Original Research Article

The characteristics of fresh-cut rambutan fruit during cold storage

Abstract

Rambutan is a delicious tropical fruit that contains various components that are beneficial for health. Damage to the skin often causes a decrease in consumer interest. Therefore, fresh-cut rambutan is preferred over whole fruit. A decrease in the quality of fresh-cut rambutan due to cold storage was observed. This study aims to determine changes in the characteristics of fresh-cut rambutan during cold storage. Whole fruit controls were prepared to observe deterioration during storage. The study used a completely randomized design with three replications. Storage time of 0, 3, 6, 9 and 12 days to determine the water content, acidity, total dissolved solids, vitamin C contents, and micrograph of fresh-cut rambutan fruit with Scanning Electron Microscope (SEM). The conclusion is cold storage treatment has an effect on the characteristics of moisture content, degree of acidity, and vitamin C of fresh-cut rambutan fruit. While the total dissolved solid has no effect on the characteristics of fresh-cut rambutan. The decrease in the characteristics of fresh-cut rambutan was sharper than that of intact fruit starting on day 6.

Comment [DBY-W091]: fruit's skin

Keywords: rambutan, fresh-cut, cold storage, quality, shelf life.

1. Introduction

Rambutan is one of the horticultural tropical fruits commonly grown in Indonesia. This fruit is popular with lots of nutrients such as sugar, calorie vitamins, minerals, and fibers which are important for the metabolic process of the body (Theapparat *et al.*, 2019). However, the problem associated with rambutan is the short-term damages related to the skin after harvest, which is usually between 2-4 days at room temperature (Suriati *et al.*, 2020). This condition makes it difficult to market, although the fruit’s quality is consumable (Hernández-Hernández *et al.*, 2019). Rambutan contains a lot of moisture which acts as a medium of decay and pathological damage due to bacterial and fungal contamination (Perumal *et al.*, 2021). The fruit is acidic and less sweet when harvested too early, however, it produces a higher taste bland when reaped late. The texture changes are due to the activity of Methyl-esterase and polygalacturonate, which increases the maturity rate (Theapparat *et al*., 2019). Temperature also contributes to some post-harvest deterioration rates of rambutan such as metabolic and aroma changes, respiration rate, ethylene production, transpiration, texture, and microbial growth (Suriati *et al*., 2020). The quality and shelf life of intact rambutan are extended through the use of edible coating with an unchanged pulp's firmness when stored at cold temperatures (Díaz-Montes and Castro-Muñoz, 2021; Yousuf and Qadri, 2020).

The damage to its hair tends to lower consumers' consumption rates. Therefore, the fresh-cut acts as a minimal alternative process to solving this problem by removing the inedible portion such as skin, thereby, making the product consumable. Some of its advantages include presenting consumers with a wide range of options in one package, shorter preparation time, reduces household waste, allows consumers to examine the inner state of the product, offer more guaranteed quality, produces the right amount of fresh fruit, facilitate the quality of purchases, and lower product volume at a cheaper rate(Wall *et al*., 2011; Cruz *et al.*, 2016; Phuong *et al.*, 2020).

The state of the fresh-cut distributed to the consumer needs to be nutritional with a preserved flavor and freshly preserved. It is referred to as the ready-to-use products that facilitate subsequent processing of the product (Suhaimi *et al*., 2021; Prakash *et al*., 2020). Peeling stresses the fruit and sends signals into the cell tissues, thereby, increasing the respiration and transpiration rates as well as the production of ethylene (Salgado-Cruz *et al*., 2021). The raw materials determine the quality, therefore, the intact fruit needs to be characterized to produce good quality. Furthermore, precise and optimum handling is required to extend the storage under cold temperature, used as an alternative preservative measure to suppress the decline rate (Silvetti *et al*., 2021). Upstream and downstream cooling is essential for fresh-cut fruit because, at low temperatures, the effects of mechanical injuries are minimized, with lower enzyme activity and metabolic rate (Nicolau-Lapeña, 2021; Suriati and Suardani, 2021; Zhang *et al.*, 2021). Therefore this research aims to determine changes in the characteristics of fresh-cut rambutan during cold storage.

2. Research Methods

Rambutan fruit 105-day old of the Aceh type obtained from Panji Village Sukasada District Buleleng Regency Bali Province was used. The tools used are chiller, pH meter, refractometer, penetrometer, oven, and plastic packaging mica. This experiment was conducted at the laboratory of Agricultural Technology Food analysis of Warmadewa University.

Comment [DBY-W092]: A 105-day-old Rambutan fruits

2.1. Research design

The random design of one factor was used to determine the storage time of 0, 3, 6, 9, and 12 days, the storage temperature of rambutan fruits at 8 ± 1°C. Each treatment was replicated 3 times to determine the water content, acidity, total dissolved solids, vitamin C contents, and micrograph with Scanning Electron Microscope (SEM). Whole fruit controls were prepared to observe deterioration during storage.

2.2. Implementation of the research

The fruit was grouped following picking age 120 days, bright red skin color, round or oval fruit, long hair and fresh, the pulp is transparent white, fruit weight 20-30g, soft skin texture. Before cutting, hydro-cooling and washing water are used to lower the temperature during harvest and transportation. This was followed by the distribution and the preparation of the fresh-cut, which is prepared with a stainless knife to suppress mechanical damage and tool contamination. This process only removes the skin while the seeds are allowed to be attached to the pulp. All fruits are partly packed in a plastic box with a hole-filled lid with a diameter of 0.5 cm and distributed on the experimental units. Furthermore, the fruit is stored at 8 ± 1°C with the periodic observation on 0, 3, 6, 9, 12, and 15 days. Data obtained from three replications in this study examined the changes in their characteristics separately for intact and fresh-cut rambutan fruit.

2.3. Statistical analysis

Data were tested by analysis of diversity using Statistical Product and Service Solutions (SPSS). If the diversity of data shows a significant result of treatment, then the test is continued with Duncan's Multiple Range Test (DMRT) to find out the real difference in the mean data from the treatment.

3. Result and Discussion

3.1. Moisture content

Moisture content is an important component of fruits, which is affected by many factors. However, this research showed that the average temperature difference of moisture content on fresh-cut rambutan. The moisture content of rambutan intact ranges from 81.64 – 90.34%, which decreases the storage rate. This is because the longer the storage time, the greater the dehydration process. Some research on tropical fruits also shows similar results, therefore, a greater chance of the respiration process leads to a higher rate of fruit loses due to water (Gürbüz and Kahramanoğlu, 2021; Deshi *et al.*, 2021; Cofelice, *et al*., 2019).

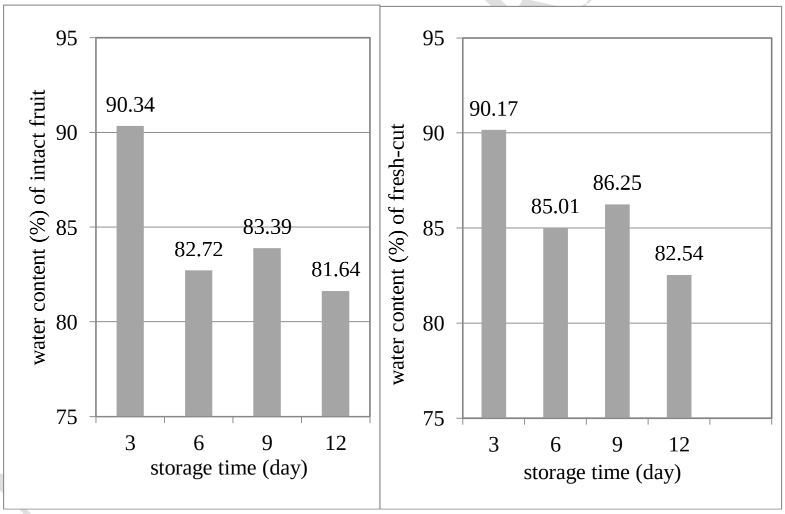

Fig. 1. Water content of intact and fresh-cut rambutan during storage

The average water content of fresh-cut rambutan is 82.54-90.17%, therefore, it is not affected by storage time as shown in Figure 1. The water content of the intact has a sharper decline than the fresh-cut during storage due to the occurrence of anaerobic fermentation. Some research on tropical fruits also shows that longer storage influences the chance of the respiration process to release water (Ncama *et al*., 2018; Zhao *et al.*, 2021; Aguilar *et al.*, 2021).

3.2. Degree of acidity

The acidity level of fruit is determined by its degree of acidity. Result of the research show that the storage time significant different on the degree of acidity fresh-cut rambutan. The intact rambutan has a degree of acidity range between 4.18 to 4.36 and is not affected by the temperature treatment and storage time. This is because, under room temperature, the enzyme becomes inactive, thereby preventing the repair of organic acids. Storage of fruits in cold temperatures (4-12°C) tends to extend the usability and maintain quality (). Therefore, the increase or decrease in pH remains in the normal range (Salgado-Cruz *et al.*, 2021; Suriati and Suardani, 2021; Piazzolla *et al.*, 2021). During storage, the degree of acidity of fresh-cut rambutan decreases from 3.23 to 4.30%. Figure 2 shows the average degree of acidity of the intact and fresh-cut rambutan during storage.

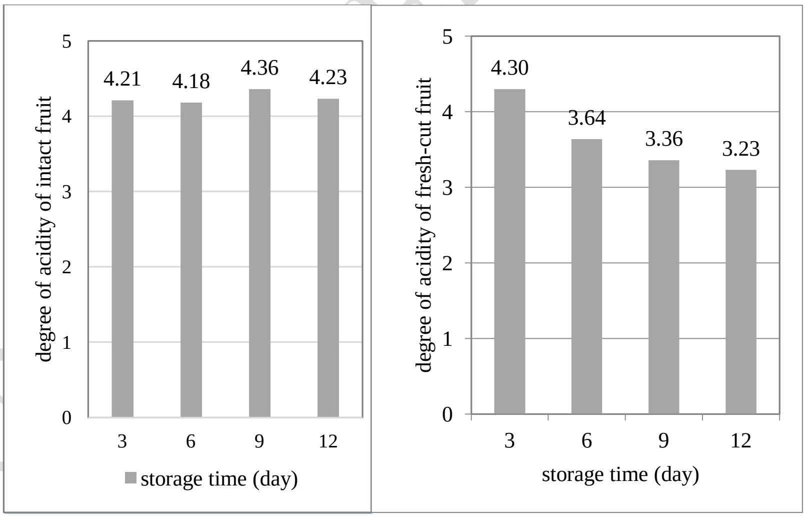

Fig. 2. Degree of acidity intact and fresh-cut rambutan during storage

The degree of acidity of fresh-cut rambutan decreases during storage at temperatures of 8 ± 1°C. This is because stripping the skin promotes the occurrence of organic acid reordering,

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Comment [DBY-W094]: Which enzyme? you should mention it

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3.3. Total Dissolved Solids

Storage time produced the same response to the average value of the total dissolved solids on fresh-cut rambutan fruit, as shown in Figure 3. The results showed that the total solids dissolved are 8.70%-10.65% of intact fruit, and 8.58 – 10.65 of fresh-cut fruit, respectively. The highest total dissolved solid of the intact fruit was obtained from the 6th day of storage, while the smallest was on the 3rd at 8.70%. The temperatures of 8 ± 1°C contribute almost the same increase in the total dissolved solids, due to the presence of sugar reshuffle**.**

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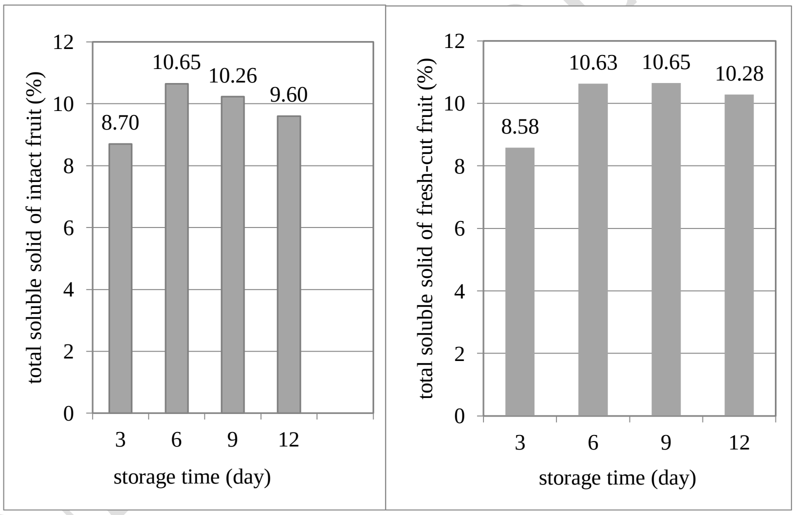

Fig. 3. Total solids dissolved by intact rambutan and fresh-cut during storage

This, in line with the research which stated that low temperature and edible coating are used to store fresh-cut products (Kumar *et al.*, 2021; Xu *et al.*, 2021; Sultan *et al.*, 2021). Rambutan fruit contains non-climacteric sugar and other dissolved solids during storage with the climacteric fruit subjected to maturation by the length of storage (Perumal *et al.*, 2021; Theapparat *et al.*, 2019).

3.4. Vitamin C

The results showed that the long-term storage has significant effect on Vitamin C in the fresh-cut fruit. The average rate for intact and fresh-cut, which ranges from 12.71-54.92mg/100 g and 11,26-54.46 mg/100 g during storage, is shown in Figure 4. The highest level is obtained from the 3rd day of storage while the smallest is on the 12th-day at a temperature treatment rate of 8 ± 1°C. The various treatments administered shrinks the vitamin C content with an increase in storage time due to the oxidation process (Suriati *et al.*, 2020; Liu *et al.*, 2021; Sadler *et al.*, 2021). Fresh-cut exfoliation results in damage that include an increase in tissue respiration, production of ethylene and unexpected metabolites, as well as a decrease in vitamin C, fruit integrity, and microbial growth *(Silvetti et al*., 2021; Toivonen and Brummell, 2008; Li *et al.*, 2021; Suriati *et al.*, 2021).

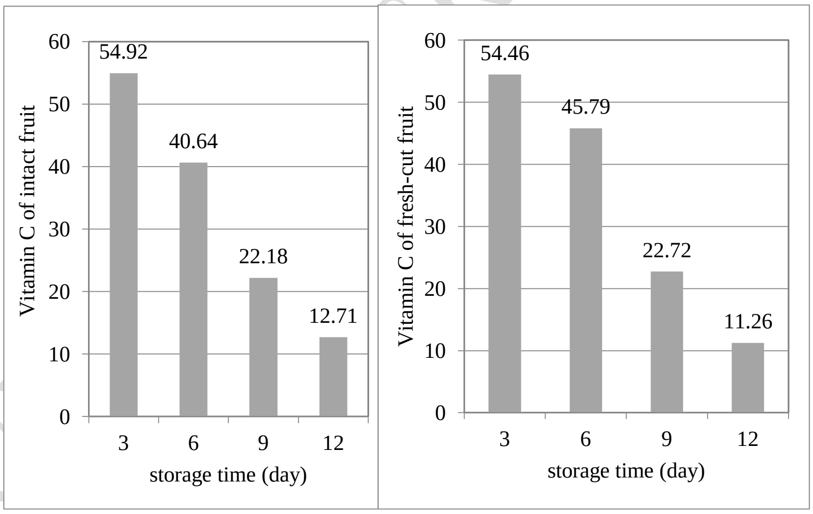

Fig. 4. Vitamin C (mg/100 g) of intact rambutan and fresh-cut during storage

3.5. Micrographs

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A micrograph is a photo taken through a microscope device, to present an enlarged image of the object of vertical and horizontal slices of rambutan fruit. The micrographs of rambutan fruit observed by SEM can be seen in Figure 5.

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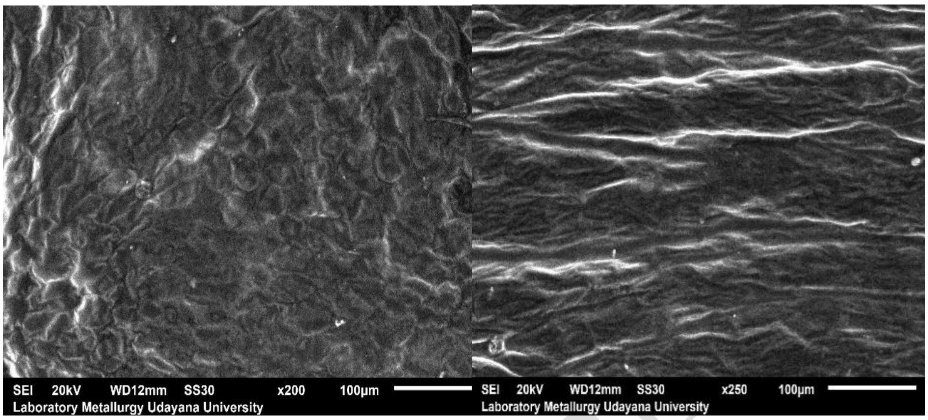

A (horizontal section) B (vertical section)

Fig. 5. Micrograph of rambutan fruit by SEM

4. Conclusion

The conclusion of this research is cold storage treatment has an effect on the characteristics of moisture content, degree of acidity, and vitamin C of fresh-cut rambutan fruit. While the total dissolved solid has no effect on the characteristics of fresh-cut rambutan. The decrease in the characteristics of fresh-cut rambutan was sharper than that of intact fruit starting on day 6.

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References

Aguilar, C., Serna-Jiménez, J., Benitez, E., Valencia, V., Ochoa, O., & Sotelo, L. I. (2021). Influence of high power ultrasound on natural microflora, pathogen and lactic acid bacteria in a raw meat emulsion. *Ultrasonics Sonochemistry*, *72*.

Arias Cruz, M. E., Velásquez Ramírez, H. A., Mateus Cagua, D., Chaparro Zambrano, H. N., & Orduz Rodríguez, J. O. (2016). Rambután: un nuevo frutal tropical para Colombia con potencial para el mercado interno y de exportación. *Revista Colombiana de Ciencias Hortícolas*, *10*(2), 262–272. https://doi.org/10.17584/rcch.2016v10i2.5761

Cofelice, M., Lopez, F., & Cuomo, F. (2019). Quality control of fresh-cut apples after coating application. *Foods*, *8*(6). https://doi.org/10.3390/FOODS8060189

Deshi, V., Homa, F., Tokala, V. Y., Mir, H., Aftab, M. A., & Siddiqui, M. W. (2021). Regulation of pericarp browning in cold-stored litchi fruit using methyl jasmonate. *Journal of King Saud University - Science*, *33*(5).

Díaz-Montes, E., & Castro-Muñoz, R. (2021). *Edible Films and Coatings as Food-Quality Preservers: An Overview*. https://doi.org/10.3390/foods10020249

Gürbüz, R., & Kahramanoğlu, İ. (2021). Possibility of using leaf extracts of tree-of-heaven (Ailanthus altissima (Mill.) Swingle) for the postharvest quality preservation of fresh apricot fruits. *Physiological and Molecular Plant Pathology*, *113*.

Hernández-Hernández, C., Aguilar, C. N., Rodríguez-Herrera, R., Flores-Gallegos, A. C., Morlett-Chávez, J., Govea-Salas, M., & Ascacio-Valdés, J. A. (2019). Rambutan(Nephelium lappaceum L.):Nutritional and functional properties. *Trends in Food Science & Technology*, *85*, 201–210. https://doi.org/10.1016/J.TIFS.2019.01.018

Kumar, S., Basumatary, I. B., Sudhani, H. P. K., Bajpai, V. K., Chen, L., Shukla, S., & Mukherjee, A. (2021). Plant extract mediated silver nanoparticles and their applications as antimicrobials and in sustainable food packaging: A state-of-the-art review. *Trends in Food Science & Technology*, *112*, 651–666. https://doi.org/10.1016/J.TIFS.2021.04.031

Li, L., Yi, P., Li, C., Xin, M., Sun, J., He, X., Sheng, J., Zhou, Z., Fengjin Zheng, |, Li, J., Liu, G., Ling, D., Tang, J., Li, Z., Yang, Y., & Tang, Y. (2021). *Influence of polysaccharide-based edible coatings on enzymatic browning and oxidative senescence of fresh-cut lettuce*. https://doi.org/10.1002/fsn3.2052

Liu, H., Liu, S., Du, B., Dong, K., Wang, Y., & Zhang, Y. (2021). Aloe vera gel coating aggravates superficial scald incidence in ‘Starking’ apples during low-temperature storage. *Food Chemistry*, *339*(September 2020), 128151. https://doi.org/10.1016/j.foodchem.2020.128151

Suriati, L., Candra, I.P. & Supardika, I.K.. (2021). Aloe-Gel Coating for Delaying Physicochemical Change of Fresh-Cut Mango. *SEAS (Sustainable Environment Agricultural Science)*, *5*(1), 58–65. https://doi.org/10.22225/seas.5.1.3302.58-65

Mohd Suhaimi, N. I., Mat Ropi, A. A., & Shaharuddin, S. (2021). Safety and quality preservation of starfruit (Averrhoa carambola) at ambient shelf life using synergistic pectin-maltodextrin-sodium chloride edible coating. *Heliyon*, *7*(2), e06279.

https://doi.org/10.1016/J.HELIYON.2021.E06279

Ncama, K., Magwaza, L. S., Mditshwa, A., & Tesfay, S. Z. (2018). Plant-based edible coatings for managing postharvest quality of fresh horticultural produce: A review. *Food Packaging and Shelf Life*, *16*, 157–167.

Nicolau-Lapeña, I., Aguiló-Aguayo, I., Kramer, B., Abadias, M., Viñas, I., & Muranyi, P. (2021). Combination of ferulic acid with Aloe vera gel or alginate coatings for shelf-life prolongation of fresh-cut apples. *Food Packaging and Shelf Life*, *27*, 100620. https://doi.org/10.1016/J.FPSL.2020.100620

Perumal, A., AlSalhi, M. S., Kanakarajan, S., Devanesan, S., Selvaraj, R., & Tamizhazhagan, V. (2021). Phytochemical evaluation and anticancer activity of rambutan (Nephelium lappaceum) fruit endocarp extract against human hepatocellular carcinoma (HepG-2) cells. *Saudi Journal of Biological Sciences*, *28*(3), 1816–1825. https://doi.org/10.1016/j.sjbs.2020.12.027

Phuong, N. N. M., Le, T. T., Van Camp, J., & Raes, K. (2020). Evaluation of the antimicrobial activity of rambutan (Nephelium lappaceum L.) peel extracts. *International Journal of Food Microbiology*, *321*, 108539. https://doi.org/10.1016/J.IJFOODMICRO.2020.108539

Piazzolla, F., Amodio, M. L., Pati, S., & Colelli, G. (2021). Evaluation of quality and storability of “Italia” table grapes kept on the vine in comparison to cold storage techniques. *Foods*, *10*(5). https://doi.org/10.3390/FOODS10050943

Prakash, A., Baskaran, R., & Vadivel, V. (2020). Citral nanoemulsion incorporated edible coating to extend the shelf life of fresh-cut pineapples. *LWT*, *118*, 108851. https://doi.org/10.1016/J.LWT.2019.108851

Sadler, C. R., Grassby, T., Hart, K., Raats, M., Sokolović, M., & Timotijevic, L. (2021). Processed food classification: Conceptualisation and challenges. *Trends in Food Science and Technology*, *112*, 149–162.

Salgado-Cruz, M. de la P., Salgado-Cruz, J., García-Hernández, A. B., Calderón-Domínguez, G., Gómez-Viquez, H., Oliver-Espinoza, R., Fernández-Martínez, M. C., & Yáñez-Fernández, J. (2021). Chitosan as a Coating for Biocontrol in Postharvest Products: A Bibliometric Review. *Membranes*, *11*(6), 421. https://doi.org/10.3390/MEMBRANES11060421

Silvetti, T., Pedroni, M., Brasca, M., Vassallo, E., Cocetta, G., Ferrante, A., De Noni, I., Piazza, L., & Morandi, S. (2021). Assessment of the possible application of an atmospheric pressure plasma jet for shelf life extension of fresh-cut salad. *Foods*, *10*(3), 1–13. https://doi.org/10.3390/foods10030513

Sultan, M., Hafez, O. M., Saleh, M. A., & Youssef, A. M. (2021). *Smart edible coating films based on chitosan and beeswax-pollen grains for the postharvest preservation of Le Conte pear*. https://doi.org/10.1039/d0ra10671b

Suriati, L, & Suardani, N. M. A. (2021). Application Ecogel Incorporation additive for maintaining the freshness of Strawberry fruit during storage. *IOP Conference Series: Materials Science and Engineering*, *1098*(6), 062055. https://doi.org/10.1088/1757-899x/1098/6/062055

Suriati, L., Utama, I. M. S., Harjosuwono, B. A., & Gunam, I. B.W. (2020). Physicochemical characteristics of fresh-cut tropical fruit during storage. *International Journal on Advanced Science, Engineering and Information Technology*, *10*(4), 1731–1736. https://doi.org/10.18517/ijaseit.10.4.10857

Suriati, L., Utama, I.M.S., Harsojuwono, B.A. and Gunam, I.B.W. (2020). Ecogel incorporated with nano-additives to increase shelf-life of fresh-cut mango. *Journal of Applied Horticulture*, 22(3), 189–195. https://doi.org/10.37855/jah.2020.v22i03.34

Theapparat, Y., Khongthong, S., Rodjan, P., Lertwittayanon, K., & Faroongsarng, D. (2019). Physicochemical properties and in vitro antioxidant activities of pyroligneous acid prepared from brushwood biomass waste of Mangosteen, Durian, Rambutan, and Langsat. *Journal of Forestry Research*, *30*(3), 1139–1148. https://doi.org/10.1007/S11676-018-0675-9

Toivonen, P. M. A., & Brummell, D. A. (2008). Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. *Postharvest Biology and Technology*, *48*(1), 1–14. https://doi.org/10.1016/j.postharvbio.2007.09.004

Wall, M. M., Sivakumar, D., & Korsten, L. (2011). Rambutan (Nephelium lappaceum L.). *Postharvest Biology and Technology of Tropical and Subtropical Fruits*, *4*, 312-335e. https://doi.org/10.1533/9780857092618.312

Xu, Y., Guan, X., Lin, B., Li, R., & Wang, S. (2021). *Oregano Oil, Epsilon-Polylysine, and Citric Acid Assisted Inactivation of Salmonella in Two Kinds of Tahini during Thermal*

Treatment and Storage. https://doi.org/10.3390/foods10061272
Yousuf, B., & Qadri, O. S. (2020). Preservation of fresh-cut fruits and vegetables by edible coatings. *Fresh-Cut Fruits and Vegetables: Technologies and Mechanisms for Safety Control*, 225–242. https://doi.org/10.1016/B978-0-12-816184-5.00011-2
Zhang, C., Huang, L., Pu, H., & Sun, D. W. (2021). Magnetic surface-enhanced Raman scattering (MagSERS) biosensors for microbial food safety: Fundamentals and applications. *Trends in Food Science and Technology*, *113*, 366–381.
Zhao, H., Fan, Z., Wu, J., & Zhu, S. (2021). Effects of pre-treatment with S-nitrosoglutathione-chitosan nanoparticles on quality and antioxidant systems of fresh-cut apple slices. *LWT*, *139*.