Food Research 7 (3) : 214 - 220 (June 2023)
Journal homepage: https://www.myfoodresearch.com

Effects of surface coating material made from Taengwood Balau resin and storage temperatures on effective skin permeances to water vapor and respiration rates of fresh cherry tomato

[1]Kampawong, H., [2]Phungam, N., [3]Pruthtikul, R.,[4]Utto, G. and [1,5,6,*]Utto, W.

[1]*Department of Agro-Industry, Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani, Thailand*
[2]*Department of Agro-Industry, Faculty of Agriculture and Technology, Rajamangala University of Technology Isan Surin, Campus, Thailand*
[3]*National Metal and Materials Technology (MTEC), National Science and Technology Development Agency (NSTDA), Thailand*
[4]*International Business Management, Faculty of Management Science, Ubon Ratchathani University, Ubon Ratchathani, Thailand*
[5]*Postharvest Technology Innovation Center, Commission on Higher Education, Bangkok, 10400, Thailand*
[6]*Indigenous Food Research and Industrial Development Center, Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani, Thailand*

Article history:
Received: 26 April 2022
Received in revised form: 15 June 2022
Accepted: 1 September 2022
Available Online: 23 June 2023

Keywords:
Coating material,
Taengwood Balu (*Shorea obtusa*),
Postharvest weight loss,
Water vapor permeance,
Tomato

DOI:
https://doi.org/10.26656/fr.2017.7(3).221

Abstract

Cherry tomatoes are vulnerable to loss their marketability under high storage temperature causing rapid fresh weight losses and other quality changes. Surface coating using shellac, wax and alike is one of the postharvest management practically implemented to mitigate such undesirables. The present research was undertaken to study the effects of the coating material made from Taengwood Balu (*Shorea obtusa*) resin (TB resin) on respiration rates and effective skin permeance to water vapor of the cherry tomatoes stored at 10-35°C. Experiment findings show that the TB resin could be transformed into the coating material providing reasonable surface adherences as well as glossiness. Both respiration rates and the skin permeances of either TB resin coated or non-coated (control) tomatoes exponentially increased in relation to increasing temperatures. The relationship was well described by the Arrhenius model, of which values of root mean square of errors were in a range of 0.012-0.030. The TB resin coated tomatoes had approximately 2-fold lower values of both respiration rates and effective skin permeance, compared to those of the controls. In all, the experimental results highlight possibilities to utilize TB resin as an alternative surface coating material, together with low storage temperature for delaying losses of water vapor, a main contributor of fresh weight loss, and those of storage qualities related to respiration processes.

1. Introduction

Cherry tomatoes (*Solanum lycopersicum* var. cerasiforme) reportedly have high nutritional and economic benefit values. Fresh weight loss is considered a key undesirable effect subsequently causing decreased marketability, especially attributed to wrinkled and shriveled appearances (Phungam *et al*., 2018; Lufu *et al*., 2020). Water vapor loss principally is a prime factor accounting for fresh weight loss. The deficit between water vapor pressure of internal fruit tissues and that of the surrounding environment is the main driving force causing water vapor diffusion out from the fruit to the environment. The water vapor loss process can be stimulated by the high storage temperature (Kabir *et al*., 2020). In addition, respiration rates and quality changes of tomatoes, as well as other horticultural commodities, becomes hastened under the high temperature (Loayza *et al*., 2020) which is a typical ambient condition (30-35°C) found among fruit and vegetable supply chains practiced in Thailand and other Association of South East Asian (ASEAN) countries (Chaomuang *et al*., 2022). The respiration process could become a main contributor to the water vapor loss under which the horticultural commodities are kept in relatively high humidity level i.e., 90% (Khalid *et al*., 2022). In practice, surface

---

*Corresponding author.
Email: *weerawate.u@ubu.ac.th*

eISSN: 2550-2166 /
Published by Rynnye Lyan Resources

coating, as well as a so-called cool chain, have been implemented to delay changes in quality attributes in relation to the water vapor loss, and respiration processes (Ali *et al*., 2022). The surface coating materials including shellac, bee wax and carnauba wax among others functionally modify the product's surface to provide additional barrier layers limiting rates of the mass transport processes of water vapor and gases between fruits and the environment (Phungam *et al*., 2018). Furthermore, the coating materials could replace and/or fill cracks of natural waxes on the fruit surface (Riva *et al*., 2020). The modifications of gas exchange properties by surface coatings as noted technically delay weight losses and other postharvest quality changes of various fruits and vegetables, including examples recently reported on cucumbers (Gutiérrez-Pacheco *et al*., 2020), papaya (Maringgal *et al*., 2020) and strawberry (Mohammadi *et al*., 2021). Examples of surface coating materials applied for cherry tomatoes reported are candelilla wax (Ruiz-Martínez *et al*., 2020), shea butter and bee wax (Osae *et al*., 2022).

The Taengwood balau resin (or TB resin for later references) excreted from *Shorea obtusa* tree which is native to Thailand, Malaysia and other ASEAN countries (Awaludin *et al*., 2007) has its general properties similar to those of the shellac coating material including reasonable strength, durability, good surface adhesion, and glossy surface appearance (Yan *et al.*, 2021). Because of its water-proof and adhesive properties, the TB resin has been utilized as material for sealing and/or caulking wooden packages or boats. The resin medically has antibiotic properties applied for wounds and dysentery treatments (Appanah and Turnbull, 1998). Given such physico- and medical properties, TB resin could be applied as an alternative and novel coating material of which the resin is locally available and potentially provides benefits in shelf-life extensions. At present there is no report on the coating material made from the TB resin and its utilizations for either cherry tomatoes or other fresh produce.

In this study, the surface coating material made from the TB resin was of interest. The present research purposely was undertaken to investigate the effects of the TB resin coating material on certain gas exchange properties such as the effective skin permeance to water vapor and respiration rates of the cherry tomatoes kept at simulated supply chain temperatures. Specific to the permeance, it is an indicator of eases for water vapor to permeate through a medium such as a plant tissue and a membrane. The higher value indicates that the water vapor in the plant could easily permeate out to the surroundings causing a high likelihood of losses of water vapor and, in turn, weight loss. It is important to note that the present study is to provide essential information on the possibilities of applying the TB resin as the surface coating material. This later was taken into account in the uses and manufactures of the resin in the forms of coating material or others including composites in multi-layer plastic films.

2. Materials and methods

2.1 Materials

Taengwood hard-resin powder 'Red Anchor' brand (Thailand) was utilized. Fresh cherry tomatoes (*Solanum Lycopersicum* var. cerasiforme) (ripe stage) were harvested from organic gardens in Warin chamrap, Ubon Ratchathani, Thailand. The fruits were transported to the Postharvest Technology Laboratory, Faculty of Agriculture, Ubon Ratchathani University, Thailand, within 30 mins by packing in a thermal insulated foam box, under an ambient condition (30-32°C). Defected tomatoes such as having cut, bruised or pitted surfaces were sorted out. The tomatoes later were disinfected by immersing them in 150 mg L^{-1} sodium hypochlorite solution for 30 s, and thereafter were left to dry on clean paper towels. The fruits were separated into three groups in accordance with experimental temperatures including 10, 25 and 35°C. They were acclimatized at individual temperatures for 18 hrs prior to being used for subsequent tests. The acclimatization technically was to prevent thermal shocks for the produce because of rapid changes in storage temperatures. The shocks could cause stress and other related symptoms for example superficial scald as cases reported for apples (Marc *et al.,* 2020). Although rates of biochemical activities during the acclimatization of the fruit kept under high temperatures are expected to be higher than those kept at lower ones, measurements made on physico-chemical properties of the fruits readily acclimatized to the storage temperatures could minimize uncertainties caused by the thermal-shock issues.

2.2 TB resin coating material preparation and surface applications

To prepare the TB surface coating material, the methods reported by Khorram and Ramezanian (2021) with modifications were utilized. In the present work, ethanol was employed as the solvent because the resin of *Shorea robusta* tree which is in the same genus as *Shorea obtusa* (a source of TB resin) has reasonable alcohol solubility (56.02% w/w) (Merish *et al.,* 2014). At present, information on ethanol dissolution as well as the melting point of the TB resin has not been reported. The knowledge of *Shorea robusta* resin was applied to this work accordingly. To dissolve the TB powder, it was mixed with 95% v/v ethanol solvent with a 1 to 2 ratio

https://doi.org/10.26656/fr.2017.7(3).221

(w/v). The glass beaker containing the TB solution later was placed in the water bath and controlled its temperature at 65-70°C for 3 hrs. Although the melting point of the *Shorea robusta* resin reported is in a range of 85-115°C (Merish *et al.,* 2014), the water bath temperature was set to be slightly lower than the melting point for minimizing rapid evaporation of ethanol vapor from the TB solution. During the water bath procedure, the TB solution contained in the beaker was manually stirred for 5 mins using a glass rod, for every 30 min-cycle. The solution subsequently was filtered using No. 4 Whatman filter paper to separate out undissolved which was a relatively small extent of impurities visually observed as black stains. The solution filtered was kept in amber reagent bottles at room temperature (30°C).

Prior to being coated, tomatoes designated for the coating treatment were taken out from their storage temperature cabinets and placed on the stainless steel tables kept under room temperature condition. The table tops were cleaned with ethyl alcohol 70% (v/v). To coat, individual fruits were coated via being dipped into the TB solution, allowing the resin to cover the fruit surface thoroughly. The fruits were taken out from the solution using the forceps and were left to dry on the wire mesh placed on the stainless steel tables, for 1 h. Once dried, the coated tomatoes were weighed immediately and returned to their test temperatures for subsequent measurements. It should be noted that the 1-hr time period in which all coated fruits were left in the room temperature condition was considered relatively shorter than the period during which they were acclimatized in the experimental temperatures. As preliminary experimental results, leaving coated tomatoes at room temperature for such a period did not cause significant changes particularly weight loss and visual wilting. It was therefore reasonable to assume that the coating procedure did not have significant effects on the storage qualities of the tomatoes. The average weight of the TB layer attached to each fruit was 0.362±0.013 g. This was calculated from the weight of individual tomatoes weighed before and after coated. This study however did not measure the thickness of the TB layer coated on the fruit. Unlike smooth surface packaging materials, the thickness of the coating layer on the horticultural product surface is likely to be highly varied because of natural surface structures such as rough or small holes. Effective permeance to water vapor measured has not taken the thickness into calculation accordingly as shown in its unit as mol s^{-1} m^{-2} Pa^{-1} (Maguire *et al.,* 2001).

2.3 Measurements on respiration rates and effective skin permeance to water vapor

To measure the respiration rates of cherry tomatoes (symbolically denoted as $r_{chr}^{CO_2}$), protocols for measuring CO$_2$ concentration evolved in a closed system as reported by Phungam *et al.* (2018) with some modifications implemented. At individual temperatures, respiration rates of 4 sets of ten tomatoes having reasonably comparable size, and shape were measured. Each set was placed in the solid screw-cap plastic box (~3 L volume), together with a CO$_2$ meter (HTI, HT-2000, Protronics Intertrade Co., Ltd., Thailand). An approximate headspace volume (excluding the CO$_2$ meter and the fruits) of which the CO$_2$ was released into- and accumulated was 2.43±0.002 L. Changes in CO$_2$ concentrations evolved i.e. at least 10-fold higher than an initial concentration level inside the box tightly closed during a certain time period (Table 1) were recorded. These were utilized with other parameters including fruit volume and mass (Table 1) as well as temperature to calculate the respiration rates (mol s^{-1}kg^{-1}) with the basis of an ideal gas law. Measurements of $r_{chr}^{CO_2}$ values were conducted for both TB-coated and non-coated (controls) tomatoes at any given temperature. The effective skin permeance to water vapor (symbolically denoted as $P_{chr}^{H_2O}$) also was measured for both tomato groups following Phungam *et al.* (2018) with some modifications. Equation 1 which is based on the Fick's first law of steady-state diffusion shows calculations of the $P_{chr}^{H_2O}$ values (Maguire *et al.,* 2001).

$$P_{chr}^{H_2O} = \frac{r_{chr}^{H_2O}}{\left(p_{chr,\text{int}}^{H_2O} - p_{env}^{H_2O}\right)A_{chr}} \tag{1}$$

where $P_{chr}^{H_2O}$ effective skin permeance to water vapor (mol s^{-1} m^{-2} Pa^{-1}); $r_{chr}^{H_2O}$ steady-state rate of water vapor loss (mol s^{-1}); A_{chr} cherry tomato surface area (m^2) which was calculated based on the geometric shape of the tomato; $p_{chr,\text{int}}^{H_2O}$ and $p_{chr,env}^{H_2O}$ partial pressures of water vapor inside of the fruit, and in the surrounding environment (Pa), respectively. Values of these partial pressures were estimated using the Antoine equation relating to tomato's water activity value (a_w = 0.99), and dry-wet bulb (Table 1) environmental temperatures (Maguire, 1998; Phungam *et al*., 2018). Values of $r_{chr}^{H_2O}$ were estimated from differences between steady-state rates of weight loss (r_{chr}^{wt}) and those of carbon loss (r_{chr}^{Closs}). The r_{chr}^{wt} values were obtained from experiments i.e. individual tomato was weighed using a 3-digit digital balance until the weight reductions became steady. Slopes of steady weight decreased (mol s^{-1}) were estimated using linear regressions (Microsoft ver 2016). For the r_{chr}^{Closs} values (mol s^{-1}), Equation 2 was employed for calculations.

$$r_{chr}^{Closs} = r_{chr}^{CO_2} M_{chr} \tag{2}$$

where r_{chr}^{Closs} cherry tomato carbon loss rate (mol s^{-1}); $r_{chr}^{CO_2}$ cherry tomato respiration rate (mol s^{-1} kg^{-1}); M_{chr}

Table 1. Some information on respiration rate measurements and wet bulb temperatures

Temperature (°C)	Information on respiration rate measurements			Wet bulb temperature (°C)
	Measuring time period (min)	Fruit mass (kg)[a]	Fruit volume (mL)[a]	
10	60	0.079±0.009	78.60±9.02	8.00
25	30	0.083±0.006	82.43±6.35	24.50
35	30	0.082±0.004	81.64±4.24	34.67

[a] Values are presented as average±standard deviation ($n = 40$)

cherry tomato mass (kg).

2.4 Experimental design and statistical analysis

The research undertaken was experimentally planned in accordance with a completely randomized design (CRD). To analyze relationships between storage temperatures and (1) $r_{chr}^{CO_2}$ and (2) $P_{chr}^{H_2O}$, the Arrhenius equation (Equation 3) was utilized. Nonlinear regression was undertaken for fitting data estimated from Equation 3 to the experiment data. The Arrhenius coefficients subsequently were estimated by minimizing sum squared residuals. Furthermore, good-of-fit between both data sets was justified via root mean square of error as reported by Yantarasri *et al.* (1995).

$$k = k_{ref} \exp\left(\frac{Ea}{R}\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)\right) \tag{3}$$

where k either $r_{chr}^{CO_2}$ or $P_{chr}^{H_2O}$ values at given temperatures (T), k_{ref} values estimated at reference temperature (T_{ref}) i.e., 15°C, R an ideal gas constant (8.314 J mol^{-1} K^{-1}) and Ea energy of activation (J mol^{-1}).

3. Results and discussion

In the present work, the TB resin could be transformed into the surface coating material for fruit and vegetable. The coating material had reasonable surface adherence to the tomato skin, in turn giving attractive yellowish glossiness visually observed from the resin thinly coated on the fruit surfaces. There was a slight rosin-like and acceptable aroma perceived by the researchers. At the time of the experiments, the resin coat was not brittle or had no crack appearances. These may be due to the relatively short-term storage methodologically required for determining the respiration rates and skin permeance properties. Respiration rates of cherry tomatoes in both experimental treatments show increased values in responses to increasing storage temperatures from 10 to 35°C (Figure 1). Such characteristics apparently were well predicted with the Arrhenius equation of which all RMSE values were lower than 2, indicating the Arrhenius equation sufficiently can be used to describe respiration rates in accordance to Yang and Chinnan (1988) (Figure 1 and Table 2). Similar influences of storage temperatures on respiration rates are reported for cherry tomatoes (Sousa *et al.*, 2017) and other horticultural products for example Braeburn apples, dragon fruit and sweet cherries (Weber *et al.*, 2020; Ho *et al.*, 2020; Zhang *et al.*, 2021). It should be noted that the respiration rate values of non-coated cherry tomatoes obtained in the present work were considered comparable to those reported in the literature for the cherry tomatoes kept in the range of 10-20°C, for example, 0.08 mmol s^{-1} kg^{-1} at 10°C (Tilahun *et al.*, 2021), and 0.29 mmol s^{-1} kg^{-1} at 20°C (Mustapha and Zhou, 2021). The respiration rates of the tomatoes coated with TB resin approximately were 2-fold lower than those of the non-coated fruits (Figure 1). The TB resin was formed as a film on the fruit surface giving an additional barrier to natural wax or cuticle layers. Rates of O_2 transport from the surrounding to the internal fruit become lower because of longer transport paths (Salehi, 2020), subsequently decreasing the respiration rates (Figure 1). In Table 2, it could be noticed that *Ea* value of TB-coated tomatoes slightly was lower than that of the non-coated. Because the *Ea* value essentially indicates sensitivity to temperature changes (Chen *et al.*, 2000), it could be implied that the non-coated fruits would be more sensitive than the TB-coated ones. Given

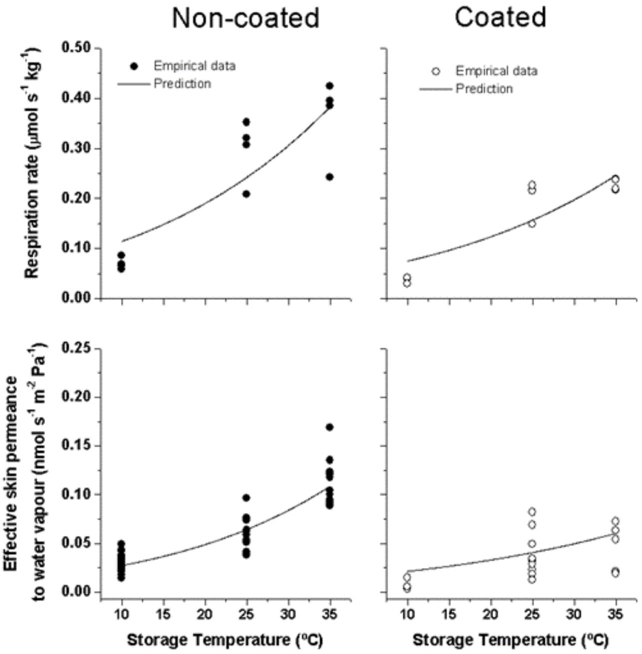

Figure 1. Changes in respiration rate ($r_{chr}^{CO_2}$) and effective skin permeance to water vapor ($P_{chr}^{H_2O}$) of cherry tomatoes of which surfaces were either coated with TB resin (coated) or non-coated, kept at 10, 25 and 35°C. Prediction shown in a line form represents data predicted by the Arrhenius equation (Equation 3).

https://doi.org/10.26656/fr.2017.7(3).221

Table 2. Nonlinear regression analysis for parameters in Arrhenius equation (Equation 3) for respiration rate and effective skin permeance to water vapor.

Parameters	k_{ref}		Ea (J mol^{-1} K^{-1})		RMSE			
	Non-coated	TB-coated	Non-coated	TB-coated	Non-coated	n	TB-coated	n
Respiration rate (mmol s^{-1}kg^{-1})	0.148	0.097	35.158	34.584	0.030	12	0.025	12
Effective skin permeance to water vapor (nmol s^{-1}m^{-2}Pa^{-1})	0.036	0.018	41.324	38.039	0.012	46	0.013	22

TB: Taengwood Balau, RMSE: root mean square of errors, k_{ref}: values of either respiration rate or effective skin permeance to water vapor estimated at 15°C as the reference temperature, Ea: energy of activation as referred to Equation 3.

the elevating temperature, the respiration rates of the non-coated tomatoes would be increased faster than those of the TB-coated fruits.

The temperature dependences of the effective skin permeances to water vapor of tomatoes in all treatments were well described by the Arrhenius equation (Figure 1 and Table 1). The permeance values exponentially increased with the elevated temperature from 10 to 35°C. The information importantly supports the knowledge on water vapor loss rates become higher under the high storage temperature (Lufu *et al*., 2020). In the study on fresh okra, Phungam *et al*. (2018) reported similar relationships between the storage temperature and the permeances. By coating the surface with the TB resin, the effective skin permeances of the coated tomatoes became reasonably lower than those of the non-coated ones. Effects of surface coating on reducing the skin permeances also were reported in mango (Acabal *et al*., 2020), pears (Rosenbloom *et al*., 2020) and sweet cherry (Zhang *et al*., 2021). Similar to gas exchanges in the respiration processes discussed above, the additional film caused by the TB resin forms a longer path for water vapor to transport from the internal to outer fruits i.e. reducing the skin permeance to water vapor. These result in lower water vapor loss rates, and subsequently lower fresh weight losses. For *Ea* values reported in Table 2, the temperature sensitivity of the effective skin permeances of the non-coated tomatoes was higher than that of the TB-coated fruits. It was reasonable to expect that the rates of water loss from the TB-coated fruit were slower compared to those from the non-coated, under increasing storage temperatures.

4. Conclusion

The experimental findings show possibilities in using the TB resin as an alternative surface coating material, which can significantly lower the effective skin permeance to water vapor as well as respiration rates for the cherry tomatoes. This study also provides information to support the necessity to incorporate the cool storage temperature for postharvest and supply chain management of the fresh cherry tomatoes i.e. as to additionally lower the permeance and the respiration rates. Further studies of the TB resin surface coating material could be in terms of its antimicrobial activities, other storage quality effects including organoleptic qualities as well as structural changes such as brittles or cracks of the coating layer. Knowledge obtained from both the present and future works could facilitate developing the surface coating material to suit the postharvest requirements of cherry tomatoes and other horticultural products.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The researchers would like to express our appreciation to the Faculty of Agriculture, Ubon Ratchathani University, Thailand for providing support on laboratory facilities and instruments.

References

Acabal, M.C.G., Yaptenco, K.F., Elauria, J.C. and Esguerra, E.B. (2020). Gas transmission rates of mango (*Mangifera indica* L. 'Carabao') peel as affected by chitosan-nanosilica composite fruit coating. *Philippine Journal of Agricultural and Biosystems Engineering*, 16(2), 3-12.

Ali, S., Akbar Anjum, M., Sattar Khan, A., Nawaz, A., Ejaz, S., Khaliq, G., Iqbal, S., Ullah, S., Naveed Ur Rehman, R., Moaaz Ali, M. and Shahzad Saleem, M. (2022). Carboxymethyl cellulose coating delays ripening of harvested mango fruits by regulating softening enzymes activities. *Food Chemistry*, 380, 131804. https://doi.org/10.1016/j.foodchem.2021.131804

Appanah, S. and Turnbull, J.M. (1998). A review of dipterocarps: Taxonomy, Ecology, and Silviculture. Indonesia: Center for International Forestry Research (CIFOR). https://doi.org/10.17528/cifor/000463

Awaludin, A., Smittakorn, W., Hirai, T. and Hayashikawa, T. (2007). Bearing properties of

Shorea obtusa beneath a laterally loaded bolt. *Journal of Wood Science*, 53(3), 204–210. https://doi.org/10.1007/s10086-006-0842-z

Chaomuang, N., Singphithak, P., Laguerre, O. and Suwapanich, R. (2022). Temperature control in a horticultural produce supply chain in Thailand and its influence on product quality. *Food Control*, 133 (Part A), 108585. https://doi.org/10.1016/j.foodcont.2021.108585

Chen, X., Hertog, M.L.A.T.M. and Banks, N.H. (2000). The effect of temperature on gas relations in MA packages for capsicums (*Capsicum annuum* L., cv. Tasty): An integrated approach. *Postharvest Biology and Technology*, 20(1), 71–80. https://doi.org/10.1016/S0925-5214(00)00113-7

Gutiérrez-Pacheco, M.M., Ortega-Ramírez, L.A., Silva-Espinoza, B.A., Cruz-Valenzuela, M.R., González-Aguilar, G.A., Lizardi-Mendoza, J., Miranda, R. and Ayala-Zavala, J.F. (2020). Individual and combined coatings of chitosan and carnauba wax with oregano essential oil to avoid water loss and microbial decay of fresh cucumber. *Coatings*, 10(7), 614. https://doi.org/10.3390/coatings10070614

Ho, P.L., Tran, D.T., Hertog, M.L.A.T.M. and Nicolaï, B.M. (2020). Modelling respiration rate of dragon fruit as a function of gas composition and temperature. *Scientia Horticulturae*, 263, 109138. https://doi.org/10.1016/j.scienta.2019.109138

Kabir, M.S.N., Ali, M., Lee, W.H., Cho, S.I. and Chung, S.O. (2020). Physicochemical quality changes in tomatoes during delayed cooling and storage in a controlled chamber. *Agriculture*, 10(6), 196. https://doi.org/10.3390/agriculture10060196

Khalid, S., Ullah, M., Khalid, M., Shahid, M. and Sultana, S. (2022). Relationship between moisture loss and physicochemical quality attributes of tomato under different storage conditions. *Journal of Postharvest Technology*, 10(1), 71–79.

Khorram, F. and Ramezanian, A. (2021). Cinnamon essential oil incorporated in shellac, a novel bio-product to maintain quality of 'Thomson navel' orange fruit. *Journal of Food Science and Technology*, 58(8), 2963–2972. https://doi.org/10.1007/s13197-020-04798-4

Loayza, F.E., Masarirambi, M.T., Brecht, J.K., Sargent, S.A. and Sims, C.A. (2020). Physiological response of mature green tomatoes to treatment with ethylene at high temperature. *HortTechnology*, 30(6), 773–780. https://doi.org/10.21273/HORTTECH04668-20

Lufu, R., Ambaw, A. and Opara, U.L. (2020). Water loss of fresh fruit: Influencing pre-harvest, harvest and postharvest factors. *Scientia Horticulturae*, 272, 109519. https://doi.org/10.1016/j.scienta.2020.109519

Maguire, K.M., Banks, N.H. and Opara, L.U. (2001). Factors affecting weight loss of apples. *Horticultural Reviews*, 25, 197-232. https://doi.org/10.1002/9780470650783.ch4

Marc, M., Cournol, M., Hanteville, S., Poisson, A.-S., Guillou, M.-C., Pelletier, S., Laurens, F., Tessier, C., Coureau, C., Renou, J.-P., Delaire, M. and Orsel, M. (2020). Pre-harvest climate and post-harvest acclimation to cold prevent from superficial scald development in Granny Smith apples. *Scientific Reports*, 10(1), 6180. https://doi.org/10.1038/s41598-020-63018-3

Maguire, K.M. (1998). Factors affecting mass loss of apples. Palmerston North, New Zealand: Massey University, PhD. Dissertation.

Maringgal, B., Hashim, N., Amin Tawakkal, I.S.M., Muda Mohamed, M.T., Hazwan Hamzah, M., Ali, M.M. and Abd Razak, M.F.H. (2020). Kinetics of quality changes in papayas (*Carica papaya* L.) coated with Malaysian stingless bee honey. *Scientia Horticulturae*, 267, 109321. https://doi.org/10.1016/j.scienta.2020.109321

Merish, S., Tamizhamuthu, M. and Walter, T.M. (2014). Review of *Shorea robusta* with special reference to traditional Siddha medicine. *Research and Reviews: Journal of Pharmacognosy and Phytochemistry*, 2 (1), 5-13. https://doi.org/10.2174/2215083801666150701162809

Mohammadi, L., Ramezanian, A., Tanaka, F. and Tanaka, F. (2021). Impact of Aloe vera gel coating enriched with basil (*Ocimum basilicum* L.) essential oil on postharvest quality of strawberry fruit. *Journal of Food Measurement and Characterization*, 15(1), 353–362. https://doi.org/10.1007/s11694-020-00634-7

Mustapha, A.T. and Zhou, C. (2021). Novel assisted/unassisted ultrasound treatment: Effect on respiration rate, ethylene production, enzymes activity, volatile composition, and odor of cherry tomato. *LWT*, 149, 111779. https://doi.org/10.1016/j.lwt.2021.111779

Osae, R., Apaliya, M.T., Alolga, R.N., Kwaw, E., Otu, P.N.Y. and Akaba, S. (2022). Influence of shea butter, bee wax and cassava starch coatings on enzyme inactivation, antioxidant properties, phenolic compounds and quality retention of tomato (*Solanum lycopersicum*) fruits. *Applied Food Research*, 2(1), 100041. https://doi.org/10.1016/j.afres.2022.100041

Phungam, N., Utto, W. and Pruthtikul, R. (2018). Interaction between surface coating using cabbage leaf wax extract and temperature on water vapour and gas exchange properties of fresh okra (*Abelmoschus esculentus* (L.) Moench). *International Food Research Journal*, 25(5), 1885-1892.

Riva, S.C., Opara, U.O. and Fawole, O.A. (2020). Recent developments on postharvest application of edible coatings on stone fruit: a review. *Scientia Horticulturae*, 262, 109074. https://doi.org/10.1016/j.scienta.2019.109074

Rosenbloom, R.A., Wang, W. and Zhao, Y. (2020). Delaying ripening of 'Bartlett' pears (*Pyrus communis*) during long-term simulated industrial cold storage: Mechanisms and validation of chitosan coatings with cellulose nanocrystals Pickering emulsions. *LWT*, 122, 109053. https://doi.org/10.1016/j.lwt.2020.109053

Ruiz-Martínez, J., Aguirre-Joya, J.A., Rojas, R., Vicente, A., Aguilar-González, M.A., Rodríguez-Herrera, R., Alvarez-Perez, O.B., Torres-León, C. and Aguilar, C.N. (2020). Candelilla wax edible coating with *Fourensia cernua* bioactives to prolong the quality of tomato fruits. *Foods*, 9(9), 1303. https://doi.org/10.3390/foods9091303

Salehi, F. (2020). Edible Coating of fruits and vegetables using natural gums: A Review. *International Journal of Fruit Science*, 20(2), 570–589. https://doi.org/10.1080/15538362.2020.1746730

Sousa, A.R., Oliveira, J.C. and Sousa-Gallagher, M.J. (2017). Determination of the respiration rate parameters of cherry tomatoes and their joint confidence regions using closed systems. *Journal of Food Engineering*, 206, 13–22. https://doi.org/10.1016/j.jfoodeng.2017.02.026

Tilahun, S., Lee, Y.M., Choi, H.R., Baek, M.W., Lee, J.S., Park, D.S., Kang, H.-M. and Jeong, C.S. (2021). Modified atmosphere packaging combined with CO_2 and 1-methylcyclopropene prolong the storability and maintain antioxidant properties of cherry tomato. *Scientia Horticulturae*, 288, 110401. https://doi.org/10.1016/j.scienta.2021.110401

Weber, A., Neuwald, D.A., Kittemann, D., Thewes, F.R., Both, V. and Brackmann, A. (2020). Influence of respiratory quotient dynamic controlled atmosphere (DCA – RQ) and ethanol application on softening of Braeburn apples. *Food Chemistry*, 303, 125346. https://doi.org/10.1016/j.foodchem.2019.125346

Yan, X., Tao, Y. and Chang, Y. (2021). Effect of shellac waterborne coating microcapsules on the optical, mechanical and self-Healing properties of waterborne primer on *Tilia europaea* L. wood. *Coatings*, 11(7), 785. https://doi.org/10.3390/coatings11070785

Yang, C.C. and Chinnan, M.S. (1998). Modeling the effect of O_2 and CO_2 on respiration and quality of stored tomatoes. *Transactions of the American Society of Agricultural Engineers*, 31(3), 920-925. http://doi:10.13031/2013.30800

Yantarasri, T., Ben-Yehoshua, S., Rodov, V., Kumpuan, W., Uthaibutra, J. and Sornsrivichai, J. (1995). Development of perforated modified atmosphere package for mango. *Acta Horticulturae*, 398, 81-92. http://doi:10.17660/actahortic.1995.398.8

Zhang, Y.L., Cui, Q.L., Wang, Y., Shi, F., Liu, Y.P., Liu, J.L. and Nie, G.W. (2021). Effect of carboxymethyl chitosan-gelatin-based edible coatings on the quality and antioxidant properties of sweet cherry during postharvest storage. *Scientia Horticulturae*, 289, 110462. https://doi.org/10.1016/j.scienta.2021.110462