International Journal of Advanced Research and Review

www.ijarr.in

HOT WATER TREATMENT: A TECHNICAL PRESERVATION TECHNIQUE FOR STORAGE OF HORTICULTURAL COMMODITIES

Fazal Ullah[1,2*], Habib Ullah[3], Ghulam Nabi[1], Gohar Ayub[1], Anam Ashraf[4]

[1]Department of Horticulture, University of Agriculture Peshawar, Pakistan
[2]Department of vegetable science, College of horticulture, China Agricultural University Beijing, China
[3]Department of Chemistry, Govt. Post Graduate College, Abdul wali khan University Mardan, Pakistan
[4]School of Environment, Tsinghua University Beijing, China
***Corresponding Author email:** fazalullah@cau.edu.cn

ABSTRACT

All fruits and vegetables generally known as horticultural commodities have short post-harvest life. Various methods has been adopt to store horticultural commodities for longer duration with less physiological disorder and high market value using preservative chemicals. A significant advantage of hot water treatment is the absence of chemical residues on the fruit surface. Hot water treatment effects on the physiology of fruit after harvest. It delays maturation, slow rate of flesh softening and pectin solubalization, and reduce ethylene production. Hot water treatments significantly retard the decrease in fruit volume, firmness, ascorbic acid, acidity and juice content of horticultural commodities. The hot water dipping for various times also decrease total soluble solids, TSS-Acid ratio, pH, weight loss and disease incidence of horticultural commodities.

Key words: Hot water treatment, horticultural commodities, preservation, post harvest life, Storage duration, Market value.

INTRODUCTION

Nature has awarded Pakistan an ideal climate for the growth of a variety of different fruits and vegetables commonly known as horticultural commodities. Thus, a wide range of tropical, subtropical and temperate fruits and vegetables can be grown in the country. Over the years, Pakistani experts have developed exclusive strains of varieties of exotic fruits. Pakistan produces a wide variety of fruits on an area of 836.0 thousand hectares with a production in total of 6926.7 thousand tons. 163.132 thousand tons of fruit are exported of these (MINFA, 2007).

Physiological disorder (cold injury) is a problem caused by low temperature resulting in significant post-harvest losses in both quality and material. Symptoms of freezing injury in horticultural commodities include pitting, water-soaked areas, brown spots and increased sensitivity etc. The use of heat treatment in the post-harvest management is applied to many types of fruits to prevent fungal and insect control (Lurie, 1998). A significant advantage of heat treatment is the absence of chemical residues remains on the fruit. Heat treatments applied in trade are hot water (HW), steam or hot air respectively. The methods of heat treatment may affect the response of the goods as well as the duration of exposure to achieve a desired effect.

HW is a heat transfer medium, which is more effective than the hot air (Shellie and Mangan, 1994). Furthermore, immersion in HW effectively controls fungal pathogens, even after only a few minutes (Paull and Chen, 2004).

Heat treatment effects on the physiology of fruit after harvest are different, including the process of delayed maturation (Woolf *et al*., 1995), slower rate of flesh softening and pectin solubalization (Klein *et al*., 1990), reduced ethylene production (Paull and McDonald, 1994).

Hot water treatment procedure

Hot water treatments always performed dipping the fruits or vegetables into hot water having different temperatures and different dipping times depending upon the nature of the fruit or vegetables. Water temperature and dipping time is different for each horticultural commodity and is discussed in detail by previous researchers who's work are discussed below. Hot water treatment often done in a water bath tank fitted with heating elements and an electronic re-circulation pump. The water bath tank temperature is constantly maintained within ±0.5 ^{o}C of the performed temperature by an electronic thermostat and probe.

Results of previously published articles on preserved horticultural commodities using hot water treatment

Brief results of different researchers on the effects of hot water treatments and storage durations on different horticultural commodities are as follows:

Naweto *et al*. (2013) reported that mature fruits of Diospyros kaki L. cv. Costata immersed in hot water (45 ^{0}C for 5 min) or edible films coated with starch, carboxymethylcellulose (CMC), chitosan and filler including glycerol coatings and stored at 0 ± 2 ^{0}C and 90-95% relative humidity during 2012 and 2013 seasons. Results showed that, discarded fruits and the loss of weight reduced with coating (CMC). The decrease in firmness and storage durability greatly improved with the treatments used up to 20 days of cold storage. While, a small effect on the TSS and acidity was observed with the treatments used. High L-ascorbic acid content was obtained in (CMC) coated fruits. Significantly respiratory rate was reduced by coating treatments, while the hot water treatment has little effect on the respiratory frequency.

Amanullah *et al.* (2012) reported that mango fruit treated with hot water showed an appreciably lower incidence of anthracnose disease (1.68 vs. 2.42), whereas the highest sugars (18.32 vs. 14.56%) with more brown coloration of the mass (0.74 against 0, 48) and total carotenoids (67.0 vs. 56.1µg / g) higher compared to control treatment. Sensory evaluation showed a consistency of the batter pulp texture in the fruit without hot water treatment. It concluded that desapping of mango with a lime solution of 1.0%, followed by hot water treatment (48 ^{0}C, 60 minutes) did not significantly affect the quality during the 21 days of storage, in addition to sap burn injury and the condition of market access requirement. Considering the effects caused by heat exposure, other studies on hot water treatment effects on different levels of maturity and development of color in mango cv. Chaunsa after storage are needed, for export to China by boat or road transport in refrigerated containers.

Rab *et al.* (2011) reported that hot water treatment (5-10 minutes at 50 ^{0}C) delayed changes associated with storage in sweet orange, but prolonged heat treatment of 15-20 minutes, turning

the positive impact and improved the decline in physical and chemical quality characteristics. Ascorbic acid continued to decline even with a modest heat treatment.

Rageh (2010) reported that a study was carried out on Supper Red tomato cultivar (Lycopersicon esculentum Mill) to evaluate a range of hot water temperature as a dipping method at different times on storability of fruits during 2007/2008 and 2008/2009 seasons. Tomato fruit weight loss, decay percentages and pitting increased, whereas, firmness, chlorophyll content and acidity were decreased with the prolongation of storage period. T.S.S % increased till its peaks at the 9th days of storage then decreased tell the end of storage period. These results indicated that tomato fruit immersion in hot water at 48 ºC for 2 min., 48 ºC for or 4 min., 52 ºC for 1 min. or and 55 ºC for 30 sec. controlled decay without causing external heat injury. On the other hand, dipping fruits at either 52 ºC for 2 min. or 55 ºC for 1 min. increased tomato fruit susceptibility to post-harvest decay and heat injury characterized by well defined pitting and poor appearance. Dipping tomato fruits in hot water treatment lead to increase in the percentage of weight loss, maintained fruit firmness and delayed the losses in chlorophyll during storage in comparison with untreated fruits. These results showed that hot water treatment was effective in controlling postharvest decay organisms and in maintaining physical and chemical fruit quality and should be considered as non-chemical control for decay during storage of tomato fruits.

Niranjana *et al.* (2009) reported that hot water treatment after harvest is important to reduce injury and keep superior quality after harvest. Mango treated with HW at 55 ^{0}C for 5 min in a controlled environment at 8 ^{0}C for 45 days and shows no signs of morphological damage and matured under ambient conditions generally.

Mahmood *et al*. (2008) observed a significant decrease in the incidence of chilling injury and severity in "Satsuma" mandarins dipped in hot water at 50 ^{0}C for 2 min. Over 50 ^{0}C temperature increased skin damage of fruit. Chilling injury was due to a higher ethylene production and respiration rate in the affected fruit, and increased amount of ethanol and acetaldehyde in the juice headspace together. Thereafter the values decreased progressively with increasing chilling injury.

Maria *et al.* (2008) reported that the hot water treatment makes peeling of oranges simple and has no effect on respiratory activity or the physio-chemical and organoleptic properties.

Khan *et al.* (2007) stated that hot water treatments and storage periods have significant effects on various parameters of citrus. In total soluble solids (TSS) there was an initial increase for the 45 days storage period, but TSS is then reduced with storage of 60 days. Total sugars and organic acids were constantly increased with increasing storage time and become to a minimum value at 60 days of storage. The content of juice was increased with increasing storage period up to 45 days, but indicated to decrease after 60 days of storage in some treatments. In heat treated fruits weight loss was maximum while in cold treatments color development, total soluble solids and content of juice were highest. In control, organic acids and sugars were maximum that decreased with increasing heat treatment duration (15 minutes at 50 ^{0}C). With increasing the duration of cold treatment (72 hours at 5 ^{0}C) chilling injury was increased.

Seok-In *et al.* (2007) observed that the respiration rate initially just after harvest was significantly higher than in hot water treated fruits of "Satsuma" mandarin. The respiratory rate was roughly the same in all treatments during storage. Hot water treatment had no negative impact on the quality characteristics, including pH, acidity, soluble solids contents, weight loss, strength and color of peel. Development of mold decay, mildew and black rot that was obviously lower in treated fruit than in controls. Sensory evaluation of HW treatment showed significantly improved fruit appearance at 60 ^{0}C for 20 sec. The results confirm that immersion in hot water may be used as a treatment to sustain fruit quality during storage.

Lau *et al.* (2006) stated that studies conducted on post-harvest life of white and red fleshed dragon fruit at the Department of Agriculture, Agriculture Research Centre, Sarawak. Fruits used in the observation were at maturity and highest quality which is 8-9 days and 5-6 days after the color change for the types of fruit with white pulp and red pulp respectively. At room temperature, fresh fruit, stayed for a couple of days after which its corporal appearance significantly deteriorated in 6-7 days. Fruit, however, sustained fresh and free of disease for 6 days at 100 ^{0}C with 90% relative humidity, but began to deteriorate and blemished after the 15th day. Both fruit types treated with hot water to 55 ^{0}C for 15 minutes and bagged in a plastic bag sealed polyethylene without holes for their much better appearance with the disease pressure reduced to a minimum, up to 21 days of refrigerated storage compared to untreated under similar conditions of storage. The quality of the consumption of these fruits was sustained. In general, white-fleshed fruit has been found to be fresher than the red pulp when kept at 100 ^{0}C.

Obeed and Harhash (2006) reported that the fruits of Mexican lime immersed in hot water were effective in prolonging the lives more than two weeks, compared with other treatments. Weight loss was more as storage duration was increased. The immersion of the fruits in hot water at 55 ^{0}C had a significant effect in reduction of fruit weight loss at room temperature (20 ^{0}C). Lowest weight loss was observed in fruits soaked in warm water with 2% calcium chloride, where highest weight loss was observed in fruits immersed at ambient temperature in water. Fruits immersed at room temperature and at 55 ^{0}C in water after four weeks degreened, while the fruits immersed in hot water with sodium chloride (1%, 2%) and calcium chloride (1%, 2%) obtained yellow color after eight weeks. Fruit immersed in warm water with calcium chloride 1% or 2% have high juice content, TSS and technical index values compared with other treatments at ten weeks of storage. All treatments had no effect on the values of fruit acidity and vitamin C. Vitamin C was decreased substantially as storage duration increased.

Syyari (2006) examined the forecast for the physiological maturity and the role of hot water treatment, calcium chloride and potassium permanganate on the sustainability of Golden delicious apples in storage. His experiment identified that the fruit treated with hot water greatly decreased the decline in weight, acidity, ascorbic acid and frimnes of fruits stored for 2.5 and 5 months at 0 ^{0}C as compared to untreated.

Rodrigueza *et al*. (2005) reported that the treatment of *Opuntia ficus indica* fruit clones in hot water have been very beneficial to reduce fungal development, frost damage and improve visual quality, the 1287 clone has better properties and long-term storage life than the local variety, and 2 ^{0}C temperature is beneficial for maintaining of fruit quality.

Fallik (2004) explained the latest developments with hot water immersion and rinsing with hot water boiling (HWRB) technology. These treatments kill the pathogens that cause surface decay while maintaining fruit quality during prolonged storage.

Jacobi *et al*. (2001) reported that post harvest hot water treatment can become more vulnerable to reduce incidence of injury symptoms in the grapefruit fruits because of too low or too high temperature. In the case of grapefruit, a little time in (53-59 ^{0}C) hot water preventing coat injuries. In addition, hot water treatment of grapefruit before storage in a controlled atmosphere at 4.5 ^{0}C not only reduce significantly the peel damage, but also increase the total soluble and non-reducing sugar.

Francisco *et al.* (2000) reported that fresh pomegranate (*Punica granatum L*. cv Mollar Elche) were stored for 90 days. Warm water treatment of a day at 20 ^{0}C and at 2-5 ^{0}C for 6 days was observed. Control fruits were stored in a conventional manner with 2 or 5 ^{0}C and 95% RH, and a shelf life of 6 days at 15 ^{0}C and 75% RH for investigations. At the end of the storage period and shelf life, intermittent heat treatment of fruits showed highest anthocyanin concentration and acidity, and excellent ocular look. Beside the shelf life while intermittent heat treatment 2 ^{0}C storage, the only treatment that resulted in the fruit with a taste like to that as at harvest. Major losses were decay (*Penicillium spp*.) at 5 ^{0}C treatments with minimum losses in the treatment intermittent heat treatment 2 ^{0}C. Chilling injury (stings and burns envelope) has been greatly reduced through the curing of 2 ^{0}C, but only after a cold storage. Lowest cooling violations were observed in the intermittent heat treatment. The severity of the burnt shell directly development is not related to the low temperature storage. intermittent heat treatment 2 ^{0}C storage was found as the best treatment for reducing cold injury and keeping the fruit quality of pomegranate.

Porat *et al*. (2000) reported that just after harvest heat treatments, including hot-water dipping and hot water boiling are preferable because of effectively cold tolerance induction in Star Ruby grapefruit without affecting the other qualities of the commodity. Among these treatments, the hot water boiling was faster and can be used to clean and disinfect fruits and to improve tolerance to cold damage.

Laurie (1998) reported that postharvest hot water treatment can cause damage and may reduce the quality of fresh fruits. Many types of fruits tolerate from 50-60 ^{0}C for 10 minutes, but it takes 60 minutes or more when the temperature is below 50 ^{0}C for disinfection. Recommended heat treatment temperature for mango is in the range between 22 and 48 ^{0}C for up to 110 minutes, while 50 ^{0}C for 4 hours for papaya and Grapefruit 43.5 ^{0}C for 4.5 hours.

Schirra *et al.* (1997) stated that Tarocco Blood oranges (grows in Sardinia, Italy) from November-April collected monthly and immersed in hot water at 53 ^{0}C for 3 min prior to storage at 3 ^{0}C for 10 weeks. After storage, fruits were placed at 20 ^{0}C for 1 week. No damage observed in fruits collected in March. Hot water immersion decreased the decay of fruits collected in February and March, but was harmful to fruits collected in April. Fruit weight loss regularly increased with maturity and was promoted by treatment with hot water. Effect of hot water immersion on respiratory rate, endogenous ethylene, maturity index (calculated by ^{0}Brix / juice acidity ratio), the ethanol concentration in juice and electrolyte leakage was not significant from flavedo tissue. It was found that pre-storage hot water immersion can limit CI,

control decay in Tarocco oranges when harvested in mid-season (January-February), but can be harmful to the fruits harvested early or late in the season.

Park and Jung (1996) stated that the effect of hot water (30, 35 or 40 ^{0}C for 24 h before storage at 0 ^{0}C) and storage temperatures (0, 3, 5, or 10 ^{0}C) on the citrus fruits storage was observed. Fruits were stored for 20 weeks. Fruit firmness, acidity and aroma were decreased with increasing storage duration. Weight loss was increased as storage temperature increased. Fruit decay (caused by *Penicillium digitatum*, *Alternaria Citri*, *P. Italicum*, Colletotrichum glosesporioides (*Glomerella cingulata*) and *Geotrichum candidum*) increased with storage and was much higher in fruits stored at 10 ^{0}C. Preheated fruits lost taste and weight with storage, but showed less decay caused by *P. digitatum*, *P. italicum* and *G. candidum* as compared to unheated fruit. Between heated and unheated fruits no difference in the rate of respiration and ethylene production was observed.

Williams *et al.* (1994) noted that valencia orange fruit, taking hot water treatment (25 ^{0}C internal temperature of 42 min) to combat infection of the fruit against Queensland fruit fly (*Bacrtrocera tryoni*) lost significantly less moisture and maintained firmness during storage (0 ^{0}C and 84% relative humidity for 5 weeks and then at 21 ^{0}C for a week) as compared to unheated fruits. Rodent control treatment significantly reduced fruit acidity and the number of viable spores' colletorichum gloeosporidles (Glomerella cingulata), *Penicilium digitaum* and *p italicm*. Associated with the gradual deactivation of the heating process was manifested in maintaining fruit quality, both surface sterilization heat treatment of hot water inside the conversion (12 min at 53 ^{0}C), or air conditioning (24 hours at 30 ^{0}C and 90% relative humidity). Heat treatment of fruits improved color development. Light and Electron microscopy studies have shown that heating has little effect on the structure of the waxes; however collapsed sebaceous glands were observed after cold storage.

CONCLUSION

According to the experimental results, it can be concluded that hot water treatments significantly retard the decrease in fruit volume, firmness, ascorbic acid, acidity and juice content of horticultural commodities. The hot water dipping for various times also decrease total soluble solids, TSS-Acid ratio, pH, weight loss and disease incidence of horticultural commodities.

REFERENCES

Amanullah, M., A. Jabbar, M. Maqbool, M. Amin, M. Saeed, and R. Hameed. 2012. Anti-sap chemicals and hot water quarantine treatment effects on storage life and fruit quality of mango cv. Samar bahisht chaunsa. Pak. J. Bot., 44(2): 757

Fallik, E. 2004. Prestorage hot water treatments (immersion, rinsing and brushing). Postharvest Biol. and Technol., 32: 125–134

Francisco, A., A.J. Tudela, and R. Villaescusa. 2000. Thermal postharvest treatments for improving pomegranate quality and shelf life. Elsevier Sci. B.V., Pp. 245

Jacobi, K.K., A.M. Elspeth and E.H. Suzan. 2001. Loss of heat tolerance in 'Kensington' mango fruit following heat treatments. Postharvest Biol. and Technol., 21: 321–330

Khan, G.A., Abdur Rab, M. Sajid and Salimullah. 2007. Effect of Heat and Cold Treatments on Post Harvest Quality of Sweet Orange CV. Blood red. Sarhad J. Agric., 23: 39

Klein J.D., S. Lurie and R. Ben-Arie. 1990. Quality and cell wall components of "Ann" and "Granny Smith" apples treated with heat, calcium and ethylene. J. Am. Soc. Hort. Sci., 115: 954–958

Lau, C. Y., F. Othman and L. Eng. 2006. The effect of heat treatment, different packaging methods and storage temperatures on shelf life of dragon fruit (*hylocereus spp*.). Agriculture Research Centre Semongok, Kuching, Sarawak, Pp. 1

Laurie, S. 1998. Postharvest heat treatments of horticultural crops. Hort. Rev., 22: 91– 121

Laurie, S. 1998. Review: Postharvest heat treatments. Postharvest Biol. Technol., 14: 257–269

Mahmood, G., M. Ken, S. Rebecca, B. Mesbah and W. Allan. 2008. Effect of hot water treatments on chilling injury and heat damage in 'satsuma' mandarins: Antioxidant enzymes and vacuolar ATPase, and pyrophosphatase. Postharvest Biol. and Technol., 48: 364–371

Maria, C.A., A.P. JacominoII, A.L. PinheiroII, R.V. RibeiroIII, M.A. LochoskiII and R.C. Moreira IV. 2008. Hydrothermal treatment favors peeling of 'Pera' sweet orange fruit and does not alter quality. Scientia Agricola. Sci. Agric., (Piracicaba, Braz.), 65: 2

MINFA. 2007. Govt. of Pak. Ministry of Food, Agric. & Livest. Govt. of Pakistan, Islamabad, 41: Pp. 101

Naweto, M., M. Mostafa and A.E. Salem. 2013. Effect of Irradiation, Hot Water and Coating as Post-Harvest Treatments on Storage ability of Costata Persimmons. Arab J. of Nuclear Sci. and Applications, 46(5): Pp.257

Niranjana P., R.K.P. Gopalakrishna, R.D.V. Sudhakar and B. Madhusudhan. 2009. Effect of controlled atmosphere storage (CAS) on antioxidant enzymes and DPPH- radical scavenging activity of mango (*Mangifera indica L*.) cv. Alphonso. African J. of Food Agri. Nutr. and Dev., 9: 779–792

Obeed, R. S and M. M. Harhash. 2006. Impact of Postharvest Treatments on Storage Life and Quality of "Mexican" Lime. J. Adv. Agric. Res. (Fac. Agric. Saba Basha), 11(3): 135

Park, Y.S and S.T. Jung. 1996. Effects of storage temperature and preheating on the shelf life of yuzu during storage. J. Korean Soc. Hort Sci., 37(2): 285-291

Paull, R.E and C.C. Chen. 2004. Mango. In: Gross K.C., Wang C.Y. and Saltveit M. (eds), The commercial storage of fruits, vegetables and florist and nursery stocks. USDA Agriculture Handbook (http://www.ba.ars.usda.gov/hb66/ accessed 27 Nov 2011), Pp. 66

Paull, R.E and R.E. McDonald. 1994. Heat and cold treatments. In: Paull, R.E., Arms'Tron'g, J.W. (Eds.), Insect Pests and Fresh Hort. Prod. CAB Int., Wallingford, Oxon., 199–222

Porat, R., A. Daus, B. Weiss, L. Cohen, E. Fallik and S. Droby. 2000. Reduction of postharvest decay in organic citrus fruit by a short hot water brushing treatment. Postharvest Biol. and Technol., 18: 151–157

Rab, A., M. Sajid, Saeeda and Najia. 2011. Effects of Wet heat treatment (WHT) durations on the quality of Sweet orange stored at room temperature. Sarhad J. Agric., 27(2): 189

Rageh, M.A.A. 2010. Effect of hot water treatment on postharvest quality of tomato fruits. Annals of Agric. Sci., 48(4): 43

Rodrigueza, S., R.M. Casólibaa, A.G. Questaa, and P. Felkerb. 2005. Hot water treatments to reduce chilling injury and fungal development and improve visual quality of two *Opuntia ficus indica* fruit clones. J. of Arid Envi., 63: 366–378

Schirra, M., M. Agabbio, G.D'-hallewin, M. Pala, and R. Ruggiu. 1997. Response of Tarocco oranges to picking date, postharvest hot water dips, and chilling storage temperature. J. Agric. And Food Chem., 45(8): 3216-3220

Seok-In, H., L. Hyun-Hee and K. Dongman. 2007. Effects of hot water treatment on the storage stability of satsuma mandarin as a postharvest decay control. Postharvest Biol. and Technol., 43: 271–279

Shellie, K.C., and R.L. Mangan. 1994. Disinfestation: effect of non-chemical treatments on market quality of fruit. In: Champ, B.R. (Ed.), Postharvest Handling of Tropical Fruits. ACIAR Proceedings, 304–310

Syyari, M. 2006. Prediction of physiological maturity and role of heat, calcium chloride and potassium permanganate on storage life Golden delicious apple in cold storage. XXVII Int. Horti. Congress – IHC. Int. Symposium on The Role of Postharvest Technology in the Globalization of Horti. ISHS Acta Horti., Pp. 768

Williams, M.H., M.A. Brown, M. Vesk, and C. Brady. 1994. Effect of post-harvest heat treatments on fruit quality, surface structure, and fungal disease in Valencia oranges. Australian J. Exper. Agric., 34(8): 1183-1190

Woolf, A.B., C.B. Watkins, J.H. Bowen, M. Lay-Yee, J.H. Maindonald, and I.B. Ferguson. 1995. Reducing external chilling injury in stored 'Hass' avocados with dry heat treat. J. Am. Soc. Hortic. Sci., 120: 1050–1056