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The Effect of Temperature and Concentration Edible Coating of Aloe Vera Gel (*Aloe Vera L.*) to The Shelf Life and Sensory of Tomatoes (*Solanum lycopersicum L. cv Momotaro*)

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ABSTRACT

Tomatoes (*Solanum lycopersicum L. cv Momotaro*) with a creeping growth or indeterminate type generally grown in the highlands have high economic value. Momotaro tomatoes were classified as climacteric fruits that are easily damaged after harvest. So, it is necessary to do low-temperature treatment and edible Aloe vera gel coating to extend shelf life and sensory. This research aims to determine the effect of low-temperature storage and the concentration of aloe vera gel edible coating, which can extend the shelf life and sensory of Momotaro tomatoes. This study used a complete randomized design of the nested pattern, with treatment edible coating aloe vera gel consisting of 3 concentrations, namely control treatment (without coating), concentration coating 50%, concentration coating 100% nested in temperatures 5°C, 10°C, 15°C, and room temperature (27°C). Conclusions from results showed that the temperature treatment of 10°C and the edible coating treatment of aloe vera gel with a concentration of 50% nested at 10°C, have better results in extending the shelf life and sensory of Momotaro tomatoes to more than 30 days because the maturity level of Momotaro tomatoes has not yet reached its chemical peak. The temperature treatment and concentration of aloe vera coating positively contribute to extending the shelf life and sensory of Momotaro tomatoes.

1. Introduction

Momotaro tomatoes are easily damaged after harvesting, so to avoid spoiling easily and extend their shelf life, it is necessary to conduct this research. The influence of low temperature and concentration of Aloe vera edible coating contributed significantly to the parameters of respiration rate, fruit weight, and water content of Momotaro tomatoes. Likewise, based on the analysis of Kruskal Wallis data (qualitative data), there is a significant contribution to sensory information from color, aroma, and freshness. Low-temperature treatment and edible coating concentration of aloe vera can extend shelf life and low sensory changes. The primary purpose of this study was to determine the effect of low temperature and concentration of aloe vera edible coating on the shelf life and sensory of Momotaro tomatoes. Research on the effect of temperature and concentration of aloe vera gel coating was carried out to find out how long the shelf life and sensory of Momotaro tomatoes; it turned out that the results of the study obtained a real contribution to the shelf life of Momotaro tomatoes as seen from the observation modifiers. The results of this study are supported by several arguments from the previous year's literature citations, as listed below.

Momotaro tomato from Japan is one of the increasingly famous varieties of beef tomatoes. It is widely cultivated on a small scale for fresh processing in the United States and Europe (Specialty Produce, 2023). Beef tomatoes are larger than others, so they have become one of the leading commodities (Sugiarti et al., 2021). According to Nisa (2020), Momotaro tomatoes are included in the indeterminate type generally grown in the highlands. Momotaro tomatoes have a high economic value compared to ordinary local tomatoes. Tomatoes contain vitamins such as vitamins, minerals, carotenoids, phosphorus, potassium, and lycopene to be used as an addition to healthy processed foods (Kulshrestha & Srivastava, 2013). The content in tomatoes is believed to cure various diseases. Tomatoes are one of the fruit vegetables that have the potential to be exported because market demand for world tomato production tends to continue to increase from time to time in line with the increasing average consumption in various countries (Fitriani & Haryanti, 2016). According to Anto (2021), Momotaro tomato demand continues to increase by 20% annually. Tomatoes include climacteric fruits easily damaged after harvest (Rusmanto et al., 2017). Tea and Yati (2022) state that climacteric fruits have a characteristic where their respiration rate increases after harvesting. This leads to the release of large amounts of CO_2 and ethylene compounds.

The process of respiration can degrade substances so that the higher respiration rate will cause damage to faster commodities (Hutapea, 2014). Tomatoes stored at room temperature will ripen until they decay. According to Yuniastri et al. (2020), Chemical breakdown in room-temperature storage is higher compared to low-temperature storage. Low-temperature storage can maintain quality and extend the shelf life of fruits (Marpaung et al., 2015). Tomato storage can affect the shelf life of tomatoes, as in the study of (Asjulia & Dyan, 2023) at temperatures of 10°C and 15°C can maintain the shelf life of tomatoes for 21 days, while in the research of (Yuniastri et al., 2020) storage for red ripe tomatoes at room temperature can last for three days. Low-temperature storage will inhibit enzyme activity and oxidation reactions. Ripening that continues quickly can cause damage and deterioration in the quality of tomatoes, including physical damage such as wrinkles on the skin and abrasions on the surface that can cause other damage (Tea & Yati, 2022). One of the materials that can be used for edible coating is aloe vera. The advantages of aloe vera are that it is easy to obtain, more economical and practical, and contains natural antimicrobials (Aminudin & Nawangwulan, 2014).

Aloe vera gel has been developed into a coating of natural food ingredients as in the research of Aminudin and Nawangwulan (2014) that the best treatment of aloe vera gel coating is found in concentrations of 100% and 50% combined with low-temperature storage (8-10°C) because it can reduce internal and external quality degradation in cucumbers during nine days of storage with fresh conditions, In addition in research of Handarini (2021) the edible coating treatment of aloe vera gel on chili. Tomatoes were able to maintain organoleptic quality and

slow down the decrease in weight loss. The results of the study by Garcia et al. (2014) showed that diluted extract of A. vera can maintain quality and delay tomato ripening during storage under ambient conditions. This study aims to determine the effect of low-temperature storage and concentration of edible coating aloe vera gel that can extend the shelf life of Momotaro tomatoes. The novelty value of this study compared to previous studies (citations of previous literature) lies in the treatment of low-temperature storage with different intervals plus room temperature as a comparison control, and there are differences in sensory intensity.

1.1. Effect of Treatment

The effect of low-temperature treatment and the concentration of Aloe vera edible coating on the shelf life and sensory of Momotaro tomatoes shows a significant (positive) effect, so it can be used to extend shelf life and slight sensory changes in color, aroma, and freshness.

1.1.1. Treatment Results

The effect of both treatments on Momotaro tomato parameters is significant; therefore, the positive effect on shelf life and sensory occurrence is low in tomatoes.

2. Methods

2.1. Time and Place

The research was conducted from May to June 2023 in a closed room in Cigombong District, Bogor Regency, West Java, and the Laboratory of the Faculty of Agriculture, Djuanda University, Bogor.

2.2. Materials and Tools

The ingredients used in this study were Momotaro tomatoes, aloe vera, equates, HCl, NaOH, and phenofthalein (PP) indicators. The tools to be used in this study were knives, blenders, woven bamboo, fans, refrigerators, jars, aerators, aerator hoses, burettes, measuring cups, erlenmeyer, drip pipettes, penetrometers, digital scales, analytical scales, ovens, refractometers, and pH meters.

2.3. Research Methods

This study used a complete randomized design of nested patterns, namely aloe vera gel coatings with concentrations (0%, 50%, and 100%) nested under storage temperatures (5°C, 10°C, 15°C as refrigerator temperature, and 27°C as room temperature). The observed treatment consisted of three repetitions, and each experimental unit consisted of five pieces, so there were 180 observation units.

2.4. Research Implementation

2.4.1. Preparation of Aloe Vera and Manufacture of Aloe Vera Gel Coating

The aloe vera used green has a length of 30-50 cm, a thickness of 2-3 cm, is not physically deformed, does not break, has no spots of disease, and is already eight months old (ready to harvest). The aloe vera used comes from the X-Suren Herbavera Indonesia Tajur Halang Aloe Vera Garden with the Chinensis variety. Aloe vera was sorted and washed to remove dirt on the surface of the leaf midrib. This aloe vera gel coating begins by separating the meat and

washing it using warm water (36°C) to remove the yellow sap on the leaf midrib flesh. The flesh of the leaf midrib was cut into small pieces and then blended until smooth for one minute. The last stage was filtration until a delicate gel of aloe vera liquid (such as aloe vera juice) was obtained. This aloe vera smooth gel was called 100% concentration aloe vera gel. A 50% concentration of aloe vera gel was obtained by adding 100% aloe vera gel, or as much as half (Aminudin & Nawangwulan, 2014).

2.4.2. Tomato Preparation and Tomato Coating

The tomatoes used were Momotaro cultivar tomatoes taken from Gapoktan Multi Tani Jaya Giri Cianjur with a second scale maturity (60% ripeness) (Table 1) and about 5-6 cm in diameter. The next stage is the washing process using clean water. The coating application is done by dipping for 2 minutes. The sample is dipped in gel according to the treatment until the entire surface is coated. Coated tomatoes were placed in a container with holes (woven bamboo) and given a breeze from a fan to dry quickly. Dried tomatoes were stored indoors and in the refrigerator at 5°C, 10°C, and 15°C.

2.5. Observation Modifiers

The observed modifiers consist of:

1. The color was performed by hedonic test (favorability) by 15 untrained panelists using visual observation every three days until 30 days of storage. The full description is shown in Table 1.

Table 1 Color criteria based on the degree of ripeness of Momotaro tomatoes

Value (scale)	Maturity Level	Color Description
1	(50 %)	Balanced yellow and pink
2	(60%)	Pink more than orange
3	(70%)	Full pink
4	(80%)	Full red
5	(100%)	Dark red

2. Aroma, performed by hedonic test, was observed with the smell of the panelists' noses. Freshness modifier criteria, namely, 1= odorless; 2= characteristic smell of tomatoes; 3= slightly sour smell; 4= foul odor (Yuniastri et al., 2020).
3. Freshness, performed by hedonic test observed by visual observation of panelists. Momotaro tomato aroma changing criteria, namely, 1= fresh; 2= less fresh; 3= slightly rotten; 4= rotten.
4. The respiration rate was carried out at the study's beginning and end by calculating CO_2 gas (mg/kg/hour) produced by the closed system gas extraction method. CO_2 gas produced from the respiration process is captured by an absorber (0,1 N NaOH solution). Then, the absorber is added with a PP indicator of 2 drops and titrated with a 0.1 N HCl solution. The rate of respiration can be calculated using the following formula:

$$R=\frac{(\text{ml blanks-ml sample})\times\text{Normality HCl}\times\text{Molecular number } CO_2}{\text{Sample weight}\times\text{time}}$$

5. Weight loss: Momotaro tomatoes were weighed using digital scales at the study's beginning and end. The formula for calculating weight loss is:

$$\frac{\text{Starting weight - Final weight}}{\text{starting weight}} \text{ x } 100\%$$

6. Moisture content is measured by drying using an oven. This test was carried out by weighing tomatoes as much as 5 g using analytical scales; then, the sample was inserted into an aluminum dish. The sample is put in the oven for 3 hours at 105°C, cooled for 15 minutes, and weighed again. The moisture content test formula, namely:

$$\frac{\text{Initial sample weight - final sample weight}}{\text{Initial sample weight}} \text{ x } 100\%$$

2.6. Data Analysis

Quality data analysis in the form of organoleptic tests (color, aroma, freshness) is calculated using particular manual calculations commonly used in food technology, namely the Kruskal-Wallis test (Test H) with the formula:

$$\mathbf{H= \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1)}$$

Information:
H : Kruskal-Wallis value
Re: Number of Ranks from I-th Group/Category
n_i: The number of cases in the sample in the I-th group/category
k : Number of groups/categories
N : Total of all observations ($N= n_1 + n_2 + n_3 + ... + n_k$)

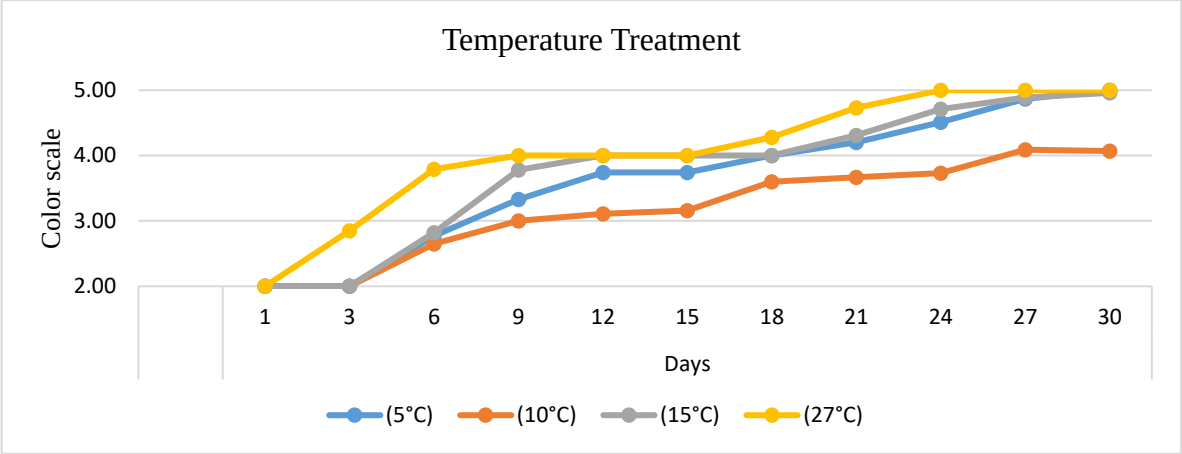
The H test that shows a real difference will be carried out further by the Kruskal-Wallis test again to compare the real difference in each treatment. Data analysis for quantitative data modifiers is carried out with the F test or looking for the ANOVA table. Further tests will be carried out for treatments that have a real effect using Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1. Results

The results obtained by the effect of cold temperature treatment and the concentration of aloe vera edible coating on Momotaro tomatoes can extend the shelf life of tomatoes seen in data analysis where the rate of respiration, weight, and evaporation of tomato fruit water slightly changes, also in the analysis of sensory data (qualitative) Kruskal Wallis slightly changes in the color, aroma, and freshness of Momotaro tomatoes. This result is very consistent with some of the literature citation arguments that have been expressed earlier. The color, aroma, and freshness change graphs are shown in Figures 1, 2, and 3. Table 2 shows the respiration rate, weight loss, and water loss (transpiration) of Momotaro tomatoes.

3.1.1. Color



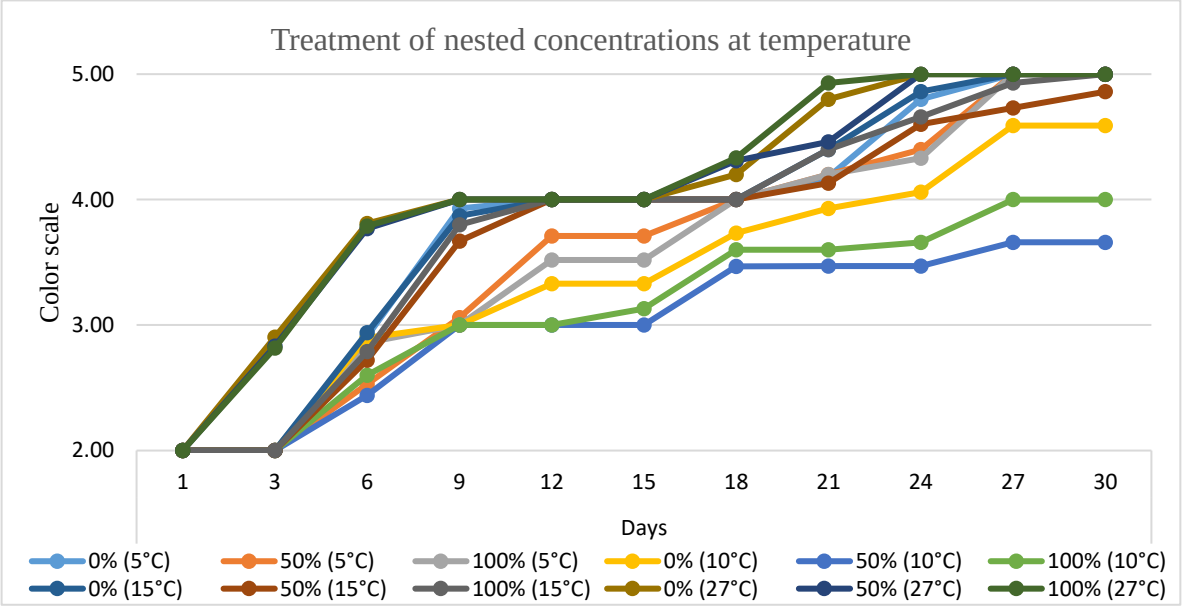


Figure 1. Momotaro Tomato Discoloration Given Temperature Treatment and Concentration of Edible Coating Aloe Vera Gel

Based on the results of the analysis using the Kruskal Wallis Test, the temperature treatment and concentration of *Aloe vera* edible coating on Momotaro tomatoes made a significant contribution to Momotaro's tomato discoloration starting from the shelf life of tomatoes (3,6,9,12,15,18,21,24,27,30) days, when compared to no coating (control). The 10°C temperature treatment had a markedly slower effect on Momotaro's tomato discoloration (Figure 1). This is because high temperatures accelerate the ripening process of the fruit and hasten the rotting of Momotaro tomatoes. This is in line with Aisyah et al. (2022), who state that low-temperature storage can inhibit the fruit ripening process so that changes in the red color index of tomato skin occur more slowly. The edible coating treatment of aloe vera gel with a concentration of 50% nested at various temperatures has a lower average color scale, so it is better to maintain the shelf life of Momotaro tomatoes because the color change becomes slow (Figure 1). This is thought to be because the discoloration of Momotaro tomatoes can be influenced by O_2, which can enter the fruit and be affected by increased respiration. According to Karmida et al. (2022), carotenoid pigments can increase as the rate of respiration increases in fruit.

3.1.2. Aroma

Based on the results of analysis using the Kruskal Wallis Test, the temperature treatment and concentration of edible coating Aloe vera on Momotaro tomatoes contributed significantly to the aroma of Momotaro tomatoes at shelf life (3,6,9) days, but at shelf life (12,15,18,21,24,27,30) days had no real effect when compared to no treatment (control). Momotaro tomato aroma changes at low temperatures of 5°C, 10°C, and 15°C, which have a slower average aroma change compared to 27°C (Figure 2). Low temperatures are suspected to slow the level of ripeness so that the volatile compounds produced are relatively few and make changes in the aroma of Momotaro tomatoes slower. According to Deglas (2023), the high storage temperature can ripen the fruit quickly and produce many volatile compounds. According to Moirangthem and Tucker (2018), the increased ripeness of the fruit can produce a delicious taste and aroma. According to Nasution et al. (2019), edible coating can retain a fruity aroma during storage.

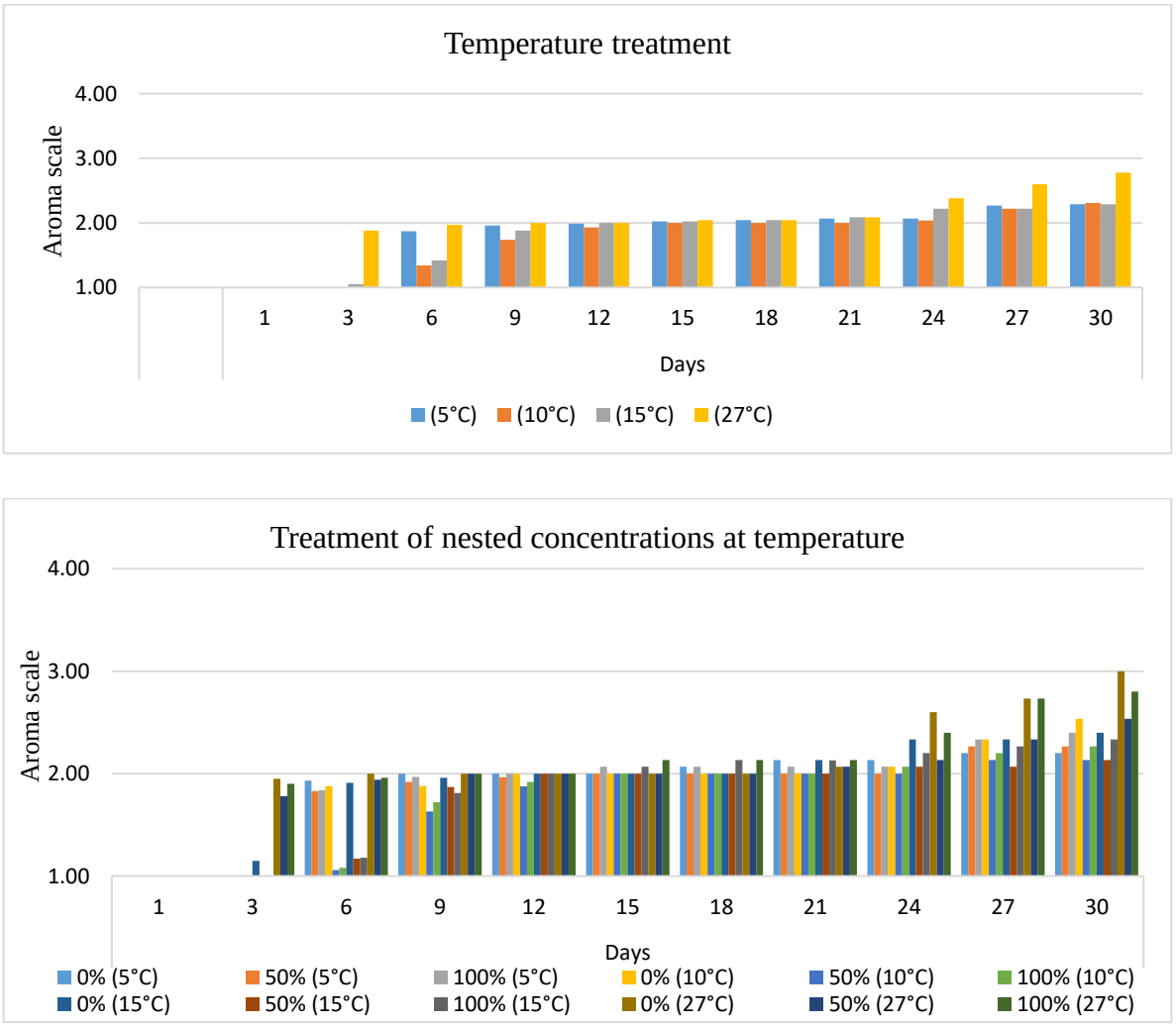


Figure 2. Changes In The Aroma Of Momotaro Tomatoes Given Temperature Treatment and Concentration of Edible Coating Aloe Vera Gel

3.1.3. Freshness

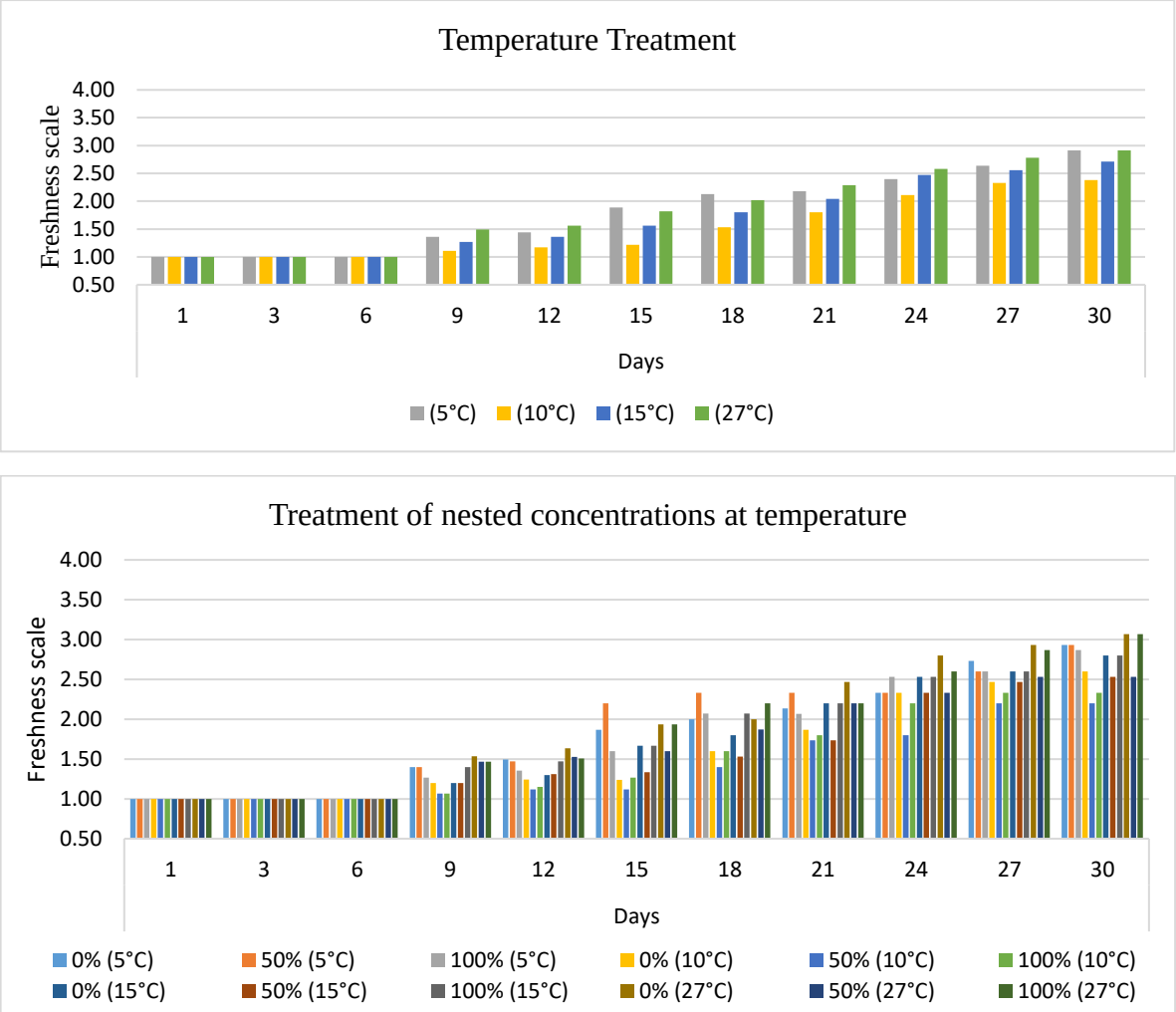


Figure 3. Changes In The Freshness of Momotaro Tomatoes Given Temperature Treatment and Concentration of Edible Coating Aloe Vera Gel

Based on the results of analysis using the Kruskal Wallis Test, the temperature treatment and concentration of edible coating Aloe vera on Momotaro tomatoes contributed significantly to the freshness of Momotaro tomatoes at shelf life (12, 15, 18, 21, and 30). However, they had no significant effect on lifespan (3, 6, 9, 24, 27) days compared to no treatment (control). Momotaro tomato freshness change with 10°C temperature treatment has the lowest average change in freshness compared to other temperature treatments (Figure 3). This is thought to be because, at low temperatures, the rate of respiration and transpiration that causes changes in freshness in Momotaro tomatoes can be inhibited. According to Wulandari and Ambarwati (2022), the transpiration process can make tomato skin wrinkled (reduced freshness), and the rapid, slow transpiration process is influenced by temperature and humidity. The edible coating treatment of aloe vera gel with a concentration of 50% nested in various temperatures had the lowest average compared to the 100% concentration and control treatment (Figure 3). It is suspected that the right concentration treatment of aloe vera gel edible coating can create a layer that closes the pores of the fruit as a path of water evaporation that can make Momotaro tomato skin wrinkled (freshness becomes reduced). The rate of respiration, weight loss, and moisture content are shown in Table 2:

Table 2. Average changes in respiration rate, weight loss, and moisture content of Momotaro tomatoes

Treatment		Respiration Rate (mg CO_2/kg/jam)		Weight loss	moisture content (%)	
		Beginning	End	(%)	Beginning	End
Temperature	5°C	2.079,66	400,93[b]	7,88[a]	93,29	95,54[b]
	10°C	2.054,50	217,23[a]	6,30[a]	93,31	94,77[a]
	15°C	2.038,40	385,10[b]	12,61[b]	93,58	95,56[b]
	27°C	2.067,90	582,47[c]	14,54[b]	93,59	96,44[c]
5°C	Concentration 0%	2.123,28	752,69[b]	9,20[b]	93,71	96,24[b]
	Concentration 50%	1.971,32	199,59[a]	6,94[a]	93,48	95,05[a]
	Concentration 100%	2.144,38	250,50[a]	7,51[a]	93,57	95,32[a]
10°C	Concentration 0%	1.939,42	389,04[b]	7,71[b]	93,21	95,33[b]
	Concentration 50%	2.170,34	91,73[a]	4,55[a]	93,1	94,23[a]
	Concentration 100%	2.053,72	170,93[a]	6,65[a]	93,56	94,75[a]
15°C	Concentration 0%	2.042,59	501,13[b]	12,37[b]	93,11	96,04[b]
	Concentration 50%	2.077,29	301,73[a]	10,70[a]	93,5	95,15[a]
	Concentration 100%	1.995,31	352,43[a]	14,76[b]	93,32	95,49[a]
27°C	Concentration 0%	2.069,76	800,60[c]	14,22[b]	93,52	97,05[b]
	Concentration 50%	2.115,66	434,62[a]	13,06[a]	93,62	96,26[a]
	Concentration 100%	2.018,29	512,20[a]	16,34[b]	94,59	96,03[a]

Information: The average score in the column followed by the same letter did not differ markedly according to the DMRT test at the level of 5%

3.1.4. Respiration Rate

The respiration rate is a major factor affecting the shelf life of horticultural products. Momotaro tomatoes, before treatment, produce high CO_2; it is suspected that after harvesting, Momotaro tomato respiration rate increases because the supply of Momotaro tomato substrate

is still high. According to Tarigan et al. (2016), tomatoes are classified as climacteric fruits with a fast respiration rate during initial storage and decrease due to the length of storage. This aligns with Utama and Antara (2013), namely that the respiration rate in climacteric fruits will increase when they enter the ripening phase. The respiration rate of Momotaro tomatoes decreases during 30-day storage. The 10°C treatment shows a slower respiration rate than other temperature treatments, while the 27°C treatment produces the highest CO_2, which means the respiration rate is still running fast (Table 2). The results suggest that a temperature treatment of 10°C can inhibit the rate of respiration better because it is the optimal temperature to store Momotaro tomatoes. According to Asgar (2017), high temperatures can cause the rate of respiration to increase. Edible coating treatment of aloe vera gel with concentrations of 50% and 100% nested at various temperatures has an average amount of CO_2 less than the control treatment nested at various temperatures (Table 2). It can be suspected that edible coating treatment with a concentration of 50% and 100% can slow down the respiration rate better because it can resist the entry of O_2 into Momotaro tomatoes. According to Prastya et al. (2015), fruits that are given coating treatment can make O_2 enter less so that enzymes involved in respiration and tissue softening can be minimized. According to Marwina et al. (2016), aloe vera gel coating treatment can slow down the rate of respiration and extend shelf life to 25 days.

3.1.5. Weight Loss

Momotaro tomato weight loss at 10°C has the lowest average weight shrinkage but is not significantly different from the 5°C treatment (Table 2). The high and low depreciation of weights is affected by temperature. High temperatures can cause high respiration and transpiration rates, so the weight of Momotaro tomatoes will decrease rapidly. Increasing temperature will accelerate the respiration rate, so the fruit's weight will decrease (Asgar, 2017). According to Ashadi et al. (2022), weight shrinkage occurs due to water in the fruit that evaporates, and the fruit emits CO_2 during respiration. Wulandari and Ambarwati (2022) found that the process of respiration and transpiration leads to substrate and water loss, resulting in weight changes. The weight of Momotaro tomatoes may decrease with the length of storage. This is in line with Saiduna and Madkar (2013), who state that the more mature the tomato, the lighter the weight of the fruit. Concentration treatment of edible coating of aloe vera gel with a concentration of 50% nested at various temperatures has the smallest weight shrinkage (Table 2). It is suspected that the concentration treatment of edible coating aloe vera gel can suppress the rate of respiration and transpiration in Momotaro tomatoes. The largest weight shrinkage was found in the coating treatment of aloe vera gel with a concentration of 100% nested at 27°C and 15°C (Table 2). It is suspected that the thickness of the coating on Momotaro tomatoes causes anaerobic respiration. According to Wulandari and Ambarwati (2022), fruits that are coated too thickly can cause the permeability to O_2 to decrease, and CO_2 cannot escape, so that air is trapped in the fruit and can cause anaerobic respiration. According to Karmida et al. (2022), anaerobic respiration can result in an overhaul of cells in the fruit and cause the decay process to be faster.

3.1.6. Moisture Content

The moisture content of Momotaro tomatoes during 30-day storage has increased. The average water content with the highest increase was found at 27°C, and the lowest average water content occurred at 10°C treatment (Table 2). This is because low temperatures can slow down the rate of respiration so that the change of carbohydrates into H_2O in Momotaro tomatoes can be inhibited. According to Roiyana et al. (2012), the increased respiration will cause an overhaul of compounds in fruit, such as carbohydrates, that produce CO_2, energy, and

water faster. Aloe vera gel coating treatments with concentrations of 50% and 100% nested at various temperatures had the lowest average increase in water content.

In contrast, the highest average increase in water content was found in the control treatment (Table 2). It is suspected that the high and low moisture content of Momotaro tomatoes can be influenced by the degree of ripeness, and the lowest average moisture content indicates that Momotaro tomatoes have a lower maturity level. According to Aisyah et al. (2022), coating treatment can be a protector of gas and water vapor to reduce the rate of respiration, which can cause a rapid decrease in water content. According to Dewi et al. (2021), the edible coating can inhibit the transpiration process, which can inhibit water loss and texture softness, while tomatoes without coating can make the metabolic process faster.

3.2. Discussion

Based on the results of Kruskal Wallis data analysis (quality data) shown in Figure 1, figure 2, and figure 3, namely the influence of cold temperature and concentration of aloe vera gel edible coating on Momotaro tomatoes which causes slight changes in color, aroma, and freshness so that a real contribution is obtained compared to no treatment (control). From Table 2, cold temperature treatment and concentration of aloe vera gel edible coating on Momotaro tomatoes also gave slight changes in the parameters of respiration rate, tomato weight, and water content of Momotaro tomatoes or statistically made a significant contribution compared to no treatment. The two data analyses above show that the shelf life can be extended, and changes occur slightly in the sensory Momotaro tomato. The results of this study are very relevant (very closely related) to several literature citations that have been revealed. Findings from several literature citations that are by this study.

The effect of aloe vera gel treatment, namely A1: without aloe vera gel, A2: 30% concentration, A3: 50% concentration, and A4: 70% concentration, while the combination of temperature, namely B1: 280C (room temperature) and B2: 100C (low temperature). The best treatment on tomatoes is a 30% aloe vera gel with a temperature of 10^0C, acceptable to consumers until day 21. The best treatment storage on the 12th day for weight loss analysis was found in the 30% aloe vera gel concentration treatment stored at 10ºC with a value of 15.52%; for the analysis of the percentage of hardness, the best treatment was found at a concentration of 30% at a low temperature of 10ºC value of 1,357kg/cm2 (Marwina et al., 2016).

The results showed that applying aloe vera-based edible coating and storage at cold temperatures better maintains the physical quality of tomato fruit. Edible coating treatment significantly affected fruit hardness parameters and color measurements (Darmawan et al., 2023). The effect of storage temperature treatment and the type of aloe vera gel significantly affect the organoleptic quality value and weight loss of stored chili. Aloe vera gel given without pasteurization to chili and tomatoes at refrigerator temperature shows higher organoleptic quality and lower weight loss than pasteurized aloe vera gel (Handarini, 2021).

4. Conclusion

Low-temperature treatment and concentration of edible aloe vera gel coating on Momotaro tomatoes extended shelf life, as seen from low respiration rate, low weight loss, and slightly reduced water content. Its effect on sensory, namely the color, aroma, and freshness of Momotaro tomatoes, changes slightly.

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