Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2021 18(2):1590-1595. **OPEN ACCESS**

Influence of Thermal Treatment to Chilling Injury of Longkong (*Lansium* sp.) Fruit

Nguyen Phuoc Minh

Binh Duong University, Vietnam

***Correspondence:** npminh@bdu.edu.vn **Received 18-02-2021, Revised: 11-05-2021, Accepted: 20-05-2021 e-Published: 21-05-2021**

Longkong (*Lansium*sp.) fruit is highly susceptible to rotten and chilling injury at low temperature and high humidity due to oxidative shock. Thermal treatment has been demonstrated to improve chilling injury resistance. This research evaluated the thermal treatment of the mature longkong fruit at 44 ^{o}C for 3 minutes in incubator and consequently subjected to 21 days of preservation at 4 ^{o}C to physical parameters (weight loss, firmness), chilling injury index and physiological indicators (electrolyte leakage, malondialdehyde), antioxidant enzyme activities (superoxide dismutase, catalase, ascorbate peroxidase). Results showed that thermal incubation of longkong fruit effectively retarded weight loss; maintained firmness; limited chilling injury score; low electrolyte leakage, malondialdehyde content; low amount of superoxide dismutase, catalase, ascorbate peroxidase emission. Thermal treatment had been recommended to be an effective approach in shelf-life extension of longkong fruit.

Keywords: Antioxidant enzyme, chilling injury, longkong, physical, physiological, thermal incubation

INTRODUCTION

Metabolic dysfunctions induced at cool temperature impair ripening, deficiency of flavor and aroma, pitting, pericarp browning, tissue damage, membrane leakiness, accumulation of dry texture, susceptable to mechanical damage, and microbial infections (Sandra and Elizabeth, 2014). Serious pericarp black spot, fruit separation, weight loss, off-flavor and chilling injury are major symptoms in post-harvest of longkong fruit especially in distribution and preservation when it's stored between 10 and 15 ◦C (Karthikeyan, 2016). It could be due to the effect of oxidoreductase enzymes (Venkatachalam and Meenune, 2012). Inappropriate temperature (too cool and hot) and high humidity are the main matters inducing the most quality degradation in longkong fruit, subsequently to severe damage (Karthikeyan et al. 2015; Venkatachalam and Meenune, 2012).

Longkong (*Lansium* sp.) fruit is one of the most important crop in Vietnam and other countries. It belongs to the Meliaceae family (Chiruvella et al. 2014). It is highly valued by its unique nutritional and organoleptic attributes (Paull et al. 1987; Karthikeyan et al. 2015). Antioxidant, anti-ageing, pharmacological and antimicrobial characteristics are major therapeutic benefits from consuming this valuable fruit (Manosroi et al., 2012). Longkong fruit contains numerous bioactive constituents such as polyphenolics, flavonoids and vitamins (Lim et al., 2007; Tilaar et al. 2008). Keeping longkong fruit at 18◦C and 85 to 90% relative humidty could retard the black spot, prolonging its stability (Lichanporn et al. 2008; Venkatachalam and Meenune, 2012). Meenune et al. (2013) noticed that longkong fruit treated with 20 µmol/L methyl jasmonate effectively limited chilling injury on pericarp. Venkatachalam and Meenune (2015) realized that longkong fruit fumigated with methyl jasmonate(30 µmol/L) and preserved at 13 ◦C slow down

chilling-induced pericarp ion leakage and fruit firmness loss.

Thermal treatment has been considered as one of the most the innovative postharvest solutions to manage chilling injury. Thermal treatment has been proven to effectively control fungal diseases and pest infestation (Sandra and Elizabeth, 2014). Hot water treatent showed limited vulnerability in cells and organelles of the pericarp tissue during chilling preservation (Yang et al. 2009). Less electrolyte leakage, respiration rate, and chilling injury appearance were noticeable remarks after applying hot water treatment (Luengwilai et al. 2012; Cruz-Mendivil et al. 2015). This thermal approach was also demonstrated to enhance antioxidant enzyme activities. Hot water treatment at 42°C for 5 min minimized the chilling injury in tomato during 15 days of chilling storage at 5 ^{o}C (Cardenas-Torres et al. 2020). Objective of our study examined the thermal treatment of the mature longkong fruit at 44 ^{o}C for 3 minutes in incubator and consequently subjected to 21 days of preservation at 4 ^{o}C to physical parameters (weight loss, firmness), chilling injury index and physiological indicators (electrolyte leakage, malondialdehyde), antioxidant enzyme activities (superoxide dismutase, catalase, ascorbate peroxidase).

MATERIALS AND METHODS

2.1 Material

Longkong fruits were harvested in KeSach district, SocTrang province, Vietnam. They were sorted by shape uniformity without any damage. They should be moved to laboratory quickly and ready for experiements. Chemical reagents were all analytical grade.

2.2 Researching method

Longkong fruits were separated into two groups: (1) store at 4 ^{o}C for 21 days in 85% relative humidity as control; (2) keep at 44 ^{o}C for 3 minutes by forced air in incubator and consequently subjected to 21 days of preservation at 4 ^{o}C in 85% relative humidity. In 7 day-interval, fruits were taken to measurephysical parameters (weight loss, firmness), chilling injury index and physiological indicators (electrolyte leakage, malondialdehyde), antioxidant enzyme activities (superoxide dismutase, catalase, ascorbate peroxidase). Weight loss (%) was estimated via comparision of initial weight and interval weight during storage. Firmness (N) was measured by penetrometer. Chilling injury index was evaluated according to procedure proposed by Vega-García et al. (2010). Electrolyte leakage (%) was measured according to procedure proposed by Zhao et al. (2009). Malondialdehyde content (µmol/kg) was evaluated according to procedure proposed by Hodges et al. (1999). Superoxide dismutase (U 10^{6}/kg) was measured by method described by Wu et al. (2008). Catalase (mol/kg.s) was evaluated by method proposed by Aebi (1984). Ascorbate peroxidase (mol/kg.s) was quantified by procedure illustrated by Nakano and Asada (1987).

2.3 Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS AND DISCUSSION

3.1 Effectiveness of thermal incubation to physical quality of longkong fruit during storage

Longkong is a non-climacteric fruit. At maturity it has a minor increasing in respiration rate, meanwhile at full maturity, the respiration rate goes down gradually (Siriphanich, 2002; Lichanporn et al. 2008). Weight loss (%) and firmness (N) of the control and treated longkong fruits were clearly presented in table 1. It's obviously noticed that thermal treatment significantly reduced weight loss while firmness was greatly conserved. Weight loss was strongly correlated to moisture removal by dehydration (Henriquez et al. 2005; Akbudak et al. 2007). High temperature and low relative humidity significantly induced respiration rate leading to much more weight loss. Chilling injury was reported to be related to physiological disorder stimulating the high respiration rate (Luengwilai et al. 2012). Firmness degradation derived from depolymerisation andsolubilisationcaused by enzymes such as cellulase, polygalacturonase, and xylanase (Prasanna et al. 2007; Romero and Rose, 2019). Our findings were similar to others in different reports (Lurie and Sabehat 1997; Henriquez et al. 2005). Decaying organisms involed inloss of firmness in longkong fruit (TechavuthipornandKaewsuksaeng, 2010). Wang et al. (2012)proved that banana immersed in hot water at 52°C for 3 min and preserved in cold storage (7°C) for 6 h exhibited significantly better quality than the control bananas.Luengwilaiet al.

(2012) applied hot water at 40°C for 7 min to control chilling injury in tomato. Bassal et al. (2011) noticed that oranges immersed in hot water at 41°C for 20 min reduced chilling injury by up to 16%, decreased weight loss. 'Gros Michel' fruit treated by hot water at 50°C for 10 min preserved higher pulp firmness compared to control fruit (Ummarat et al. 2011). Cectarines treated with hot water immersion at 48° C for 12 min followed by storage at 0°C for 2 weeks had better firmness (Jemric et al. 2013). Hot air treatment at 38°C for 4 days combined with a chitosan coatinghas been used to delay softening of apple (Shao et al. 2012).

3.2 Effectiveness of thermal incubation to chilling injury index and physiological indicators of longkong fruit during storage

Chilling injury index and physiological indicatior (electrolyte leakage, malondialdehyde) of the control and treated longkong fruits were reported in table 2. It's obviously noticed that thermal treatment significantly reduced chilling injury index, electrolyte leakage and malondialdehyde. Tomato subjected to hot water treatment and further cool storage had low chilling injury index, membrane damage (electrolyte leakage) and lipid peroxidation (malondialdehyde content) (Cardenas-Torres et al. 2020). Our findings were similar to others in different reports (Yang et al. 2009; Luengwilai et al. 2012; Cruz-Mendivil et al. 2015; Zhang and Tian, 2010). Longkongpericarp was rich in polyphenols involving in enzymatic browning (Venkatachalamand Meenune, 2015). Techavuthiporn et al. (2010) proved that longkong fruit preserved at 4 ◦C had chilling injury-induced pericarp discoloration. Venkatachalam and Meenune (2012) presented that longkong fruit stored at 13 ◦C and 85% RH for 16 days resulted serious chilling-induced pericarp darkness. Hot water treatment (47 ◦C for 3 min) combined with prochloraz (750 ppm for 3 min) could effectively control decay in longkong fruit during postharvest (Sangchote et al. 2012). Ma et al. (2014) implemented hot water for 10 min at 35 and 45°C treatments enhanced fruit quality, limiting malondialdehyde content, lipoxygenase activity. Peel spotting on banana was inhibited by hot air at 42°C for 6-24 h (Kamdee et al. 2009).

3.3 Effectiveness of thermal incubation to antioxidant enzyme activities of longkong fruit during storage

Antioxidant enzyme activities **(**superoxide dismutase, catalase, ascorbate peroxidase**)** of the control and treated longkong fruits were presented in table 3. It's obviously noticed that thermal treatment significantly increased superoxide dismutase, catalase, ascorbate peroxidase activities. Zhang et al. (2013) proved that superoxide dismutase activity was increased in tomato during cool storage. Hot water treatment increased superoxide dismutase, catalase, ascorbate peroxidase activities during the cool storage at 5°C (Cardenas-Torres et al. 2020). Our findings were similar to others in different reports (Ding et al. 2015; Zhao et al. 2009; Zhang et al. 2013).

Table 1: Weight loss (%) and firmness (N) of treated longkong fruit during 21 days of storage at 4 ^{o}C

Storage (days)	Treatment	7	14	21
Weight loss (%)	Control	1.13±0.01^{b}	3.45±0.02^{ab}	6.71±0.00^{a}
	Incubated	0.24±0.03^{b}	0.89±0.01^{ab}	1.26±0.02^{a}
Firmness (N)	Control	2.59±0.00^{a}	2.02±0.03^{ab}	1.48±0.01^{b}
	Incubated	2.96±0.02^{a}	2.75±0.00^{ab}	2.51±0.03^{b}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2 :Chilling injury index, electrolyte leakage (%), malondialdehyde content (µmol/kg) of treated longkong fruit during 21 days of storage at 4^{o}C

Storage (days)	Treatment	7	14	21
Chilling injury index	Control	0.34±0.03^{b}	0.67±0.00^{ab}	0.83±0.01^{a}
	Incubated	0.12±0.00^{b}	0.15±0.01^{ab}	0.17±0.02^{a}
Electrolyte leakage (%)	Control	17.39±0.04^{b}	25.51±0.03^{ab}	37.40±0.05^{a}
	Incubated	11.05±0.03^{b}	12.66±0.02^{ab}	13.71±0.01^{a}
Malondialdehyde (µmol/kg)	Control	14.23±0.04^{b}	19.78±0.01^{ab}	27.54±0.00^{a}
	Incubated	8.64±0.02^{b}	9.15±0.03^{ab}	9.67±0.01^{a}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted

above), the difference between them was not significant (α = 5%).

Table 3: Chilling injury index, electrolyte leakage (%), malondialdehyde content (µmol/kg) of treated longkong fruit during 21 days of storage at 4 °C

Storage (days)	Treatment	7	14	21
Superoxide dismutase (U 10^6/kg)	Control	76.26±0.05^a	51.12±0.04^{ab}	40.34±0.00^b
	Incubated	109.59±0.03^a	101.97±0.02^{ab}	97.82±0.01^b
Catalase (mol/kg.s)	Control	0.47±0.01^a	0.26±0.00^{ab}	0.11±0.02^b
	Incubated	0.72±0.00^a	0.69±0.01^{ab}	0.60±0.00^b
Ascorbate peroxidase (mol/kg.s)	Control	1.16±0.03^a	0.64±0.03^{ab}	0.34±0.02^b
	Incubated	1.93±0.01^a	1.87±0.02^{ab}	1.75±0.03^b

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Superoxide dismutase, glutathione peroxidase and catalase activities accelerated in longkong fruit maturation (Karthikeyan, 2016). Peaches treated with hot air at 38°C for 12 h with 1 mol/L methyl jasmonate prior to storage at 0° C for 3-5 weeks induced superoxide dismutase (Jin et al. 2009). Bassal et al. (2011) noticed that oranges immersed in hot water at 41°C for 20 min increased more catalase activity.

CONCLUSION

Longkong fruit has excellent taste and pleasant aroma. Susceptible pericarp discoloration, degradation of freshness and firmness in handling and distribution in market are the popular obstacles for longkong fruit. Chilling injury directly affects flavor and nutritional composition leading to the degradation of commercial value of longkong fruit. Thermal treatment effectively controls chilling injury of longkong fruit by incubating at 44 °C for 3 minutes in incubator and consequently subjected to 21 days of storage at 4 °C. Thermal incubation may minimize chilling injury and rotten, without impairing physico-chemical attributes.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

We acknowledged the financial support for the publication provided by Binh Duong University, Vietnam.

AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript

REFERENCES

Aebi H. Catalase in vitro.*Methods of Enzymology* 1984; 105: 121-126.

Akbudak B, Akbudak N, Seniz V, Eris A. Sequential treatments of hot water and modified atmosphere packaging in cherry tomatoes. *Journal of Food Quality* 2007; 30: 896-910.

Bassal M and El-Hamahmy M. Hot water dip and preconditioning treatments to reduce chilling injury and maintain postharvest quality of Navel and Valencia oranges during cold quarantine. *Postharvest Biology and Technology* 2011; 60: 186-191.

Cardenas-Torres FI, Cruz-Mendivil A, Lopez-Valenzuela JA, Ayon-Reyna LE, Lopez-Lopez ME, Tamayo-Limon R, Martinez-Tellez MA, Vega-Garcia MO. Tolerance to chilling injury induced by hot water treatment increases activities of antioxidant enzymes in tomato fruits. *International Food Research Journal* 2020; 27: 1111 – 1120.

Chiruvella KK, Mohammad M, Thammineni C, Paritala V, Ghanta GP. In vitro propagation, phytochemical investigations and biological activities of an endemic medicinal plant, Indian red wood (Meliaceae): A Review. *Int. J. Med. Plant.* 2014; 107: 558−571.

Cruz-Mendivil A, Lopez-Valenzuela JA, Calderon-Vazquez CL, Vega-Garcia, MO, Reyes-Moreno C, Valdez-Ortiz A. Transcriptional

changes associated with chilling tolerance and susceptibility in 'Micro-Tom' tomato fruit using RNA-Seq. *Postharvest Biology and Technology* 2015; 99: 141-151.

Ding Y, Sheng J, Li S, Nie Y, Zhao J, Zhu Z, Tang X. The role of gibberellins in the mitigation of chilling injury in cherry tomato (*Solanumlycopersicum* L.) fruit.*Postharvest Biology and Technology* 2015; 101: 88-95.

Henriquez C, Gonzalez R, Krarup C. Heat treatments and progression of chilling damage and pigmentation of tomatoes in postharvest. *Ciencia e InvestigaciónAgraria* 2005; 32: 113-123.

Hodges D, DeLong J, Forney C, Prange R. Improving the thiobarbituric acid-reactive-substances assay for estimating lipid peroxidation in plant tissues containing anthocyanin and other interfering compounds. *Planta* 1999; 207: 604-611.

Jemric T and Fruk G. Postharvest quality of nectarine cv. 'Venus' as affected by hot water dips and length of storage. *Agroknowledge Journal* 2013; 14: 19-28.

Jin P, Zheng Y, Tang S, Rui H, Wang CY. A combination of hot air and methyl jasmonate vapor treatment alleviates chilling injury of peach fruit. *Postharvest Biology and Technology* 2009; 52: 24-29.

Kamdee C, Ketsa S, van Doorn WG. Effect of heat treatment on ripening and early peel spotting in cv. Sucrier banana.*Postharvest Biology and Technology* 2009; 52: 288-293.

Karthikeyan V. Postharvest physiology and handling of longkong fruit: A review. *Fruits* 2016; 71: 289-298.

Lichanporn I, Srilaong V, Wongs-Aree C, Kanlayanarat S. Effect of storage temperature on peel colour and physiological changes of lonkong fruit (*Aglaiadookkoo*Griff.).*ActaHortic.* 2008; 804: 599−604.

Lim YY, Lim TT, Tee JJ. Antioxidant properties of several tropical fruits: A comparative study. *Food Chem.* 2007; 103: 1003−1008.

Luengwilai K, Beckles DM, Saltveit ME. Chilling-injury of harvested tomato (*Solanumlycopersicum* L.) cv. Micro-Tom fruit is reduced by temperature pre-treatments. *Postharvest Biology and Technology* 2012; 63: 123-128.

Lurie S and Sabehat A. Prestorage temperature manipulations to reduce chilling injury in tomatoes.*Postharvest Biology and Technology* 1997; 11: 57-62.

Ma Q, Suo J, Huber DJ, Dong X, Han Y, Zhang Z, Rao J. Effect of hot water treatments on chilling injury and expression of a new C-repeat binding factor (CBF) in 'Hongyang' kiwifruit during low temperature storage. *Postharvest Biology and Technology* 2014: 97: 102-110.

Meenune M, Thongpanja H, Kongsuwan S. Influence of methyl jasmonate on quality changes in longkong fruit during storage under low temperature. *Agric. Sci. J.* 2013; 44: 257−260.

Nakano A and Asada K. Purification of ascorbate peroxidase in spinach chloroplasts; its inactivation in ascorbate-depleted medium and reactivation by monodehydroascorbate radical.*Plant and Cell Physiology* 1987; 28: 131-140.

Paull RE, Goo T, Chen NJ.Growth and compositional changes during development of lanzone fruit.*HortSci.* 1987; 22: 1252−1253.

Prasanna V, Prabha TN, Tharanathan RN.Fruit ripening phenomena - an overview.*Critical Reviews in Food Science and Nutrition* 2007; 47: 1-19.

Romero P and Rose JKC. A relationship between tomato fruit softening, cuticle properties and water availability.*Food Chemistry* 2019; 295: 300-310.

Sandra E and Elizabeth JM.Progress in heat treatments.*Stewart Postharvest Review* 2014; 3: 2.

Sangchote S, Khewkhom N, Sungsiri T. Fruit rot control in longkong (*Aglaiadookkoo*Griff.) with chemical and hot water treatment. *ActaHortic.* 2012; 943: 219−222.

Shao XF, Tu K, Tu S, Tu J. A combination of heat treatment and chitosan coating delays ripening and reduces decay in "Gala" apple fruit. *Journal of Food Quality* 2012: 35: 83-92.

Siriphanich J. Postharvest physiology of tropical fruit.*ActaHortic.* 2002; 575: 623−633.

Techavuthiporn C and Kaewsuksaeng S. Quality changes of different form of minimally processed longkong at low temperature storage.*ActaHortic.* 2010; 877: 635−640.

Tilaar M, Wih LW, Ranti SA, Wasitaatmadja SM, Suryaningsih, Junardy DF, Maily. Review of LansiumDomesticum Correa and its use in cosmetics. *BoletínLatinoamericano y del Caribe de PlantasMedicinales y Aromáticas*2008; 7: 183−189.

Vega-Garcia MO, Lopez-Espinoza G, Chavez-

Ontiveros J, Caro-Corrales JJ, Vargas FD, Lopez-Valenzuela JA. Changes in protein expression associated with chilling injury in tomato fruit. *Journal of the American Society for Horticultural Science* 2010; 135: 83-89.

Venkatachalam K and Meenune M. Effect of methyl jasmonate on alleviation of chilling injury in longkong fruit during storage. *Agric. Sci. J.* 2012; 43: 423−426.

Venkatachalam K and Meenune M. Effect of packaging on postharvest quality changes of longkong.*Walailak J. Sci. Technol.* 2015; 12: 229−236.

Wang H, Zhang Z, Xu L, Huang X, Pang X. The effect of delay between heat treatment and cold storage on alleviation of chilling injury in banana fruit.*Journal of the Science of Food and Agriculture* 2012: 92: 2624-2629.

Wu T, Cao J, Zhang Y. Comparison of antioxidant activities and endogenous hormone levels between bush and vine-type tropical pumpkin (*Cucurbitamoschata* Duchesne). *ScientiaHorticulturae* 2008; 116: 27-33.

Yang J, Fu MR, Zhao YY, Mao LC. Reduction of chilling injury and ultrastructural damage in cherry tomato fruits after hot water treatment. *Agricultural Sciences in China* 2009; 8: 304-310.

Zhang C and Tian S. Peach fruit acquired tolerance to low temperature stress by accumulation of linolenic acid and N-acylphosphatidylethanolamine in plasma membrane. *Food Chemistry* 2010; 120: 864-872.

Zhang X, Shen L, Li F, Meng D, Sheng J. Arginase induction by heat treatment contributes to amelioration of chilling injury and activation of antioxidant enzymes in tomato fruit. *Postharvest Biology and Technology* 2013; 79: 1-8.

Zhao DY, Shen L, Fan B, Liu KL, Yu MM, Zheng Y, Sheng JP. Physiological and genetic properties of tomato fruits from 2 cultivars differing in chilling tolerance at cold storage.*Journal of Food Science* 2009; 74: 348-352.