Food Research 9 (6) : 32 - 40 (December 2025)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Improvement of shelf life of strawberry using *Aloe vera* gelatin as an edible coating

[1,*]Ansar, A., [2]Lestarini, I.A. and [3]Hidayati, A.R.

[1]*Department of Agricultural Engineering, Faculty of Food Technology and Agroindustry, University of Mataram, Indonesia*
[2]*Department of Clinical Pathology, Faculty of Medicine, University of Mataram, Indonesia*
[3]*Department of Pharmacology, Faculty of Medicine, University of Mataram, Indonesia*

Article history:
Received: 11 September 2023
Received in revised form: 21 December 2023
Accepted: 12 May 2025
Available Online: 19 November 2025

Keywords:
Aroma,
Color,
Quality,
Postharvest,
Taste,
Weight loss

DOI:
https://doi.org/10.26656/fr.2017.9(6).301

Abstract

Strawberries are a perishable fruit, so a post-harvest processing method is needed that can increase the shelf life of the fruit. The right method to maintain the shelf life of strawberries is edible coating. Therefore, the purpose of this study was to apply *Aloe vera* gelatin (AVG) as an edible coating to increase the shelf life of strawberries. The research was conducted by soaking strawberries in an edible coating solution for 3 min, then storing them in plastic packaging. The results showed that strawberries coated with AVG had a slower reduction in quality parameters than uncoated fruit. The sensory test results showed that the fruit coated with the edible coating still had the taste and aroma of fresh fruit until the 5th day of storage, while those that were not coated with flavor and aroma had only been able to survive on the 2nd day. The ability of AVG as an edible coating to maintain the shelf life of strawberries is the novelty of this research.

1. Introduction

Strawberry (*Fragaria ananassa* Duch.) is in high demand by people all over the world because it has an attractive aroma, taste and color (Giampieri *et al*., 2014; Li *et al*., 2018; Hwang *et al*., 2020). This fruit has a high respiration rate after harvest (Ozcan and Barringer, 2011; Zhang *et al*., 2014). As a result, this fruit has a short shelf life (Chisari *et al*., 2007; Li *et al*., 2020), which can only last 1-2 days at room temperature (Souza *et al*., 2014; Abountiolas *et al*., 2018; Lesme *et al*., 2020). Strawberry fruit is oval-shaped, similar to a tomato, but the skin is scaly (Blanch and Castilo, 2012; Li *et al*., 2019; Abdelmaksoud *et al*., 2020).

Strawberries can be eaten directly or processed into processed products (Alikhani and Garmakhany, 2012; Crecelius *et al*., 2017). Food products from strawberries can be found on the market in various types, such as candy, dodol, syrup, and fruit ice (Patras *et al*., 2009), but the general public still likes fresh strawberries because of the different aroma and taste after being processed into processed products (Xu *et al*., 2006; Watson *et al*., 2020). In addition, the delicious taste and attractive colors of fresh fruit have caused market demand to increase every year (Jouquand *et al*., 2008). In line with this, a method is needed to maintain the shelf life of strawberries so that they have a longer shelf life (Liu and Peng, 2017; Amiri *et al*., 2021).

In recent years, research on edible coatings for fresh fruit has become more focused on making coatings from plant sources (Nor and Ding, 2020). This is in line with the desires of consumers who demand reduced use of chemicals and look for natural ingredients that can be used as coatings (Yong *et al*., 2022). At present, there are various types of coatings that have been developed to increase fruit shelf life (Shetty *et al*., 2018; Thakur *et al*., 2019). Each coating material has different advantages and disadvantages depending on fruit varieties (Zambrano-Zaragoza *et al*., 2018).

Increasing the shelf life of fruit using the edible coating method has been developed by previous researchers (Galus and Kadzinska, 2015). This method is a thin coating technique to inhibit the growth of fungi and bacteria, so that fruit shelf life can increase (Davoodi *et al*., 2020). The main edible coating material must be made from plants that can be consumed safely (food grade) (Liu *et al*., 2013; Kim *et al*., 2016).

Several compounds have been applied as edible coatings, such as polysaccharides, proteins, lipids and composite-based layers (Malaka *et al*., 2017; Hassan *et*

*Corresponding author.
Email: *ansar72@unram.ac.id*

eISSN: 2550-2166 / © 2025 The Authors.
Published by Rynnye Lyan Resources

al., 2018). The use of edible coatings cannot replace the use of traditional packaging material. However, this method has advantages in certain applications (Hanani *et al*., 2018). Most coatings are formulated as liquid solutions to regulate humidity, solutes and gas exchange between the internal and external atmosphere (Ncama *et al*., 2018; Hamid *et al*., 2020). The functional properties of edible coating can be improved by adding antimicrobial compounds (Warkoyo *et al*., 2022). Some researchers have used this antimicrobial compound and have proven it to be effective in improving mechanical properties and reducing water vapor permeability (Motamedi *et al*., 2018; Ansar *et al*., 2022).

Commonly used edible coating materials are synthetic materials that can interfere with health (Saucedo-Pompa *et al*., 2009). Even though abundant plants are available that can be used as raw materials for making edible coatings. One of them is *Aloe vera,* which contains phenolic compounds that can be used as antioxidants because they can inhibit the growth of pathogenic microorganisms in the fruit (Mendy *et al*., 2019). Phenolic compounds are secondary metabolites found in the *Aloe vera* plant and have been applied to the food and drug industries as antioxidants, antimicrobials, antivirals and anti-inflammatories (Banerjee and Bose, 2019).

Improvement of postharvest handling using edible coating methods to extend fruit shelf life is very important. Maintaining post-harvest fruit quality is a complex process because fruit tends to lose quality during storage and distribution to consumers (Ansar *et al*., 2019). Therefore, this study aimed to apply AVG as an edible coating to increase the shelf life of strawberries. The new thing from this research is the application of edible coating on strawberries using AVG as a coating material without using other additives. This s important because it is able to protect fruit from decay due to microbial attack. In addition, the fruit that is coated with AVG can look fresher.

2. Materials and methods

2.1 Materials and experimental design

The research sample was the Sweet Charlie variety strawberry obtained from the farmer in Mataram, West Nusa Tenggara, Indonesia. In the laboratory, 300 pieces were selected with homogeneous colors and sizes and not injured. One hundred fruits were used for the analyses of their properties at harvest, and the rest were coated with AVG (pharmaceutical quality, 100% purity) produced at the Bioprocess Engineering Laboratory, Mataram University, Indonesia. AVG was diluted using mineral water to produce 3 different concentration variations, namely 10% (AVG-1), 20% (AVG-2) and 30% (AVG-3). Each sample was immersed for 3 min in AVG at a temperature of 29±2°C. After treatment, strawberries were air-dried, divided randomly into 7 groups (mean mass 300 g) and stored at 29±2°C and RH at 80-90%. Each group for treatment and control fruit was excluded due to the need for fruit quality analysis every day during storage.

2.2 Color

Strawberry fruit color was measured by using the Hunter Lab System and the Minolta colorimeter CR200TM model (Minolta Camera Co., Osaka, Japan). The observed sample color consisted of lightness (L*), green to red (a*) and blue to yellow (b*). It is measurement using the Hunter L* a* b* system (Ansar *et al*., 2020).

For lightness was defined as:

$$L* = L*_d - L*_f$$

For redness was defined as:

$$a* = a*_d - a*_f$$

For yellowness was defined as:

$$b* = b*_d - b*_f$$

Where, L* = lightness (L* = 0 for black, L* = 100 for white), a* = green-red (a*<0 for green, a*>0 for red), b* = blue-yellow (b*<0 for blue, b*>0 for yellow), subscript ‘f’ refers to fresh weight and ‘d’ to the values of after storage.

2.3 Weight loss

The weight loss of the strawberry fruit was measured before and after storage using the following equation:

$$Weight\ loss = \frac{w_f - w_s}{w_f} \times 100\%$$

where, wf = mass of strawberry fruit before storage (grams), ws = mass of strawberry fruit after storage (grams).

2.4 Texture

The strawberry fruit texture was measured using a texture analyzer (Brookfield, UK). The loading was carried out from the vertical axis with a compression speed of 4 mm/s and a compressibility level of 30%. Each test was repeated 3 times. The deformation curve of the test results was recorded in real-time.

2.5 Sensory evaluation

A sensory evaluation was conducted to compare the aroma and taste qualities of coated and uncoated fruit. This evaluation used a panel of 20 people aged 25 to 45

https://doi.org/10.26656/fr.2017.9(6).301

years. Panelists were trained in the pre-test to assess the aroma and taste characteristics of strawberries with a rating scale of 1-5. The ratings for aroma are: 5 = very fresh, 4 = slightly fresh, 3 = less fresh, 2 = slightly rancid, and 1 = smell rancid. The rating scale for taste are: 5 = very sweet, 4 = very sweet, 3 = slightly sweet, 2 = slightly sour, and 1 = very sour.

2.6 Data analysis

Data was presented in tables and graphs. Comparisons between different treatment groups were carried out using one-way analysis of variance (ANOVA). All statistical analyzes were performed using Data Processing Systems (DPS) statistical software. A *P*-value <0.05 was considered statistically significant (Ansar *et al*., 2021).

3. Results and discussion

3.1 Strawberry color

The results of measuring the color of strawberries in various treatments are shown in Figure 1. After storage, it can be seen that the samples without edible coating experienced a faster color change than the samples the edible coating. The color of the fruit that is not given an edible coating is dark, although it still shows the specific color of the strawberry. The most attractive fruit color was in the AVG-3 treatment with bright colors. This is presumably because aloe vera gel, as an edible coating, can protect the color of strawberries during storage.

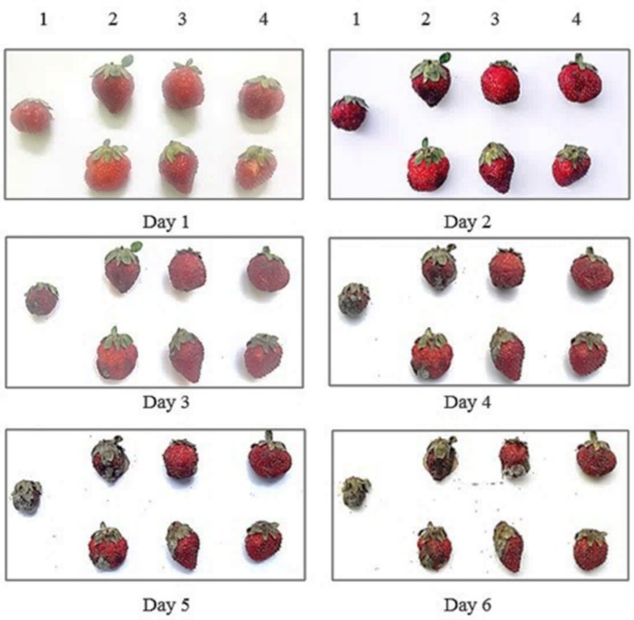

Figure 1. Effect of an edible coating on the strawberries during storage at room temperature (29±2°C). In the first column, representing the control sample, was AVG-0, the second column was AVG-1, the third column was AVG-2, and the fourth column was AVG-3.

The observations showed that all samples underwent color changes during storage. However, uncoated fruit suffered very high damage compared to coated fruit (Figure 1). This data is in line with the reports by Gol *et al.* (2015), which state that edible coatings from polysaccharides are able to prevent discoloration in lychees, tomatoes, papayas and apples. Liu *et al.* (2017) also reported that the use of edible coatings can inhibit the discoloration of apples because the coating is able to delay the ripening process. The benefits of using AVG as an edible coating have been proven by Mendy *et al.* (2019) that edible coating can maintain the color and texture of papaya in a fresh condition.

Based on Figure 1, it can be seen that the strawberries stored on AVG-1 and AVG-2 have decreased brightness on the 3rd day, whereas on the AVG -3 treatment, the brightness begins to decrease on the 5th day. This data shows that strawberries coated with edible coating have a significant influence (P<0.05) on fruit brightness. The treatment without coating (AVG-0) shows the greatest decrease in brightness because it does not have a coating that can inhibit the rate of damage. This data is in accordance with the results of research by Zahedi *et al.* (2019), who reported that mangoes stored without an edible coating decompose faster because the respiration process takes place quickly, whereas those using an edible coating, enzymatic browning reactions run slower.

The use of AVG at a concentration of 30% can maintain the lightness (L*) of strawberries compared to concentrations of 20 and 10% (Figure 2). These data indicate that aloe vera as an edible coating is able to maintain the brightness of the strawberry color. Some of the results of previous studies have also reported the same thing that brightness is an excellent index for evaluating colors in fruit. Barrett *et al.* (2010) reported that acetic acid-based edible coatings can maintain the color of garlic during storage. Similarly, edible coatings from chitosan can also reduce pineapple discoloration during storage, as reported by George *et al.* (2017).

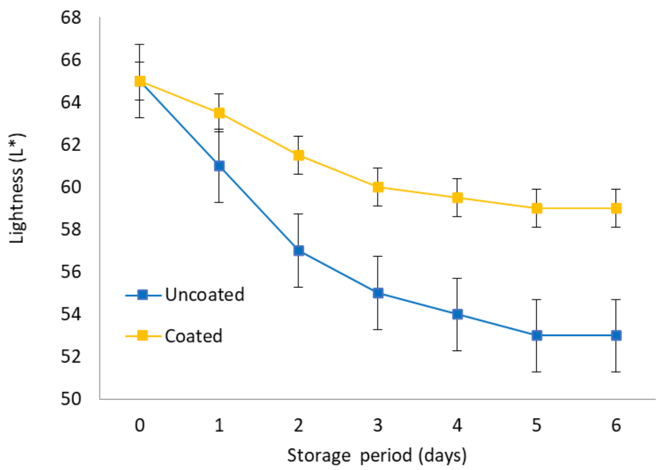

Figure 2. A lightness color change (L*) of strawberries during storage at room temperature.

https://doi.org/10.26656/fr.2017.9(6).301

Strawberries stored using an edible coating showed better brightness compared to those without an edible coating. This shows that edible coating is able to maintain the freshness of strawberries. The same research results have been revealed by Li *et al.* (2017) that strawberries that are stored without an edible coating are very prone to decay because it has been contaminated directly with dust, which can trigger the growth of spoilage bacteria. Yan *et al*. (2019) showed very good results from the addition of antimicrobials combined with edible coatings, so that fruit browning was inhibited.

During storage, it was also seen that all the research samples changed color. The highest color change occurred in the AVG-0 treatment, and the lowest was in the AVG-3 treatment. After 2 days of storage, the color of the sample has not changed much. Changes increased drastically starting on day 2 for AVG-1, and day 3 for AVG-2 and AVG-3. These data indicate that aloe vera gel as an edible coating can inhibit enzymatic reactions in samples during storage. The results of the study are in line with what has been reported by Corduas *et al.* (2013), that the use of edible coatings can inhibit the rate of color change in fruit.

Color is an important attribute and is most easily seen to detect the quality and extent of fruit damage (Aamer *et al*., 2021). Damaged fruit has a distinctive color that is different from fresh fruit. The appearance of colors that are not suitable for fruit indicates a loss of freshness or damage. Consumers generally have certain preferences that are taken into consideration when they want to buy fruit.

3.2 Weight loss

Weight loss can damage fruit tissue and disrupt various physiological processes that can cause a decrease in fruit quality. Weight loss is driven by the water potential gradient between the fruit surface and the surrounding air. Prevention of weight loss can be done with an edible coating. This coating forms a barrier to the transmission of water vapor by maintaining surface moisture, thereby reducing water vapor pressure. Some researchers have proven a reduction in weight loss by using edible coatings (Yan *et al*., 2019).

All samples in this study showed a decrease in weight loss during storage (Figure 3). The highest weight loss occurred in the AVG-0 treatment, and the lowest was in the AVG-3 treatment. At the beginning of storage, the weight loss of the sample is still constant, then decreases dramatically starting on day 3 for AVG-0 and day 5 for AVG-3. The use of AVG as an edible coating can prevent loss of sample water content. Weight loss control during storage is very important so that the quality of the fruit is maintained. Many researchers have reported the benefits of using edible coatings to control fruit weight loss during storage. Mendy *et al.* (2019) reported that the use of lipid-based edible coatings can inhibit the weight loss of papaya fruit. Arroyo *et al.* (2020) using alginate and chitosan in edible coating formulations can reduce the weight loss in quavers because this coating can prevent water evaporation.

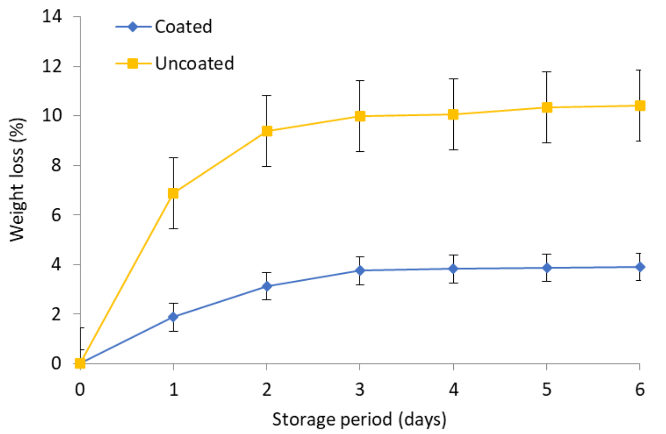

Figure 3. The weight loss changes in strawberries during storage at room temperature.

It was estimated that around 20-75% of fruit weight loss occurs during storage if not using edible coatings that comply with standards. Weight loss can occur at any post-harvest and distribution stages. This has led to low consumer acceptance of fruit (Arah *et al*., 2015). In fact, Barrett *et al.* (2010) have identified the initial loss in fruit weight that occurs during the harvest stage by 18-28%. This loss will continue to occur during storage, transportation, marketing and trade. These losses have a major impact on fruit farmers, consumers, and the income of exporting countries (Nor and Ding, 2020). For example, the Philippines suffered losses of around 27-42%, 15-35% in Malaysia, 20-25% in Indonesia, 17-35% in Thailand, and 20-25% in Vietnam (Mendy *et al*., 2019). The main cause of these losses is that the fruit is prone to loss of water, so it must be coated with an edible coating.

3.3 Texture of strawberries

Texture is one of the important parameters for assessing the quality and shelf life of fruit. The results of measurements of strawberry texture during storage are shown in Figure 4.

Figure 4 shows the different strawberry textures in each coating treatment. Strawberries in the AVG-0 treatment had a lower texture than the other treatments. The highest strawberry texture on AVG-3 was caused by the inhibited respiration process, so that evaporation of water content was also inhibited. Whereas the AVG-0

https://doi.org/10.26656/fr.2017.9(6).301

sample decreased texture faster because strawberries experienced a faster metabolic process. In line with the results of this study, Fan *et al*. (2019) have succeeded in extending the shelf life of star fruit until 21 days of storage by using an edible coating.

Changes in the texture of strawberries are influenced by turgor pressure through an overhaul of the components of the cell wall, so that the strawberries become softer. According to Li *et al*. (2017), during storage, there will be changes in protopectin, which is not water-soluble to water-soluble, so that the cohesion of cell walls with other cells continues to decline, and as a result, the texture of the fruit becomes soft. Ncama *et al*. (2018) also reported that texture changes can occur in fruit from hard to soft due to water loss during respiration and transpiration.

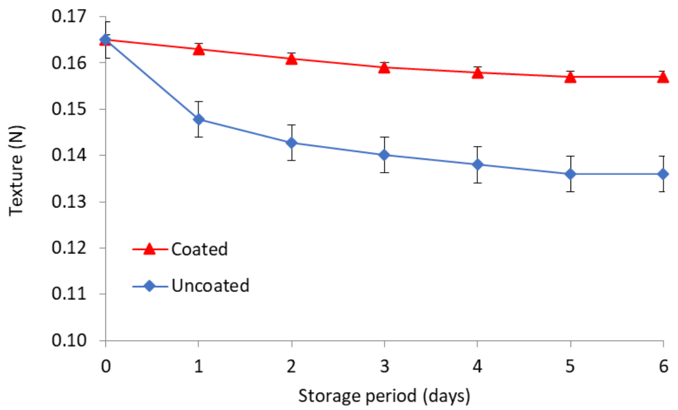

Figure 4. Change in texture of the strawberries during storage at room temperature.

Texture is an important parameter to determine fruit quality and shelf life. The decrease in texture shows a decrease in fruit quality (Motamedi *et al*., 2018; Ansar *et al*., 2020). A good coating must provide adequate texture strength and be free from minor defects. This attribute can be achieved by having a flexible edible coating that is resistant to mechanical impacts (Senna *et al*., 2014). Compressive strength is the parameter that leads to this property. Important factors for texture according to Menezes and Athmaselvi (2016) include polymer structure, type of plasticizer, plasticizer concentration, molecular weight of the coating material, type of solvent and layer thickness. The structural cohesion of edible coatings contributes significantly to the effect of the mechanical properties of the coating. The ability of edible coatings to form many strong molecular bonds between polymer chains can inhibit the separation between fruit cells.

3.4 Aroma of strawberry

The results of the panellists' assessment of the aroma of strawberries at various concentrations of AVG during storage are presented in Figure 5. The scent of strawberries that was most liked by the panellists was that of a very fresh fruit aroma in the AVG-3 treatment, and the one that was disliked was a slightly rancid aroma found in AVG-0. This data shows that the AVG as an edible coating can keep the strawberry aroma fresh. The results of this study are in line with the research of Mendy *et al.* (2019), who reported that the edible coating of CMC and gum can retain fruit aroma for 120 days stored at 4°C.

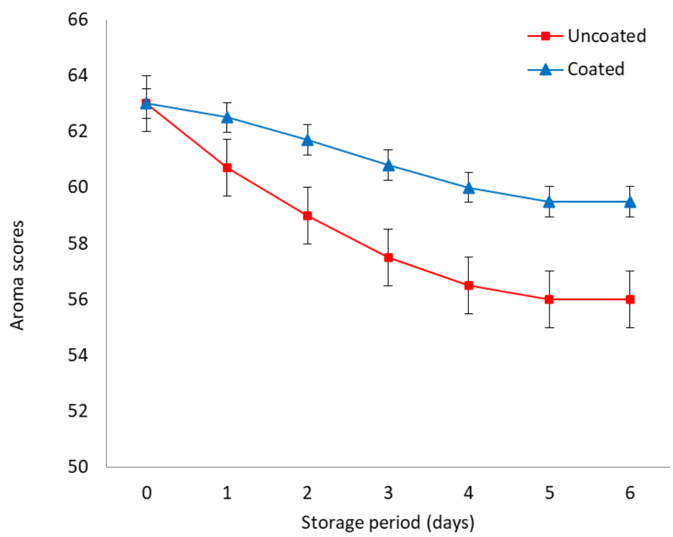

Figure 5. The results of panellists' assessment of the strawberries' aroma during storage.

The use of edible coating on strawberries has been shown to retain the aroma of the fruit, so that they do not easily rot due to oxidation reactions. This also shows that the edible coating is able to cover the surface of the fruit and prevent the evaporation of moisture content, so that the fruit smells fresh. The same thing has been reported by Peng *et al.* (2013) that the edible coating can act as a permeable membrane against the exchange of O_2 and CO_2, so that it can retain the fruit aroma. Another thing that needs to be explained is that strawberries without an edible coating, according to the panellists' assessment, have an unpleasant aroma, which began to occur on the 3rd day. This is thought to be because oxygen readily absorbs into the fruit, which can cause an unpleasant aroma. This unpleasant aroma is thought to be because the respiration rate is not inhibited, resulting in a rapid decay process.

3.5 Taste of strawberry

The results of the panellists' assessment of the taste of strawberries at various concentrations of AVG showed that strawberries without edible coating had a lower value than strawberries that were given an edible coating, and there was a significant difference ($P<0.05$). The taste of strawberries without edible coating was considered less sweet starting on the 3rd day of storage. Strawberries coated with an edible coating have a very

https://doi.org/10.26656/fr.2017.9(6).301

sweet taste according to the panellist's assessment in the AVG-3 treatment. This is thought to be because AVG, as an edible coating, is able to maintain the sugar content in strawberries. The same has been reported by Souza *et al*. (2014) that AVG can retain the sweetness of the fruit during storage.

The results of the panellists 'assessment of the taste of strawberries showed that the higher the AVG concentration, the higher the panellists' assessment scores (Figure 6). The highest value was obtained in strawberries coated with 30% AVG concentration, and the lowest was in the strawberry treatment without an edible coating. This happened because the sweet taste did not evaporate during storage at the 30% concentration of AVG treatment. The same has been reported by Lesme *et al*. (2020) that fruit that has been coated with an edible coating has a fresher taste and is preferred by panellists than fruit without coating.

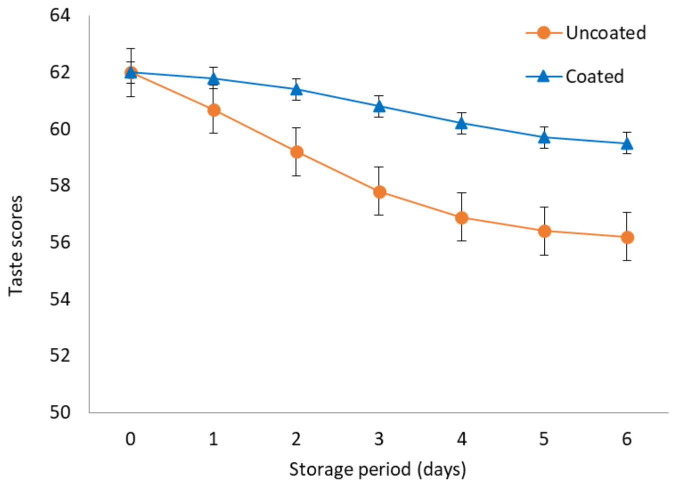

Figure 6. The results of panellists' assessment of the strawberries' taste during storage.

Like other fresh fruit quality parameters, taste is an important quality attribute that can determine consumer acceptance. Strawberry fruit has a distinctive taste because there are volatile compounds (Guarino and Sciarrillo, 2018). These compounds are generally volatile during storage. Therefore, the use of edible coating is important to maintain the taste of strawberries during storage.

4. Conclusion

AVG can be used as an edible coating to maintain strawberry characteristics such as color, texture, weight loss, aroma, and taste. The shelf life of strawberries can be up to 5 days using an AVG as an edible coating. There is a significant difference between fruit coated with fruit not coated with AVG in the shelf life of strawberries. AVG can be used as an edible coating to increase the shelf life of the strawberries.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgments

Thank you to the Dean of the Faculty of Food Technology and Agroindustry, University of Mataram, for the facilities provided for conducting this research.

References

Aamer, R.A., Amin, W.A. and Attia, R.S. (2021). Enhancement of color stability in strawberry nectar during storage. *Annals of Agricultural Sciences,* 66 (3), 121-130. https://doi.org/10.1016/j.aoas.2021.08.003

Abdelmaksoud, E.M., El-Refai, S.A., Mahmoud, K.W. and Ragab, M.E. (2020). Susceptibility of some new strawberry genotypes to infestation by western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) in the nursery. *Annals of Agricultural Sciences,* 65(4), 144-148. https://doi.org/10.1016/j.aoas.2020.08.002

Abountiolas, M., Kelly, K., Yagiz, Y., Li, Z., Mahnken, G., Borejsza-Wysocki, W. and do Nascimento Nunes, M.C. (2018). Sensory quality, physicochemical attributes, polyphenol profiles, and residual fungicides in strawberries from different disease-control treatments. *Journal of Agricultural and Food Chemistry,* 66(27), 6986-6996. https://doi.org/10.1021/acs.jafc.8b02153

Alikhani, M. and Garmakhany, A.D. (2012). Effect of microencapsulated essential oils on storage life and quality of strawberry (*Fragaria ananassa* cv. Camarosa). *Quality Assurance and Safety of Crops and Foods,* 4(2), 106-112. https://doi.org/10.1111/j.1757-837X.2012.00128.x

Amiri, A., Mortazavi, S.H., Ramezanian, A., Sourestani, M.M., Ramezanian, A., Mottaghipisheh, J., Iriti, M. and Vitalini, S. (2021). Prevention of decay and maintenance of bioactive compounds in strawberry by application of UV-C and essential oils. *Journal of Food Measurement and Characterization,* 15(1), 5310-5317. https://doi.org/10.1007/s11694-021-01095-2

Ansar, Nazaruddin and Azis, A.D. (2020). New frozen product development from strawberries (*Fragaria Ananassa* Duch.). *Heliyon,* 6(9), e05118. https://doi.org/10.1016/j.heliyon.2020.e05118

Ansar, A., Murad, M., Sukmawaty, S. and Ilmaknun, L. (2022). Comparison of the mass tissue strength of strawberry fruit between vertical and horizontal compaction. *Food Research,* 6(3), 107-114. https://doi.org/10.26656/fr.2017.6(3).373

Ansar, Nazaruddin and Azis, A.D. (2019). Effect of vacuum freeze-drying condition and maltodextrin on the physical and sensory characteristics of passion fruit (*Passiflora edulis* Sims) extract. Makassar, *IOP Conference Series: Earth and Environmental Science*, 2(1), 012067. https://doi.org/10.1088/1755-1315/355/1/012067

Ansar, Nazaruddin, Azis, A.D. and Fudholi, A. (2021). Enhancement of bioethanol production from palm sap (*Arenga pinnata* (Wurmb) Merr) through optimization of *Saccharomyces cerevisiae* as an inoculum. *Journal of Materials Research and Technology,* 14(5), 548-554. https://doi.org/10.1016/j.jmrt.2021.06.085

Arah, I.K., Amaglo, H., Kumah, E.K. and Ofori, H. (2015). Pre-harvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: A mini review. *International Journal of Agronomy,* 6 (1), 478041. https://doi.org/10.1155/2015/478041

Arroyo, B.J., Bezerra, A.C., Oliveira, L.L., Arroyo, S.J., Melo, E.A. and Santos, A.P. (2020). Antimicrobial active edible coating of alginate and chitosan add ZnO nanoparticles applied in guavas (*Psidium guajava* L.). *Food Chemistry,* 309(3), 125566. https://doi.org/10.1016/j.foodchem.2019.125566

Banerjee, D. and Bose, S. (2019). Effects of aloe vera gel extract in doped hydroxyapatite coated titanium implants on *in vivo* and *in vitro* biological properties. *ACS Applied Bio Materials,* 2(8), 3194-3202. https://doi.org/10.1021/acsabm.9b00077

Barrett, D.M., Beaulieu, J.C. and Shewfelt, R. (2010). Color, flavor, texture, and nutritional quality of fresh-cut fruits and vegetables: Desirable levels, instrumental and sensory measurement, and the effects of processing. *Critical Reviews in Food Science and Nutrition,* 50(5), 369-389. https://doi.org/10.1080/10408391003626322

Blanch, G.P. and Castilo, M.L. (2012). Changes in strawberry volatile constituents after pre-harvest treatment with natural hormonal compounds. *Flavour and Fragrance Journal,* 27(1), 180-187. https://doi.org/10.1002/ffj.3086

Chisari, M., Riccardo, N.B. and Spagna, G. (2007). Characterization of polyphenol oxidase and peroxides and influence on browning of cold-stored strawberry fruit. *Journal of Agriculture and Food Chemistry,* 55 (1), 3469-3476. https://doi.org/10.1021/jf063402k

Corduas, M., Cinquanta, L. and Ievoli, C. (2013). The importance of wine attributes for purchase decisions: A study of Italian consumers' perception. *Food Quality and Preference,* 28(2), 407-418. https://doi.org/10.1016/j.foodqual.2012.11.007

Crecelius, A.C., Holscher, D., Hoffmann, T., Schneider, B., Fischer, T.C., Hanke, M.V. and Schubert, U.S. (2017). Spatial and Temporal Localization of Flavonoid Metabolites in Strawberry Fruit (Fragaria × ananassa). *Journal of Agricultural and Food Chemistry,* 65(17), 3559-3568. https://doi.org/10.1021/acs.jafc.7b00584

Davoodi, S., Davachi, S.M., Golkhajeh, A.G., Shekarabi, A.S. and Abbaspourrad, A. (2020). Development and characterization of *Salvia macrosiphon*/chitosan edible films. *ACS Sustainable Chemistry and Engineering,* 8(3), 1487-1496. https://doi.org/10.1021/acssuschemeng.9b05894

Fan, X.J., Zhang, B., Yan, H., Feng, J.T., Ma, Z.Q. and Zhang, X. (2019). Effect of lotus leaf extract incorporated composite coating on the postharvest quality of fresh goji (*Lycium barbarum* L.) fruit. *Postharvest Biology and Technology,* 148(1), 132-140. https://doi.org/10.1016/j.postharvbio.2018.10.020

Galus, S. and Kadzińska, J. (2015). Food applications of emulsion-based edible films and coatings. *Trends in Food Science and Technology,* 45(2), 273-283. https://doi.org/10.1016/j.tifs.2015.07.011

George, H. C., Renato, L.D., Alex, S.B., Luciana, G.S., Raylson, D.S., Rosana, S.D., Renato, P.L., Rejane, M.N., Randolph, M.B. and Silvanda, D.M. (2017). Impact of cassava starchalginate based coatings added with ascorbic acid and elicitor on quality and sensory attributes during pineapple storage. *African Journal of Agricultural Research,* 12(9), 664-673. https://doi.org/10.5897/AJAR2016.11652

Giampieri, F., Alvarez Suarez, J. and Battino, M. (2014). Strawberry and human health: Effects beyond antioxidant activity. *Journal of Agricultural and Food Chemistry,* 62(18), 3867-3876. https://doi.org/10.1021/jf405455n

Gol, N., Chaudhari, M. and Rao, T.V. (2015). Effect of edible coatings on quality and shelf life of carambola (*Averrhoa carambola* L.) fruit during storage. *Journal of Food Science and Technology,* 52(1), 78-91. https://doi.org/10.1007/s13197-013-0988-9

Guarino, C. and Sciarrillo, R. (2018). The identification of allergen proteins in two different varieties of strawberry by two different approaches: Proteomic and Western blotting method. *Annals of Agricultural Sciences,* 63(1), 181-189. https://doi.org/10.1016/j.aoas.2018.11.003

Hamid, H.A., Nurrulhidayah, A.F., Sani, M.A., Muhammad, N.F., Othman, R. and Rohman, A. (2020). Discrimination of porcine and bovine gelatines based on reducing sugar types on Maillard reaction. *Food Research,* 4(2), 301-306. https://doi.org/10.26656/fr.2017.4(2).297

Hanani, Z.N., Husna, A.A., Syahida, S.N., Khaizura, M.N. and Jamilah, B. (2018). Effect of different fruit peels on the functional properties of gelatin/polyethylene bilayer films for active packaging. *Food Packaging and Shelf Life,* 18(2), 201-211. https://doi.org/10.1016/j.fpsl.2018.11.004

Hassan, B., Ali, S., Chatha, S., Hussain, A.I., Zia, K.M. and Akhtar, N. (2018). Recent advances on polysaccharides, lipids and protein based edible films and coatings: A review. *International Journal of Biological Macromolecules,* 109(2), 1095-1107. https://doi.org/10.1016/j.ijbiomac.2017.11.097

Hwang, E.J., Jeong, S.Y., Kim, M.J., Jeong, J.S., Lee, K.H., Jeong, N.R. and Kim, I. (2020). Year-round trap capture of the spotted-wing drosophila, *Drosophila suzukii* (Diptera: Drosophilidae), in Korean strawberry greenhouses. *Journal of Asia-Pacific Entomology,* 23(1), 204-213. https://doi.org/10.1016/j.aspen.2020.01.004

Jouquand, C., Chandler, C., Plotto, A. and Goodner, K. (2008). A sensory and chemical analysis of fresh strawberries over harvest dates and seasons reveals factors that affect eating quality. *Journal of The American Society for Horticultural Science,* 133(6), 859-867. https://doi.org/10.21273/JASHS.133.6.859

Kim, D.K., Sim, B.R. and Khang, G. (2016). Nature-derived aloe vera gel blended silk fibroin film scaffolds for cornea endothelial cell regeneration and transplantation. *ACS Applied Materials and Interfaces,* 8(24), 15160-15168. https://doi.org/10.1021/acsami.6b04901

Lesme, H., Courcoux, P., Alleaume, C., Famelart, M.H., Bouhallab, C., Prost, C. and Rannou, C. (2020). Contribution of temporal dominance of sensations performed by modality (M-TDS) to the sensory perception of texture and flavor in semi-solid products: a case study on fat-free strawberry yogurts. *Food Quality and Preference,* 80(1), 103789. https://doi.org/10.1016/j.foodqual.2019.103789

Li, D., Zhang, X., Qu, H., Li, L., Mao, B., Xu, Y., Lin, X. and Luo, Z. (2020). Delaying the biosynthesis of aromatic secondary metabolites in postharvest strawberry fruit exposed to elevated CO_2 atmosphere. *Food Chemistry,* 306(3), 125611. https://doi.org/10.1016/j.foodchem.2019.125611

Li, L., Sun, J., Gao, H., Shen, Y., Li, C., Yi, P., He, X., Ling, D., Sheng, J., Li, J., Liu, G., Zheng, F., Xin, M., Li, Z. and Tang, Y. (2017). Effects of polysaccharide-based edible coatings on quality and antioxidant enzyme system of strawberry during cold storage. *International Journal of Polymer Science,* 4(1), 9746174. https://doi.org/10.1155/2017/9746174

Li, M., Li, X., Han, C., Ji, N., Jin, P. and Zheng, Y. (2019). Physiological and metabolomic analysis of cold plasma treated fresh-cut strawberries. *Journal of Agricultural and Food Chemistry,* 67(14), 4043-4053. https://doi.org/10.1021/acs.jafc.9b00656

Li, M., Li, X., Li, J., Ji, Y., Han, C., Jin, P. and Zheng, Y. (2018). Responses of fresh-cut strawberries to ethanol vapor pretreatment: Improved quality maintenance and associated antioxidant metabolism in gene expression and enzyme activity levels. *Journal of Agricultural and Food Chemistry,* 66(31), 8382-8390. https://doi.org/10.1021/acs.jafc.8b02647

Liu, B. and Peng, B. (2017). Modelling and Optimization of Process Parameters for Strawberry Osmotic Dehydration Using Central Composite Rotatable Design. *Journal of Food Quality,* 2017(1), 2593213. https://doi.org/10.1155/2017/2593213

Liu, F., Jiang, Y., Du, B., Chai, Z., Jiao, T., Zhang, C. and Leng, X. (2013). Design and characterization of controlled-release edible packaging films prepared with synergistic whey-protein polysaccharide complexes. *Journal of Agricultural and Food Chemistry,* 61(24), 5824-5833. https://doi.org/10.1021/jf4009923

Liu, R., Liu, D., Liu, Y., Song, Y., Wu, T. and Zhang, M. (2017). Using soy protein SiOx nanocomposite film coating to extend the shelf life of apple fruit. *International Journal Food Science and Technology,* 52(5), 2018–2030. https://doi.org/10.1111/ijfs.13478

Malaka, R., Hatta, W. and Baco, S. (2017). Evaluation of using edible coating and ripening on Dangke, a traditional cheese of Indonesia. *Food Research,* 1(2), 51-56. https://doi.org/10.26656/fr.2017.2.006

Mendy, T.K., Misran, A., Mahmud, T.M. and Ismail, S.I. (2019). Application of aloe vera coating delays ripening and extend the shelf life of papaya fruit. *Scientia Horticulturae,* 246(2), 769-776. https://doi.org/10.1016/j.scienta.2018.11.054

Menezes, J. and Athmaselvi, K.A. (2016). Polysaccharide based edible coating on sapota fruit. *International Agrophysics,* 30(4), 551-557. https://doi.org/10.1515/intag-2016-0019

Motamedi, E., Nasiri, J., Ranjbar, T.M., Kalantari, S., Naghavi, M.R. and Safari, M. (2018). Performance of carnauba wax-nanoclay emulsion coatings on postharvest quality of 'Valencia' orange fruit. *Scientia Horticulturae,* 24(1), 170-178. https://doi.org/10.1016/j.scienta.2018.06.002

Ncama, K., Magwaza, L.S., Mditshwa, A. and Tesfay, S.Z. (2018). Plant-based edible coatings for managing postharvest quality of fresh horticultural produce: A review. *Food Packaging and Shelf Life,* 16(4), 157-167. https://doi.org/10.1016/j.fpsl.2018.03.011

Nor, M.S. and Ding, P. (2020). Trends and advances in edible biopolymer coating for tropical fruit: A review. *Food Research International*, 134, 109208. https://doi.org/10.1016/j.foodres.2020.109208

Ozcan, G. and Barringer, S. (2011). Effect of enzymes on strawberry volatiles during storage, at different ripeness levels, in different cultivars, and during eating. *Journal of Food Science,* 76(2), 324-334. https://doi.org/10.1111/j.1750-3841.2010.01999.x

Patras, A., Brunton, N.P., Pieve, S.D. and Butler, F. (2009). Impact of high-pressure processing on total antioxidant activity, phenolic, ascorbic acid, anthocyanin content and color of strawberry and blackberry purees. *Innovative Food Science and Emerging Technology* 10(1), 308-313. https://doi.org/10.1016/j.ifset.2008.12.004

Peng, Y., Li, Y. and Yin, Y. (2013). Effects of edible coatings on some quality parameters of Chinese water chestnut (Eleocharis tuberosa) during storage. *International Journal of Food Science and Technology,* 48(7), 1404-1409. https://doi.org/10.1111/ijfs.12102

Saucedo-Pompa, S., Rojas-Molina, R., Aguilera-Carbo, A.F., Saenz-Galindo, A., Garza, H.L., Jasso-Cantú, D. and Aguilar, C.N. (2009). Edible film based on candelilla wax to improve the shelf life and quality of avocado. *Food Research International,* 42(4), 511-515. https://doi.org/10.1016/j.foodres.2009.02.017

Senna, M.H., Al-Shamrani, K.M. and Al-Arifi, A.S. (2014). Edible coating for shelf-life extension of fresh banana fruit based on gamma irradiated plasticized poly (vinyl alcohol)/carboxymethyl cellulose/tannin composites. *Materials Sciences and Applications,* 5 (5), 395-415. https://doi.org/10.4236/msa.2014.56045

Shetty, M., Geethalekshmi, P.R., Mini, C. and Beena, R. (2018). Relationship of waxing treatments to certain physiological, browning and sensory characteristics of rambutan (*Nephelium lappaceum* L.). *International Journal of Pure and Applied Bioscience,* 6(1), 265-271. https://doi.org/10.18782/2320-7051.6048

Souza, V.R., Pereira, P.A., Silva, T.L., Lima, L.C. and Pio, R. (2014). Determination of the bioactive compounds, antioxidant activity and chemical composition of Brazilian blackberry, red raspberry, strawberry, blueberry, and sweet cherry fruits. *Food Chemistry,* 56(1), 362-368. https://doi.org/10.1016/j.foodchem.2014.01.125

Thakur, R., Pristijono, P., Bowyer, M., Singh, S.P., Scarlett, C.J., Stathopoulos, C.E. and Vuong, Q.V. (2019). A starch edible surface coating delays banana fruit ripening. *LWT-Food Science and Technology,* 100(3), 341–347. https://doi.org/10.1016/j.lwt.2018.10.055

Warkoyo, P.I., Siskawardani, D.D. and Hasna, A. (2022). The effect of konjac glucomannan and Aloe vera gel concentration on physical and mechanical properties of edible film. *Food Research,* 6(3), 298-305. https://doi.org/10.26656/fr.2017.6(3).415

Watson, T.T., Noling, J.W. and Desaeger, J.A. (2020). Fluopyram as a rescue nematicide for managing sting nematode (*Belonolaimus longicaudatus*) on commercial strawberry in Florida. *Crop Protection,* 132(4), 105108. https://doi.org/10.1016/j.cropro.2020.105108

Xu, Y., Zhang, M., Mujumdar, A.S., Duan, X. and Jin-cai, S. (2006). A two-stage vacuum freeze and convective air-drying method for strawberries. *Drying Technology: An International Journal,* 24(8), 1019-1023. https://doi.org/10.1080/07373930600776209

Yan, J., Luo, Z., Ban, Z., Lu, H., Li, D., Yang, D., Aghdam, M.S. and Li, L. (2019). The effect of the layer-by-layer (LBL) edible coating on strawberry quality and metabolites during storage. *Postharvest Biology and Technology,* 147(2), 29-38. https://doi.org/10.1016/j.postharvbio.2018.09.002

Yong, Y.Y., Mohd Adzahan, N., Abas, F., Kim, D.O. and Kamarul Zaman, A.A. (2022). Alginate and *Aloe vera* gel-based edible coating for the storage stability enhancement of fresh-cut MD2 pineapple. *Food Research,* 6(5), 380-389. https://doi.org/10.26656/fr.2017.6(5).628

Zahedi, S., Hosseini, M., Karimi, M. and Ebrahimzadeh, A. (2019). Effects of postharvest polyamine application and edible coating on maintaining quality of mango (*Mangifera indica* L.) cv. Langra during cold storage. *Food Science and Nutrition,* 7(2), 433-441. https://doi.org/10.1002/fsn3.802

Zambrano-Zaragoza, M.L., Ricardo, G.R., Mendoza-Muñoz, N., Miranda-Linares, V., Bernal-Couoh, T.F., Mendoza-Elvira, S. and Quintanar-Guerrero, D. (2018). Nanosystems in edible coatings: A novel strategy for food preservation. *International Journal of Molecular Science,* 19(3), 705. https://doi.org/10.3390/ijms19030705

Zhang, H., Ge, L., Chen, K., Zhao, L. and Zhang, X. (2014). Enhanced Biocontrol Activity of *Rhodotorula mucilaginosa* Cultured in Media Containing Chitosan against Postharvest Diseases in Strawberries: Possible Mechanisms Underlying the Effect. *Journal of Agricultural and Food Chemistry,* 62(18), 4214-4224. https://doi.org/10.1021/jf500065n

