International Journal of Advances in Applied Sciences (IJAAS)
Vol. 15, No. 2, June 2026, pp. 696~704
ISSN: 2252-8814, DOI: 10.11591/ijaas.v15.i2.pp696-704

Analysis of weight loss rate, color, sugar content, and total acidity in tomatoes during storage with edible coating

Rafli Zulfa Kamil, Fahira Adibah Thalib, Nurwantoro, Fariz Nurmita Aziz, Heni Rizqiati, Nurul Hasniah
Department of Food Technology, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia

Article Info

Article history:

Received Apr 25, 2025
Revised May 5, 2026
Accepted May 23, 2026

Keywords:

Edible coating
Maturation process
Post-harvest handling
Shelf life
Tomato

ABSTRACT

Tomatoes, as climacteric fruits, offer numerous advantages, making them popular among many individuals. However, they are prone to mechanical and microbiological harm, which is why applying an edible coating is a viable post-harvest handling technique for tomatoes. A combination of corn starch, chitosan, and glycerol serves as an effective edible coating, with corn starch providing hardness, chitosan offering antimicrobial properties, and glycerol acting as a plasticizer. This research seeks to assess the rate of weight loss, color, sugar content, and total acidity in tomatoes during storage with an edible coating. The preparation of the edible coating involves using 2% (w/v) corn starch, 1.5% (w/v) chitosan dissolved in 0.5% (w/v) acetic acid, and 0.25% (w/v) glycerol. The tomatoes were immersed in the edible coating twice, with each immersion lasting 1 minute and a drying period of 5 minutes. Subsequently, the tomatoes were stored for 15 days, with observations made every 5 days. The edible coating has been shown to slow down the deterioration of tomatoes during storage by forming a barrier that restricts the movement of water and air, which are essential for the physicochemical reactions involved in the tomato ripening process.

Corresponding Author:

Nurul Hasniah
Department of Food Technology, Faculty of Animal Science and Agriculture, Universitas Diponegoro
Prof. Soedarto SH St., No. 13, Tembalang, Semarang 50275, Indonesia
Email: hasniah@live.undip.ac.id

1. INTRODUCTION

Tomatoes, categorized as climacteric fruits, present numerous benefits. They are recognized as a functional food due to their substantial nutritional composition, which encompasses essential vitamins such as A, B, and C, in addition to minerals like iron and calcium [1], [2]. Nonetheless, tomatoes possess a significant drawback: they are susceptible to physical damage and rapid spoilage. Inadequate handling post-harvest can result in a diminution of both nutritional value and flavor of tomatoes [3], [4]. Furthermore, any deterioration in quality or damage can reduce their market value, potentially leading to financial losses for vendors. As a climacteric fruit, tomatoes continue ripe even after harvesting. Stating that during ripening phase, tomatoes undergo an increased respiration rate that stimulates higher ethylene production, leading to several physiological changes such as weight loss, color alteration due to chlorophyll degradation and browning, elevated sugar content resulting from starch breakdown, and a rise in total acid levels through acid oxidation [1], [5]. This statement shows the need for proper post-harvest technology to maintain the quality of tomatoes.

Edible coating refers to a thin, consumable layer applied to food products, typically through dipping or spraying, to minimize moisture loss, preserve sensory quality, and enhance visual appeal by imparting a glossy surface finish [6]. This coating interacts with the surface microenvironment of fruits and vegetables, modifying gas composition and enzymatic activity, thereby maintaining metabolic balance and delaying deterioration during storage [7]. Functionally, edible coatings act as natural packaging, extending the shelf life of food products by forming a semi-permeable layer that inhibits respiration and microbial growth. These coatings are generally composed of a combination of polysaccharides, proteins, and lipids [8]. Recent studies indicate that incorporating nanoemulsions into polysaccharide-based coatings, such as chitosan, alginate, and starch blends, can enhance their antimicrobial efficiency, mechanical strength, and film stability, leading to extended shelf life and improved quality of coated fruits and vegetables [9]. Edible coatings slow respiration and moisture loss by forming a semi-permeable barrier that limits gas exchange and water vapor transfer, thereby reducing oxygen intake, carbon dioxide release, and enzymatic activity, which in turn slows ripening and extends shelf life [10].

The utilization of edible coatings has the potential to mitigate post-harvest losses and bolster local agricultural practices [11]. Edible coatings composed of chitosan, glycerol, and cornstarch typically incorporate 1.0–2.0% (w/v) chitosan dissolved in 0.5-1% acetic acid, 1.0–3.0% (w/v) pre-gelatinized cornstarch heated at 70–80 °C, and 0.25–1.5% (v/v) glycerol as a plasticizer. This formulation generally exhibits a viscosity of 20–80 mPa·s and a slightly acidic pH of 5.0–5.8, attributable to the acetic acid used to dissolve chitosan. Within this mixture, chitosan serves as the primary film-forming and antimicrobial agent, cornstarch enhances structural integrity, and glycerol improves flexibility. The resultant coating forms a smooth, semi-permeable film that diminishes respiration, moisture loss, and microbial proliferation, thereby effectively prolonging the shelf life of food products [12]. Starch, chitosan, and glycerol are efficacious components for edible coatings on fruits, as starch comprises amylose and amylopectin linked by hydrogen bonds that augment the viscosity of the coating solution, chitosan aids in reducing the fruit's respiration rate by regulating gas permeability, and glycerol functions as a plasticizer that enhances the mechanical flexibility and integrity of the coating [13]. In the context of food preservation and sustainable packaging, edible coatings are increasingly acknowledged as eco-friendly alternatives to synthetic plastics due to their biodegradability and functional capacity to maintain food quality and extend storage life [14].

Tomatoes are subjected to a dual application of edible coating to achieve enhanced coating efficacy. Notably, both referenced journals lack observational data during the storage period, thereby presenting a research gap that this study seeks to address. This investigation aims to examine the impact of edible coatings on the weight loss, color, sugar content, and total acidity of tomatoes during storage, as well as their potential to prolong the fruit's shelf life. It is posited that the application of edible coatings may decelerate weight loss, delay color changes, and inhibit the increase in both sugar content and total acidity throughout the storage period [15]. Consequently, the objective of this research is to compare the rate of deterioration in tomatoes coated with an edible film composed of cornstarch, chitosan, and glycerol to that of uncoated tomatoes, based on the aforementioned parameters.

2. METHOD

2.1. Research design

The study used two treatments: T0, which had uncoated tomatoes, and T1, where tomatoes were dipped in an edible coating. Each treatment was done three times. The tomatoes were kept for 15 days at room temperature (25-30 °C), and checked every 5 days. The tomatoes came from Rasamala Market in Banyumanik, Semarang. The study aimed to find out which quality aspect of tomatoes, like weight loss, color, sugar, or acidity, changes fastest with the coating. The method involved dipping tomatoes in a chitosan–starch coating with glycerol, then checking weight loss, firmness, color, pH, and total soluble solids to see how quality changed after harvest.

2.2. Research procedure

2.2.1. Manufacturing of edible coating

The edible coatings were prepared as described by Yusof *et al.* [13], with modifications. The manufacturing process of the edible coating commences with the dissolution of 1.5% (w/v) chitosan in 0.5% (w/v) acetic acid, which is stirred for 24 hours at 350 rpm until the chitosan is fully dissolved. Subsequently, 2% (w/v) cornstarch is dissolved in 0.25% (w/v) glycerol, with continuous stirring for 30 minutes at 350 rpm, while being heated on a hotplate at 75 °C until complete gelatinization is achieved. The chitosan-acetic acid solution is then combined with the gelatinized cornstarch-glycerol solution. The combination of chitosan, cornstarch, and glycerol is considered optimal for edible coating components due to their natural origin and complementary properties. These materials are cost-effective and widely available in the market, facilitating their use in the construction of edible coatings. Additionally, they offer ease of application through dipping, spraying, or brushing methods, which are adaptable to industrial processes. All ingredients are food-grade and recognized as safe by the FDA; however, large-scale production necessitates consistent material quality and adherence to food safety and labeling regulations.

2.2.2. Sortation of tomatoes

Tomatoes are chosen if they have no bruises or peeled skin and are about 70 to 80% ripe, showing a red color with a bit of greenish-yellow. These tomatoes are then weighed to make sure they are between 90 and 110 grams. After that, the tomatoes are washed well under running water and left to air-dry until they are completely dry.

2.2.3. Application of edible coating

The process of making the edible coating starts by dipping the tomatoes in the coating solution for one minute. Then, they are drained and dried for five minutes. This is done twice to make sure the coating is even. To keep it uniform, the solution is mixed well, and the surfaces are clean and dry. The dipping and drying are done consistently. After this, the tomatoes are kept in a container to check changes in weight, color, sugar, and acidity over 0, 5, 10, and 15 days. They are stored at room temperature (25–30 °C) with normal indoor humidity (about 30–60%) and under LED light.

2.2.4. Parameter testing

The parameter assessment was conducted on tomatoes treated with an edible coating (T1) and a control group (T0). The evaluation of weight loss was performed using analytical scales; specifically, weight loss was calculated as the difference between the initial and final weights, divided by the initial weight, and then multiplied by 100% [16]. The color analysis was conducted using a color analyzer application on iOS software, ensuring consistent location and lighting conditions for all samples to obtain L*, a*, and b* values. The sugar content was measured using a Brix refractometer. The total acidity was determined through a base titration method, employing phenolphthalein as an indicator and NaOH as the titrant [17].

2.3. Data analysis

Analysis of variance (ANOVA) was used to study the data. A two-way ANOVA checked how treatment and storage time affected the results. It also looked at how these two factors worked together. If there were important differences ($p < 0.05$), Tukey's HSD test was used to determine which groups differed. The analyses were conducted using SPSS (version 29, IBM Corp., Armonk, NY, USA). Microsoft Excel 2019 was also used to find the equation of the line. This helped us see how fast tomatoes got damaged during storage based on the treatment. The equation was in the form $y = ax + b$. Here, the slope (a) shows how fast the tomatoes got damaged, and the coefficient of determination (R^2) shows how much the factors affected the damage rate during storage.

3. RESULTS AND DISCUSSION

3.1. Weight loss

The two-way ANOVA demonstrated that both the treatment and the duration of storage significantly influenced weight loss ($p < 0.05$). There was also a notable interaction between treatment and storage time, suggesting that the impact of treatment on weight loss differed across various storage durations. As illustrated in Figure 1, weight loss progressively increased during storage for both samples. However, T1 showed a lower percentage of weight loss compared to T0, especially after 10 and 15 days of storage. Where in the figure, * indicates a significant difference between treatments at the same time point. The application of an edible coating based on carboxymethyl cellulose (CMC) on strawberries can also prevent weight loss [18]. A similar outcome was noted with the beeswax-based edible coating in terms of tomato weight loss during storage. Tomatoes that are not treated with a beeswax coating experience greater weight loss [19]. The enhancement of weight loss is affected by several physiological processes, including respiration, which decomposes glucose into energy while generating water and carbon dioxide; transpiration, which results in water evaporation; and starch hydrolysis, which transforms complex carbohydrates into simpler molecules such as glucose [20]–[22].

The trendline indicates a relatively high R^2 value for both treatments, with 0.9662 for tomatoes coated with an edible coating and 0.9895 for those without coating. The R^2 value for weight loss surpasses that of other parameters, suggesting a stronger correlation with the storage period. Specifically, weight loss in the control treatment (T0) accounts for 98.95% of the variation during storage, whereas the edible coating treatment (T1) accounts for 96.62%. The control treatment (T0) exhibited a weight loss rate of 2.8755% per day, which exceeded that of the edible coating treatment (T1) at 2.1539% per day. This finding demonstrates that the application of an edible coating effectively reduces the rate of weight loss in tomatoes. Cornstarch and glycerol-based edible coatings are capable of inhibiting transpiration and respiration processes that generate water and gases, thereby minimizing fruit mass reduction. Moreover, the hydrophilic nature of glycerol aids in regulating water vapor exchange, further contributing to reduced moisture loss during storage [23], [24]. Chitosan serves as a coating material that limits the diffusion of oxygen, thereby inhibiting the respiration process and helping to maintain the weight of tomatoes by preventing excessive shrinkage [25].

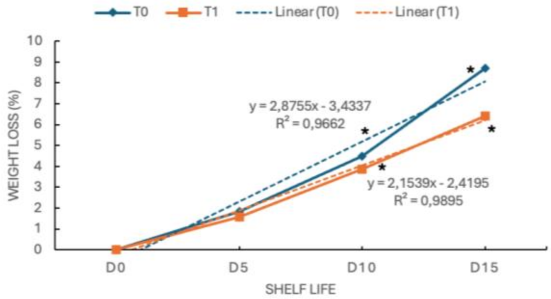

Figure 1. Weight loss value of tomato fruit during 15 days of shelf life
*Indicates a significant difference between treatments at the same time point

3.2. Color

The color of tomatoes, as quantified by the L*, a*, and b* values, is intricately linked to their ripening process. The L* value measures brightness or lightness on a scale ranging from 0 to 100, where 0 corresponds to black and 100 to white. The a* value represents the red-green spectrum, with positive values signifying redness and negative values indicating greenness. Conversely, the b* value pertains to the yellow-blue spectrum, with positive values denoting yellowness and negative values indicating blueness [26].

The two-way ANOVA showed that both treatment and storage time affected the L*, a*, and b* values ($p < 0.05$). There was also an interaction between these factors. Figure 2 shows the change of tomato fruit's color during 15 days of shelf life, where * indicates a significant difference between treatments at the same time point. Figure 2(a) shows that the L* value went down during storage for both treatments, meaning the product got darker over time. Figure 2(b) shows the a* value went up during storage for both treatments, meaning the product got redder. At first, T1 samples had higher a* values than the control (T0), meaning the treatment made them redder at the start. But the control group's a* value increased faster, ending with higher values. Figure 2(c) shows the b* value went down during storage for both treatments, meaning the product became less yellow. At first, T1 samples had higher b* values than the control (T0), meaning the treatment made them more yellow at the start. However, both treatments showed a steady decrease, with T0 decreasing slightly faster, as shown by its steeper slope. Color changes in tomatoes treated with an edible coating have also been observed by several other researchers. Lightness tends to decrease due to carotenoid accumulation, the a* value tends to increase, indicating a shift towards a redder color, and the b* value decreases due to reduced intensity of yellow coloring in the tomatoes [27], [28]. The application of edible coating with the addition of mineral oil shows the same trend, namely, a slower rate of color change compared to the control.

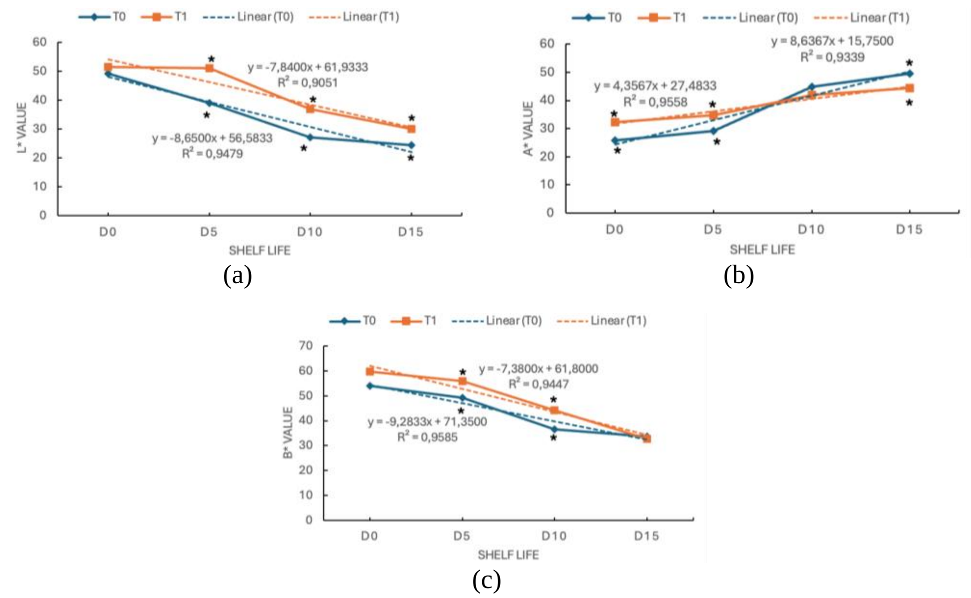

Figure 2. The change of tomato fruit's color during 15 days of shelf life (a) L* value, (b) a* value, and (c) b* value
*Indicates a significant difference between treatments at the same time point

The R^2 values for these parameters were notably high, indicating robust correlations between color change and storage duration. Specifically, L* values exhibited R^2 values of 0.9479 for T0 and 0.9051 for T1, the a* values demonstrated 0.9339 for T0 and 0.9558 for T1, and the b* values showed 0.9585 for T0 and 0.9447 for T1. This implies that the L* value of the T0 treatment accounted for 94.79% of the variance in the tomato storage period, while the L* value of T1 accounted for 90.51%. Similarly, the a* value of T0 accounted for 93.39% of the variance compared to 95.58% for T1, and the b* value of T0 accounted for 95.85% compared to 94.47% for T1. The constant values for T0 in L* and b* were -8.6500 and -9.2833, respectively, which were lower than those of T1 at -7.8400 and -7.3800. Conversely, the constant for the a* value was higher in T0 (8.6367) than in T1 (4.3567), indicating a more rapid rate of color change in uncoated tomatoes.

According to the observed trend, the L* value decreased more rapidly at T0, likely due to the enzymatic browning process involving polyphenol oxidase enzymes, oxygen, and fruit phenolic substrates, which results in the darkening of tomato color [29]. As illustrated in Figure 3, the trend indicates an increase, suggesting that the color of tomatoes becomes redder as they ripen. The United States Department of Agriculture (USDA) classifies the ripeness of fresh tomatoes into six levels, ranging from green to red [30]. The b* value depicted in Figure 4 demonstrates a decreasing trend, as during the ripening process, tomatoes synthesize lycopene pigment, transitioning the fruit's color from yellowish tones to deep red hues [31].

3.3. Sugar content

The sugar content in tomatoes reflects the concentration of sugars present. During storage, both coated and uncoated tomatoes exhibit a tendency to increase in sugar content as a result of carbohydrate degradation into simpler sugars that occurs alongside the natural ripening process [32], [33]. The two-way ANOVA showed that both treatment and storage time affected the sugar content (°Brix) significantly ($p < 0.05$). There was also an important interaction between these factors. Figure 3 shows that the °Brix value increased slightly but steadily during storage for both treatments. Where * indicates a significant difference between treatments at the same time point. This suggests that soluble solids gradually increased over time. During storage, the control samples (T0) always had higher °Brix values than the treated samples (T1). This means the treatment might have limited sugar concentration or slowed the increase in soluble solids. Although the increase in °Brix was small, the different trends between T0 and T1 show that both treatment and storage time affect sugar content. The interaction effect suggests that the rate of change in °Brix depends on the treatment used. The application of nanoemulsion coating on tomatoes also showed similar results, namely that the coating was able to prevent the rate of carbohydrate degradation into sugar [28].

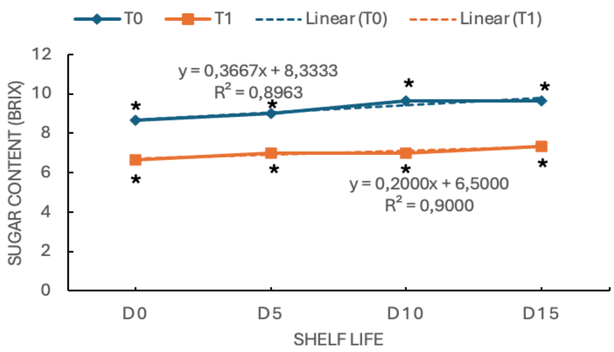

Figure 3. Sugar content value of tomato fruit during 15 days of shelf life
*Indicates a significant difference between treatments at the same time point

The sugar content values reveal an R^2 of 0.8963 for the control treatment (T0) and 0.9000 for the edible coating treatment (T1). This indicates that the variation in sugar content in T0 accounts for 89.63% of the changes associated with the storage period of tomatoes, while in T1, it accounts for 90%. The regression coefficient (a) for T0 is higher, at 0.3667 °Brix/day, compared to 0.2000 °Brix/day for T1. This suggests that the rate of quality deterioration in uncoated tomatoes is greater than that in coated tomatoes. As the fruit ripens, the sugar content naturally increases due to the conversion of starch into simple sugars [33]. The higher a value of T0 compared to T1 indicates that the increase in sugar content in T0 occurs at a faster rate than in T1.

3.4. Total acid

Total acid content serves as a critical indicator of tomato quality in both coated and uncoated treatments during storage. The two-way ANOVA revealed that both the treatment type and the duration of storage significantly influenced the total acid content ($p < 0.05$), as depicted in Figure 4. Where * indicates a significant difference between treatments at the same time point. Additionally, a significant interaction between these variables was observed. Figure 4 illustrates that the total acid content decreased over the storage period for both treatments. Initially, up to day 5 of storage, there was no significant difference in total acid content between the control samples (T0) and the treated samples (T1). However, this trend shifted on days 10 and 15, with the control samples (T1) exhibiting a higher total acid content. The gradual decrease in total acid content in both treatments can be attributed to the utilization of organic acids as substrates in the respiration process for energy production, leading to a reduction in total acid levels over time. A similar phenomenon was also observed in tomatoes coated with a nanoemulsion coating containing bioactive compounds of cactus fruit acids.

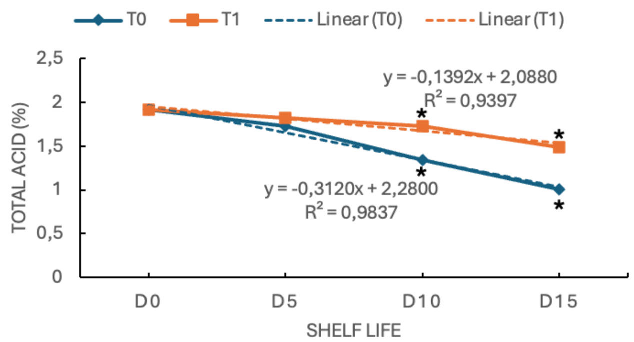

Figure 4. Sugar content value of tomato fruit during 15 days of shelf life
*Indicates a significant difference between treatments at the same time point

The R^2 for the total acid value is 0.9837 for T0 and 0.9397 for T1. These relatively high R^2 values suggest that the variations in total acid content for T0 (98.37%) and T1 (93.97%) are significantly influenced by the storage duration of the tomatoes. The rate of change in the total acid content, denoted as a value, is -0.3120%/day for T0 and -0.1392%/day for T1. This indicates a more rapid deterioration in T0 compared to T1, as evidenced by a more pronounced decrease in total acid content in T0. Tomatoes treated with an edible coating maintain higher total acid levels than those without coating, as the respiration rate in uncoated fruits is higher, resulting in a more rapid depletion of organic acids [34], [35]. According to Shahnawaz *et al*. [36], the fruit possesses a reserve of organic acids during its ripening stage. As the duration of storage extends, these organic acids are transformed into sugars, which are subsequently utilized for metabolic processes, resulting in a reduction in the acidity of the medium.

4. CONCLUSION

Tomatoes treated with edible coatings demonstrated a reduced rate of weight loss and color changes, as indicated by L*, a*, and b* values, alongside an increase in sugar content and a decrease in total acidity, compared to untreated tomatoes. Among the parameters observed, weight loss exhibited the most rapid deterioration. These findings are consistent with recent studies showing that chitosan–starch composite coatings significantly mitigated weight loss, delayed color changes, and preserved firmness and acidity in coated tomatoes relative to controls. It is anticipated that the application of edible coatings could be extended to a variety of other fruits and vegetables in the future. The application process may involve uniform spraying followed by drying. Future advancements could include the incorporation of natural antimicrobials or antioxidants, conducting sensory evaluations to assess product quality, and integrating the coating with active or biodegradable packaging to enhance preservation and sustainability. This study contributes to postharvest and food technology by demonstrating that edible coatings represent a practical and sustainable strategy to extend shelf life and reduce postharvest losses in fresh produce. The approach has strong potential for broader application in fruits and vegetables, particularly with further development through incorporation of natural bioactive compounds and integration with active or biodegradable packaging systems.

ACKNOWLEDGMENTS

The authors wish to express their gratitude to the Faculty of Animal and Agricultural Sciences for providing the facilities.

FUNDING INFORMATION

This research was funded by DIPA Faculty of Animal and Agricultural Sciences 2025 with the grant number 21/UN7.F5/PP/I/2025.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Rafli Zulfa Kamil	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	
Fahira Adibah Thalib		✓	✓		✓	✓	✓	✓	✓	✓	✓			
Nurwantoro	✓	✓			✓					✓		✓		
Fariz Nurmita Aziz		✓	✓			✓	✓		✓	✓		✓		
Heni Rizqiati		✓				✓	✓		✓	✓	✓	✓		
Nurul Hasniah	✓	✓		✓				✓	✓	✓	✓	✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [NH], upon reasonable request.

REFERENCES

[1] M. Quinet *et al.*, "Tomato fruit development and metabolism," *Frontiers in Plant Science*, vol. 10, 2019, doi: 10.3389/fpls.2019.01554.
[2] M. Y. Ali *et al.*, "Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: a review," *Foods*, vol. 10, no. 1, 2021, doi: 10.3390/foods10010045.
[3] M. E. Isack and M. Lyimo, "Effect of postharvest handling practices on physicochemical composition of tomato," *International Journal of Vegetable Science*, vol. 21, no. 2, pp. 118–127, 2015, doi: 10.1080/19315260.2013.837134.
[4] L. Kanski, M. Naumann, and E. Pawelzik, "Flavor-related quality attributes of ripe tomatoes are not significantly affected under two common household conditions," *Frontiers in Plant Science*, vol. 11, 2020, doi: 10.3389/fpls.2020.00472.
[5] J. Brumos, "Gene regulation in climacteric fruit ripening," *Current Opinion in Plant Biology*, vol. 63, 2021, doi: 10.1016/j.pbi.2021.102042.
[6] N. Nain, G. K. Katoch, S. Kaur, and P. Rasane, "Recent developments in edible coatings for fresh fruits and vegetables," *Journal of Horticultural Research*, vol. 29, no. 2, pp. 127–140, 2021, doi: 10.2478/johr-2021-0022.
[7] M. Ma, Y. Liu, S. Zhang, and Y. Yuan, "Edible coating for fresh-cut fruit and vegetable preservation: biomaterials, functional ingredients, and joint non-thermal technology," *Foods*, vol. 13, no. 23, 2024, doi: 10.3390/foods13233937.
[8] M. L. Z.-Zaragoza *et al.*, "Effect of nano-edible coating based on beeswax solid lipid nanoparticles on strawberry's preservation," *Coatings*, vol. 10, no. 3, 2020, doi: 10.3390/coatings10030253.
[9] G. P. Yemiş, E. Sezer, and H. Sıçramaz, "Inhibitory effect of sodium alginate nanoemulsion coating containing myrtle essential oil (*Myrtus communis L.*) on Listeria monocytogenes in Kasar Cheese," *Molecules*, vol. 27, no. 21, 2022, doi: 10.3390/molecules27217298.
[10] W. Hu, Sarengaowa, and K. Feng, "Effect of edible coating on the quality and antioxidant enzymatic activity of postharvest sweet cherry (*Prunus avium L.*) during storage," *Coatings*, vol. 12, no. 5, 2022, doi: 10.3390/coatings12050581.
[11] V. Patil, R. Shams, and K. K. Dash, "Techno-functional characteristics, and potential applications of edible coatings: a comprehensive review," *Journal of Agriculture and Food Research*, vol. 14, 2023, doi: 10.1016/j.jafr.2023.100886.
[12] S. Wardejn, S. Wacławek, and G. Dudek, "Improving antimicrobial properties of biopolymer-based films in food packaging: key factors and their impact," *International Journal of Molecular Sciences*, vol. 25, no. 23, 2024, doi: 10.3390/ijms252312580.

[13] N. M. Yusof, J. Jai, Z. I. M. Sharif, F. A. Mustapha, and S. Pinijsuwan, "Effect of different amount chitosan, starch and glycerol in composite edible coating," in *Journal of Physics: Conference Series*, 2019, vol. 1349, no. 1, doi: 10.1088/1742-6596/1349/1/012077.
[14] B. Hassan, S. A. S. Chatha, A. I. Hussain, K. M. Zia, and N. Akhtar, "Recent advances on polysaccharides, lipids and protein based edible films and coatings: A review," *International Journal of Biological Macromolecules*, vol. 109, pp. 1095–1107, 2018, doi: 10.1016/j.ijbiomac.2017.11.097.
[15] S. Soradech, J. Nunthanid, S. Limmatvapirat, and M. Luangtana-anan, "Utilization of shellac and gelatin composite film for coating to extend the shelf life of banana," *Food Control*, vol. 73, Mar. 2017, doi: 10.1016/j.foodcont.2016.10.059.
[16] K. M. Moneruzzaman, A. B. M. S. Hossain, W. Sani, and M. Saifuddin, "Effect of stages of maturity and ripening conditions on the physical characteristics of tomato," *American Journal of Biochemistry and Biotechnology*, vol. 4, no. 4, pp. 329–335, 2008, doi: 10.3844/ajbbsp.2008.329.335.
[17] AOAC International, *Official methods of analysis of AOAC International*, 21st ed. Rockville, United States: Oxford University Press, 2019, doi: 10.1093/9780197610138.001.0001.
[18] D. Khodaei, Z. H.-Esfahani, and E. Rahmati, "Effect of edible coatings on the shelf-life of fresh strawberries: a comparative study using TOPSIS-shannon entropy method," *NFS Journal*, vol. 23, pp. 17–23, 2021, doi: 10.1016/j.nfs.2021.02.003.
[19] W. N. S. H. W. Ibrahim, Rudiyanto, and R. M. Shah, "Effect of edible beeswax coating on tomato (*Solanum lycopersicum*) postharvest quality," in *E3S Web of Conferences*, 2023, vol. 444. doi: 10.1051/e3sconf/202344404010.
[20] J. Ferdousi *et al.*, "Postharvest physiology of fruits and vegetables and their management technology: a review," *Journal of Animal and Plant Sciences*, vol. 34, no. 2, pp. 291–303, 2024, doi: 10.36899/JAPS.2024.2.0717.
[21] G. T. Xanthopoulos, A. A. Athanasiou, D. I. Lentzou, A. G. Boudouvis, and G. P. Lambrinos, "Modelling of transpiration rate of grape tomatoes. Semi-empirical and analytical approach," *Biosystems Engineering*, vol. 124, pp. 16–23, 2014, doi: 10.1016/j.biosystemseng.2014.06.005.
[22] M. Thammawong and O. Arakawa, "Starch degradation characteristics in relation to physiological and biochemical properties during growth and maturation of apple fruit," *Journal of Applied Horticulture*, vol. 11, no. 1, pp. 23–30, 2009, doi: 10.37855/jah.2009.v11i01.04.
[23] K. Chen *et al.*, "Moisture loss inhibition with biopolymer films for preservation of fruits and vegetables: a review," *International Journal of Biological Macromolecules*, vol. 263, 2024, doi: 10.1016/j.ijbiomac.2024.130337.
[24] P. Bergo, I. C. F. Moraes, and P. J. A. Sobral, "Effects of plasticizer concentration and type on moisture content in gelatin films," *Food Hydrocolloids*, vol. 32, no. 2, pp. 412–415, 2013, doi: 10.1016/j.foodhyd.2013.01.015.
[25] M. I.-Moreno *et al.*, "Progress in chitosan-based materials: enhancing edible coatings and films through modifications and functionalization for food preservation," *Process Biochemistry*, vol. 156, pp. 175–190, 2025, doi: 10.1016/j.procbio.2025.06.001.
[26] J. Yi, B. Kebede, K. Kristiani, T. Grauwet, A. V. Loey, and M. Hendrickx, "Minimizing quality changes of cloudy apple juice: The use of kiwifruit puree and high pressure homogenization," *Food Chemistry*, vol. 249, pp. 202–212, 2018, doi: 10.1016/j.foodchem.2017.12.088.
[27] J. E. de J. D.-Aviña *et al.*, "Effect of edible coatings, storage time and maturity stage on overall quality of tomato fruits," *American Journal of Agricultural and Biological Science*, vol. 6, no. 1, pp. 162–171, 2011, doi: 10.3844/ajabssp.2011.162.171.
[28] E. P.-Soto *et al.*, "Coating of tomatoes (*Solanum Lycopersicon L.*) employing nanoemulsions containing the bioactive compounds of cactus acid fruits: quality and shelf life," *Processes*, vol. 9, no. 12, 2021, doi: 10.3390/pr9122173.
[29] F. Tinello and A. Lante, "Recent advances in controlling polyphenol oxidase activity of fruit and vegetable products," *Innovative Food Science and Emerging Technologies*, vol. 50, pp. 73–83, 2018, doi: 10.1016/j.ifset.2018.10.008.
[30] USDA Agricultural Marketing Service, *United States standards for grades of fresh tomatoes*. Washington, United States: USDA, 1991.
[31] L. Su *et al.*, "Carotenoid accumulation during tomato fruit ripening is modulated by the auxin-ethylene balance," *BMC Plant Biology*, vol. 15, no. 1, May 2015, doi: 10.1186/s12870-015-0495-4.
[32] D. Kaur, R. Sharma, A. A. Wani, B. S. Gill, and D. S. Sogi, "Physicochemical changes in seven tomato (*Lycopersicon esculentum*) cultivars during ripening," *International Journal of Food Properties*, vol. 9, no. 4, pp. 747–757, 2006, doi: 10.1080/10942910600575716.
[33] P. A. Antala *et al.*, "Phytochemical and metabolic changes associated with ripening of *Lycopersicon esculentum*," *Scientific Reports*, vol. 15, no. 1, 2025, doi: 10.1038/s41598-025-95255-9.
[34] C. Li, J. Tao, and H. Zhang, "Peach gum polysaccharides-based edible coatings extend shelf life of cherry tomatoes," *3 Biotech*, vol. 7, no. 3, 2017, doi: 10.1007/s13205-017-0845-z.
[35] A. Yadav, N. Kumar, A. Upadhyay, Pratibha, and M. Kieliszek, "Mango kernel starch-based edible coating with lemongrass oil: a sustainable solution for extending tomato shelf life," *Journal of Food Measurement and Characterization*, vol. 19, no. 3, pp. 1929–1945, 2025, doi: 10.1007/s11694-024-03084-7.
[36] M. Shahnawaz, S. A. Sheikh, A. H. Soomro, A. A. Panhwar, and S. G. Khaskheli, "Quality characteristics of tomatoes (*Lycopersicon esculentum*) stored in various wrapping materials," *African Journal of Food Science and Technology*, vol. 3, no. 5, pp. 123–128, 2012.

BIOGRAPHIES OF AUTHORS

Rafli Zulfa Kamil is a lecturer in the Food Technology Program, Department of Agricultural Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro. He received his Dr. in 2021. His research interests are gut microbiota, probiotics, prebiotics, and dietary fiber. He can be contacted at email: rafli.zulfa@live.undip.ac.id.

Fahira Adibah Thalib is a bachelor's degree in the Food Technology Program, Department of Agricultural Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro. Her research interest is post-harvest handling. She can be contacted at email: adibahfahira@gmail.com.

Nurwantoro is an associate professor in the Food Technology Program, Department of Agricultural Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro. He received his Dr. in 2013. His research interests are separation chemistry, biochemistry, and food science. He can be contacted at email: nurwantoro.tehate@gmail.com.

Fariz Nurmita Aziz is a lecturer in the Food Technology Program, Department of Agricultural Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro. He received his M.Sc. in 2023. His research interests are probiotic product development and fermentation. He can be contacted at email: fariznurmita@live.undip.ac.id.

Heni Rizqiati is a lecturer and researcher in the Food Technology Program at the Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Indonesia. She got her bachelor's degree in Food Technology from Universitas Diponegoro. She then did her postgraduate and doctoral studies at IPB University. Her main research areas are food microbiology, dairy products, kefir, and cheese. She can be contacted at email: heni.rizqi@gmail.com.

Nurul Hasniah is a lecturer and researcher at the Food Technology Program, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Indonesia. She earned her bachelor's degree in Food and Agricultural Product Technology from Universitas Gadjah Mada and completed her master's degree in Food Science and Technology at Chulalongkorn University, Thailand. Her research interests focus on fermented foods, probiotics, filamentous fungi, and encapsulation. She can be contacted at email: hasniah@live.undip.ac.id.