ANALYSIS AND MODELING OF WEIGHT LOSS OF TOMATO WITH AVOCADO SEED STARCH EDIBLE COATING

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ABSTRACT

Tomato is a climacteric fruit that has a short shelf life and shows deterioration quickly. It needs a treatment to prolong the shelf life and reduce the quality change during storage. Avocado seed starch edible coating could be one of the innovations to prevent tomato damage. Weight loss is one of the quality change parameters that can be analyzed for the behavior of the tomato storage with avocado seed starch edible coating. This study aims to analyze the effect of the avocado seed starch edible coating on the weight loss behavior of tomatoes during storage and model it with kinetics and polynomial regression equations. This study used a Completely Randomized Design (CRD) with a factor of the avocado seed starch concentration variations of 0, 1, 3, 5, and 7% as edible coating. The quality observed was the behavior of weight loss of tomato with avocado seed starch edible coating during storage in ambient temperature and relative

humidity. The tomato quality showed different weight loss after 240 hours of storage. The variations of the avocado seed starch edible coating influenced the behavior of weight loss of tomatoes during storage, and it showed by kinetics value with a range from 1.21 x 10-2 to 1.90 x 10-2 %/hour. The weight loss behavior was modeled by a zero-order kinetics equation and polynomial regression model with a determination coefficient (R^2) of more than 0.900 for both models with the avocado seed starch concentration variations of 0-7%.

Keywords: Avocado; edible coating; modeling; seed starch; tomato.

1. Introduction

Tomato (*Solanum lycopersicum* L.) is an essential horticultural plant and one of the favored commodities that contain fiber, vitamins A and C, and minerals to provide health benefits (Poovai et al., 2023; Sucharitha et al., 2018; Thole et al., 2020; Utama et al., 2022; Wan et al., 2018). Tomato productivity in Indonesia gradually increased from 2014 to 2022, reaching 1,116.74 thousand metric tons (Statista, 2023). With the significant number of productivities, there are main concerns about the postharvest treatment with a short shelf life. Tomato is a climacteric fruit, a fresh product that quickly shows deterioration (Colombié et al., 2017; Kumar & Saini, 2021). The tomato deterioration is associated with ethylene production and respiration rate because of the ripening process. It can be shown as

weight loss, impacting product quality (Aragüez et al., 2020).

An innovation is needed to control the deterioration to maintain tomatoes' quality and shelf life, such as edible coating for tomato storage. The previous studies conducted by Al-Tayyar et al. (2020), Candir et al. (2018), Lopez-Polo et al. (2021), Rohasmizah & Azizah (2022), and Suhag et al. (2020) stated that edible coating could be a tomato treatment innovation to reduce the weight loss, improve the quality, control the ripening, reduce the respiration rate, and antibacterial during storage. Edible coating is a thin layer or biopolymer that has been widely investigated and could preserve fresh products, especially climacteric fruit that shows deterioration quickly. It is also an eco-friendly packaging material and avoids mycobacterial containment or environment (Rohasmizah & Azizah, 2022; Suhag et al., 2020). Edible coating for tomato have investigated with various ingredients such as durian seed starch (Prabowo & Mawarani, 2020), carnauba wax (Miranda et al., 2022), banana peel waste (Sigiro et al., 2022), and other natural resources (Aguilar-Veloz et al., 2022; Kumar & Saini, 2021; Poovai et al., 2023; Rodriguez-Garcia et al., 2016; Sucharitha et al., 2018).

Avocado seed starch is one of the natural resources widely investigated to preserve not only fresh products such as sweet cherries (Afonso et al., 2023) and strawberry (Rangkuti et al., 2019) but also processed

products such as french fries (Castro et al., 2022) and jenang dodol (Indonesian's snack) (Susilowati & Lestari, 2019). Avocado seed starch could delay the ripening index of fresh products, slow down product deterioration, and reduce product weight loss. It can be an alternative to an effective coating to maintain food quality (Afonso et al., 2023; Castro et al., 2022; Rangkuti et al., 2019).

The previous research conducted by Susilowati & Lestari (2019) stated that avocado seed starch reduced the deterioration based on the concentration. Using the high concentration in making edible coating was recommended to maintain better product quality. The best avocado seed starch concentration must be investigated to apply in tomatoes to innovate to preserve tomatoes. The influence of avocado seed starch concentration on weight loss can be an indicator to assess the tomato quality. The behavior of weight loss of fresh products could be modeled by kinetics equation as the study conducted by Chettri et al. (2023) and Maringgal et al. (2020), which successfully modeled it with kinetics equation. It also could be modeled by polynomial regression, as the study conducted by Fatharani et al. (2023) and Zhao et al. (2022), which successfully modeled it with polynomial regression. The analysis and modeling of weight loss of tomatoes with avocado seed starch edible coating have not been done before, so this study aims to analyze the effect of the avocado seed

starch edible coating on the weight loss behavior of tomatoes during storage and model it with kinetics and polynomial regression equations.

2. Research Methodology

2.1 Time and place

This research was carried out from January to February 2023 in the Agricultural Technology Laboratory, Department of Agricultural Technology, Faculty of Agriculture, University of Bengkulu, Bengkulu.

2.2 Material

The ingredients of this research were tomato, avocado seed, distilled water, 200 ppm of Sodium Metabisulfite ($Na_2S_2O_5$), 0.5% of Carboxymethyl Cellulose (CMC), 3% of Glycerol ($C_3H_8O_3$), 0.5% of Potassium Sorbate ($C_6H_7KO_2$), 0.5% of Stearic Acid ($C_{18}H_{36}O_2$), starch solution, 0.01N of iodine solution, and buffer solution. The tools of this research were 80 mesh sieve, beaker glass, hot plate, oven, and digital scale.

2.3 Experimental design

This experiment used a Completely Randomized Design (CRD) with a factor of the avocado seed starch concentration variations of 0, 1, 3, 5, and 7% as edible coating. The tomato was observed in 15 days or 360 hours of storage.

2.4 Experimental procedure

The experiment started with sample preparation of tomatoes with the same size and average weight of ± 65 g. At the same time, the avocado seed starch was conducted with (Rahmiati et al., 2020). The cleaned avocado seed was soaked in 200 ppm of $Na_2S_2O_5$ solution for 24 hours with a ratio of 1:5. After that, the avocado seed was mashed in a blender and added water with a ratio of 1:1 until turned into avocado seed porridge. It was filtered and settled in 12 hours and then dried in an oven with a temperature of 40℃ for 6 hours until it turned into a starch, and it was mashed with grinder and sifted by 80 mesh sieves.

The edible coating was made by conducted with Picauly & Tetelepta (2018). It was started by heating the hot plate at the temperature of 70℃, and 0.5% of CMC was dissolved by distilled water in 3 minutes until it became homogeneous. Avocado seed starch was added to the solution based on the 1, 3, 5, and 7% treatments. After that, the $C_6H_7KO_2$ and $C_{18}H_{36}O_2$ were added to the solution and stirred for 1 minute for each ingredient until it became homogeneous. The edible coating was ready and stored at ambient temperature. The edible coating application to the tomato was done by dyeing the tomato into the edible coating solution in each concentration variation (1, 3, 5, and 7%). The coating tomatoes were stored at ambient temperature for 15 days or 360 hours.

2.5 Analysis

2.5.1 Weight Loss

The sample weight was observed by the digital scale and calculated by the following equation (You et al., 2022; Zhao et al., 2022),

$$\Delta W = \frac{W_0 - W_t}{W_0} \, 100\% \quad (1)$$

where ΔW is weight loss (%); W_0 is the initial weight of tomato (g); and W_t is the weight of tomato at t hours (kg).

2.5.2 Kinetics

The weight loss of tomato during storage was analyzed by zero-order kinetics by the following equation (Fatharani, 2020; Prabhakar et al., 2022; Zhang et al., 2021),

$$\frac{dW}{dt} = -k.\, W^n \quad (2)$$

$$W_t = W_0 - k.\, t \quad (3)$$

where k is the rate constant (%/hour); W is the weight of tomato; and t is time (hour); and n is the kinetics order.

2.5.3 Polynomial Regression

The non-linear data could be performed and modeled by polynomial regression by the following

equation (Mısır & Akar, 2022; Schneider et al., 2022; Sinha, 2013),

$$y = \sum_{n=0}^{n} \beta_{+j} x_i^n + \varepsilon_{+i} \quad (4)$$

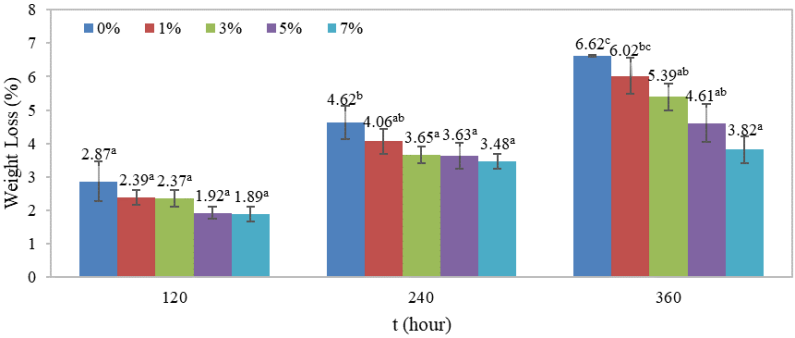
$$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \varepsilon \quad (5)$$

2.5.4 Statistical Analysis

The data were analyzed by the analysis of variance (ANOVA) at 5% level. The statistical difference treatment with $p<0.05$ was compared by Duncan's Multiple Range Test (DMRT).

3. Result

3.1 Weight Loss Analysis



At the same time, different superscripts show that the values are significantly different at $p<0.05$ DMRT test.

Figure 1. The weight loss of tomato with avocado seed starch edible coating during storage

Figure 1 provides information regarding the weight loss of tomatoes with avocado seed starch edible coating, which is stored from 0 to 360 hours or 15 days. In general, the weight loss of samples went up until the end of the storage period. The avocado seed starch concentration of 0% increased significantly, while the concentration of 7% changed gradually, especially from 240 to 360 hours. Based on the statistical analysis, the weight loss of samples was not influenced by the variations from the beginning to 120 hours of the storage period ($p<0.05$). After that, the variations influenced the samples from 240 hours to the end of the storage period, and it was shown a significant difference by the DMRT test ($p<0.05$).

3.2 Weight Loss Modeling

3.2.1 Kinetics Analysis

Table 1 provides information regarding kinetics value and weight loss prediction equations for each sample variation. The weight loss modeling used the zero-order kinetics analysis, which ranged from 1.21 . 10-2 to 1.90 . 10-2 %/hour. Then, the kinetics value could be analyzed to determine the weight loss prediction for each sample variation.

Table 1. Quality Kinetics value and weight loss prediction equations of tomato with avocado seed starch edible coating using zero-order kinetics analysis

Avocado Seed Starch Concentration (%)	Kinetics (10^{-2} %/hour)	Weight Loss Prediction Equation
0	1.90 ± 0.09^{c}	$\mathrm{WL_t} = \mathrm{WL_0} + (1.90 \,.\, 10^{-2} \,.\, \mathrm{t})$
1	1.70 ± 0.34^{bc}	$\mathrm{WL_t} = \mathrm{WL_0} + (1.70 \,.\, 10^{-2} \,.\, \mathrm{t})$
3	1.54 ± 0.09^{ab}	$\mathrm{WL_t} = \mathrm{WL_0} + (1.54 \,.\, 10^{-2} \,.\, \mathrm{t})$
5	1.37 ± 0.13^{ab}	$\mathrm{WL_t} = \mathrm{WL_0} + (1.37 \,.\, 10^{-2} \,.\, \mathrm{t})$
7	1.21 ± 0.10^{a}	$\mathrm{WL_t} = \mathrm{WL_0} + (1.21 \,.\, 10^{-2} \,.\, \mathrm{t})$

In the same column, different superscripts show that the values are significantly different at p<0.05 DMRT test.

Table 1 provides information regarding kinetics value and weight loss prediction equations for each sample variation. The weight loss modeling used the zero-order kinetics analysis, which ranged from 1.21 . 10-2 to 1.90 . 10-2 %/hour. Then, the kinetics value could be analyzed to determine the weight loss prediction for each sample variation.

3.2.2 Polynomial Regression Analysis

Figure 2 illustrates the polynomial regression analysis for the kinetics value of each sample variation. Overall, the kinetics value was significantly dropped in the increase of avocado seed starch concentration of edible coating. Based on the graph, it can be analyzed to show the polynomial regression equation, as shown by Equation 6.

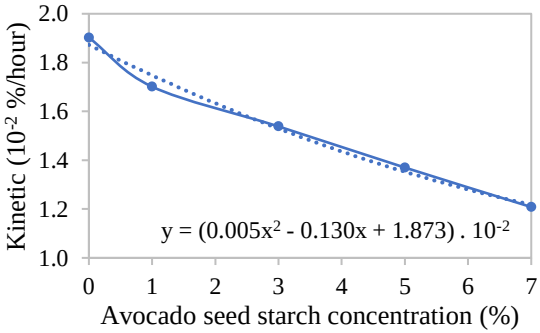


Figure 1. Polynomial regression of weight loss kinetics of tomato with avocado seed starch edible coating

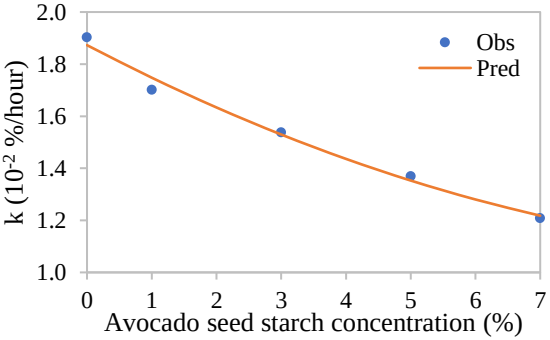


Figure 2. Kinetics observation and prediction of weight loss of tomato with avocado seed starch edible coating using polynomial regression

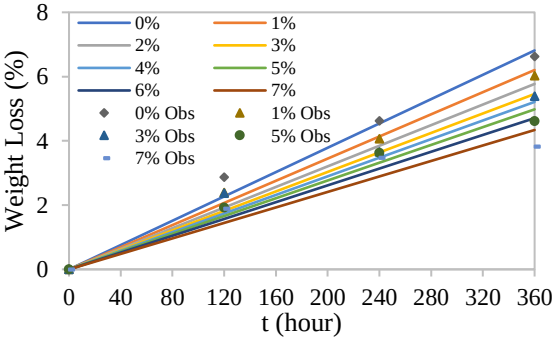


Figure 4. Weight loss prediction and observation of weight loss of tomato with avocado seed starch edible coating during storage period

$$k_{prediction} = (0.05x^2 - 0.130x + 1.873) \,.\, 10^{-2} \qquad (6)$$

Table 2 displays the result of the kinetics prediction equation for the avocado seed starch concentration from 0 to 7%. The kinetics prediction range for each concentration was from 1.22 . 10-2 to 1.87 . 10-2 %/hour. Based on the kinetics prediction, the weight loss prediction equation was determined by comparison of kinetics prediction and zero-order kinetics analysis. The kinetics observation and prediction value can be formed in Figure 3. From the kinetics prediction, the weight loss prediction could be analyzed (Table 3) and shown in Figure 4.

3.2.3 Determination coefficient (R^2)

Table 3 shows the Determination Coefficient (R^2) of modeling of weight loss of tomatoes with avocado seed starch edible coating using kinetics and polynomial regression. Overall, the R^2 values of both models were more than 0.900. The R^2 values were from 0.9300 to 0.9952.

Table 2. Prediction of kinetics value and weight loss equations of tomato with avocado seed starch edible coating using polynomial regression analysis

Avocado Seed Starch Concentration (%)	Kinetics prediction (10^{-2} %/hour)	Weight Loss Prediction Equation
0	1.87	$WL_t = WL_0 + (1.87 \times 10^{-2} \times t)$
1	1.75	$WL_t = WL_0 + (1.75 \times 10^{-2} \times t)$
2	1.63	$WL_t = WL_0 + (1.63 \times 10^{-2} \times t)$
3	1.53	$WL_t = WL_0 + (1.53 \times 10^{-2} \times t)$
4	1.44	$WL_t = WL_0 + (1.44 \times 10^{-2} \times t)$
5	1.35	$WL_t = WL_0 + (1.35 \times 10^{-2} \times t)$
6	1.28	$WL_t = WL_0 + (1.28 \times 10^{-2} \times t)$
7	1.22	$WL_t = WL_0 + (1.22 \times 10^{-2} \times t)$

Table 3. Determination coefficient (R^2) of modeling of weight loss of tomato with avocado seed starch edible coating using kinetics and polynomial regression

Avocado Seed Starch Concentration (%)	R^2	
	Kinetics	**Polynomial Regression**
0	0.9880	0.9880
1	0.9952	0.9952
3	0.9860	0.9860
5	0.9812	0.9812
7	0.9300	0.9300

4. Discussion

4.1 Weight Loss Analysis

The weight loss of tomatoes increased until the end of the storage period for all samples, as You et al. (2022) reported that the weight loss of all samples went up until the end of the storage period. In this research, with every 2% increase in avocado seed starch concentration, the weight loss decreased from 0.5 to 1 time higher. This phenomenon also happened in the research by Sucharitha et al. (2018), that the higher coating concentration prevented weight loss due to the coating preventing moisture evaporation from samples. Gardesh et al. (2016) stated that fresh products cause weight loss due to respiratory processes and transpiration. In the research, the higher coating concentration also reduced the weight loss of samples because the coating reduced the water loss in fresh products during storage.

4.2 *Weight Loss Modeling*

According to Zhang et al. (2021), kinetics modeling could describe and predict the behavior of fresh product quality, such as weight loss. In this research, with every 2% increase in avocado seed starch concentration, the kinetics value of the weight loss reduced from 9 to 12%. It was also conducted by by

Gardesh et al. (2016) and Sucharitha et al. (2018). The high coating concentration could reduce weight loss because the coating could maintain the quality from evaporation, respiratory process, and transpiration. The weight loss prediction equation could describe the weight loss prediction. In this research, the zero-order kinetics equation succeeded in describing it with a Determination Coefficient (R^2) of more than 0.900. It was conducted by Zhang et al. (2021), which also succeeded in describing the weight loss prediction with R^2 of more than 0.900.

According to Mısır & Akar (2022), polynomial regression was the model in which the relationship between the y and x-axis was not linear. With this equation, the kinetics prediction could be analyzed by a function. It still used the zero-order kinetics to determine the weight loss prediction equation. The advantage of this model is that it could describe the tomato weight loss prediction with avocado seed starch concentration of 0-7% as the research is done. In this research, polynomial regression succeeds in describing it with the Determination Coefficient (R^2) of more than 0.900. It was conducted by Qambrani et al. (2022) which also *succeed to describe the weight loss prediction with R^2 of more than 0.900.*

5. Conclusion

The weight loss of samples went up until the end of the storage period for all samples. The avocado seed starch concentration of 0% was shown to have a significant increase, while the concentration of 7% was shown to have a gradual change, especially from 240 to 360 hours. The avocado seed starch concentration of 0% was shown to increase significantly, while the concentration of 7% was shown to have a gradual change, especially from 240 to 360 hours. For every 2% increase in avocado seed starch concentration, the weight loss decreased from 0.5 to 1 time lower, and the kinetics value of the weight loss reduced from 9 to 12%. The weight loss behavior was modeled by a zero-order kinetics equation and polynomial regression model with a determination coefficient (R^2) of more than 0.900 for both models with the avocado seed starch concentration variations of 0-7%.

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