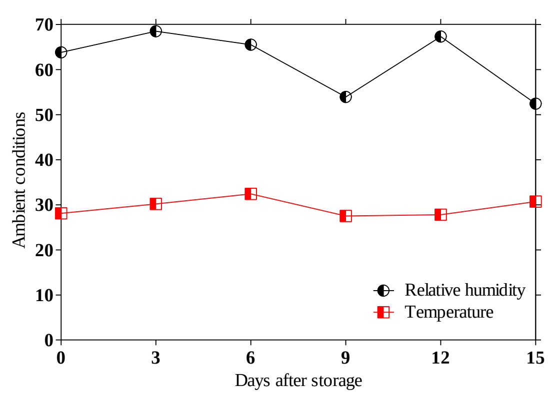

Figure 1. Temperature and relative humidity during the study.

Table 1. Mean squares of quality parameters of carrots as effected by different post-harvest treatments and storage duration.

SOV	Df	Weight loss	Moisture content	Fungal incidence	TSS	Firmness
Replication	2	0.6	6.350E-04	1.8	0.0138	1232.85
Treatments (T)	3	240.5**	72.7388**	938.7**	5.3311**	1245.97*
Durations (D)	5	11848.1**	478.643**	13524.8**	42.4810**	1276.42*
T*D	15	30.3**	5.93163**	77.7**	0.6498**	1234.69*
Error	40	0.9	4.565E-04	0.8	0.0085	1233.86
Total	65	-	-	-	-	-

** Highly significant at $p<0.01$, * Significant at $p<0.05$

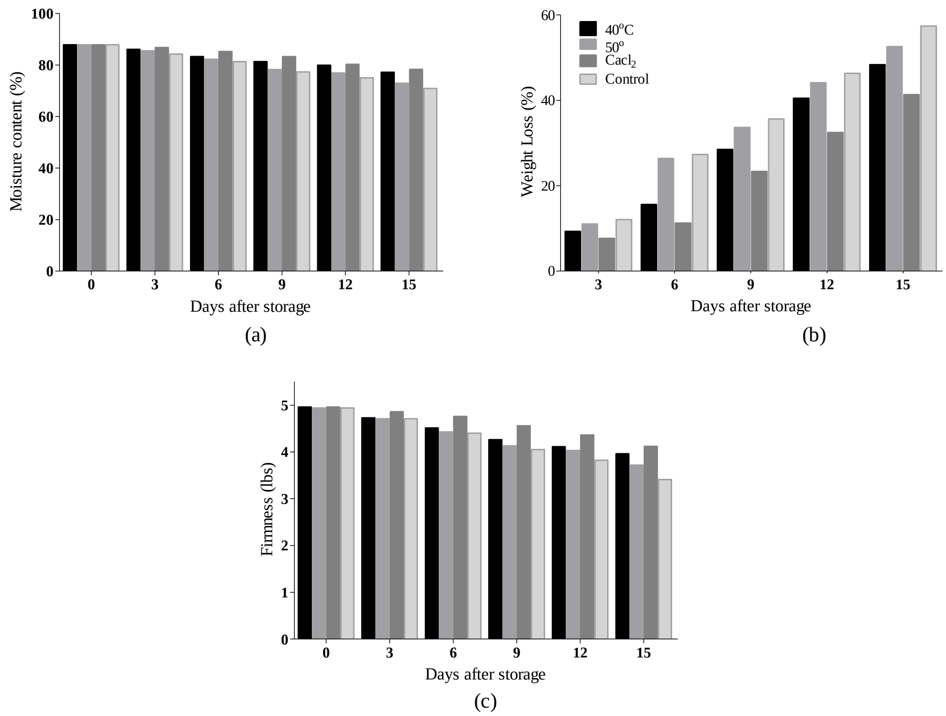

Figure 2. Effect of treatment and storage duration on moisture content (a), weight loss (b) and firmness (c).

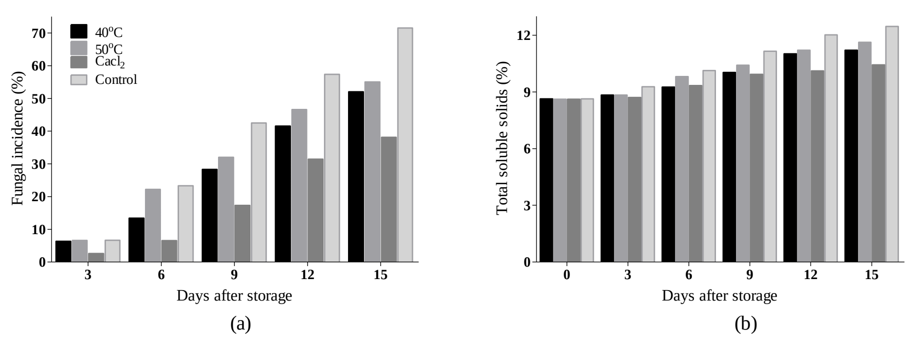

Figure 3. Effect of treatment and storage duration on fungal incidence (a) and total soluble solids (b).

Weight loss

Mean squares revealed significant variations in weight loss of carrot. The result were significantly different for treatment, storage duration and the interaction of treatment × duration (Table **1**). Weight loss of carrots increased with increasing days of storage (Figure **2b**). The lowest weight loss with 41.33% was observed in carrots when treated with0.4% $CaCl_2$ dip for 2 minutes, followed by 40 ºC hot water dip for 2 minutes (48.32%), 50 ºC hot water dip for 2 minutes (52.94%) and then with control (57.37%). Calcium chloride strengthens the cell walls of fruits and vegetables causing minimal loss when treated with $[CaCl_2]_{0.4\%}$ dip for 2 minutes. The present results of the study are in agreement with the findings of Niari et al.[30], who stated that five minutes of calcium chloride dip of carrots sample was effective in maintaining the weight of the carrots. Similar result has also been observed by Marta et al.[31]

Firmness

The statistical analysis revealed a significant difference among treatment, storage duration and interaction between treatment × duration (Table **1**). A decreasing trend (4.96 to 3.41 lbs) with increasing duration was observed for the carrots in all treatments (Figure **2c**). The maximum firmness with 4.12lbs after 15 days of storage was observed in carrots when treated with0.4% $CaCl_2$ dip for 2 minutes, followed by 40 ºC hot water dip for 2 minutes (3.96lbs), 50 ºC hot water dip for 2 minutes(3.72lbs) and then with control (3.41lbs). The loss of firmness might be due to high rate of physiological process and attack of microorganisms, leading to deterioration and senescence. Zudairea et al.[32] stated that postharvest practices significantly affects the quality and physiological changes in products. Koh & Melton[33]stated that the chemical treatment i.e. calcium chloride reduces the ripening of fruits, resulting with increased firmness. Heat treatment according to Gil et al.[34]has the tendency of removing disease-causing spores that cause deterioration on the surface of fruits and vegetables. Gonçalves et al.[35]reported that decay organisms soften fruits and vegetable tissues, which increases the rate of respiration and loss of moisture, and as a result decreases its hardness.

Fungal incidence

The carrots were initially free from any fungal incidence, which then gradually increased during the entire storage duration as shown in Figure **3a**. Mean squares revealed significant differences in fungal incidence of carrot under different treatments, duration and the interaction of treatment × duration (Table **1**). The highest fungal incidence with 71.53%was observed in control carrots, followed by 50 ºC hot water dip for 2 minutes, 40 ºC hot water dip for 2 minutes and lowest when treated with 0.4% $CaCl_2$ dip for 2 minutes (38.14%). Augspole et al.[36] stated calcium chloride is a chemical sanitizer that prevents fungal infections and their associated germinating spores. Kaka et al.[37]for their study reported that hot water treatment is helpful in decreasing rot spores at the surface of fruits and vegetables. Fallik[38] similarly stated that heat treatment has direct effect on fungal pathogens by inactivating germination spores, which can also cause antifungal chemicals in the product that inhibit fungal growth.

Total soluble solids

The mean squares for total soluble solids of carrots showed significant variations among treatment, storage duration and interaction between treatment × duration (Table **1**). Total soluble solids of carrots increased with increasing days of storage (Figure **3b**). Minimum values with 10.43% for TSS among the postharvest treatments was observed for0.4% $CaCl_2$ dip for 2 minutes, followed by 40 ºC hot water dip for 2 minutes, 50 ºC hot water dip for 2 minutes and then washed with tap water (12.47%). Bahri & Rashidi[29] while conducting an experiment on carrots observed an increase in total soluble solids with increasing day of storage. Similar results has also been reported by Rashidi et al.[39] and Gupta et al.[40], whom reported that the total soluble solids level in carrots significantly increased with storage duration.

CONCLUSIONS

The calcium chloride and hot water treatments showed a significant effect on the quality characteristics of carrots during storage at ambient conditions for 15 days. Carrots treated with 0.4% concentration of $CaCl_2$ dip for 2 minutes showed better quality (high moisture content, low weight loss, high firmness, least fungal incidence and lower total soluble solids) followed by 40 ºC hot water dip for 2 minutes, 50 ºC hot water dip for 2 minutes and with control. Storage period significantly increased weight loss, fungal incidence and TSS. However moisture content and firmness of carrots decreased with increasing storage period. The adoption of treatment viz. 0.4% concentration of $CaCl_2$ for 2 minutes should be encouraged in the developing countries for extending the quality characteristics of carrots.

CONTRIBUTOR STATEMENT

Benish Nawaz Miran and Shakeel Hussain Chattha contributed in study conception and design. Benish Nawaz Miran, Shakeel Ahmed Soomro and Babar Mustafa Ansari contributed in performing the experiments. Zaheer Ahmed Khan and Ghassan Zahid contributed in analysis of data. Bakhtawar Wagan, Shakeel Hussain Chattha and Imtiaz Ali Dahri supervised and contributed in interpretation of data. Shakeel Ahmed Soomro contributed in writing the manuscript.

CONFLICTS OF INTERST

No conflict of interest.

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None.

LIST OF ABBREVIATIONS

None

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