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The Effect of Edible Coating Material Formulation and Storage Long on The Response of Tomato (Solanum Lycopersicum L.) at Cooling Temperature (Lycopersicon Esculentum Mill)

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Abstract: Post-harvest handling of horticultural products is very influential on product quality, because storage temperature is one of the important factors to maintain product quality, especially fresh fruits and vegetables. The purpose of this study were to determined the effect of calcium chloride concentration ($CaCl_2$) and starch type as edible coating material against inhibition of chilling injury of tomato. The research method were carried in two stages, namely the preliminary research and main research. The preliminary research was conducted to determine the temperature and time of starch drying. The main research using Randomized Block Design (RAK) method with 3x4 factorial with 2 replications. The first factor was chloride calcium concentration consisting of 3 levels of a1 (1%), a2 (2%) and a3 (3%). The second factor is type of starch as edible coating material which consists ogf 4 levels of b1 (without edible coating), b2 (sweet potato starch), b3 (cassava starch) and b4 (ganyong starch). The main research responses include chemical responses (vitamin C and total soluble solid), physical responses (weight loss and firmness), and organolptic reponses (color and appearance). Preliminary research results were obtained the temperature of 60 ° C and the best 5 hours for starch drying. The main research results showed that the concentration factor of calcium chloride (A) affected the color and appearance either on day 5 or day 10. The type of starch as an edible coating material (B) had an effect on vitamin (C) content, total soluble solid, color and appearance on day 5 and day 10. Factor interaction of calcium chloride concentration and type of starch as edible coating material influenced to shrinkage oweight, color and appearance on day 5 and day 10. Ganyong starch has better results based on the response of vitamin C, total soluble solid and weight loss.

Keywords: Calcium chloride; Edible coating; Starch; Chilling injury; Cherry tomato

Introduction

The tomato (*Licopersicum esculentum Mill*) is a valuable commodity that is used in various products, including vegetables, seasonings, table fruit, food coloring agents, cosmetics, and medicines. The market demand for tomatoes continues to increase. This cannot be separated from the role of the tomato as an important horticultural commodity, especially as a vegetable crop (Wiryanta, 2002).

Storage temperature is an important factor in maintaining the quality of a food product, especially fruits and vegetables, so that they remain fresh during storage. The storage temperature used will depend on the type of food and the type of spoilage to be prevented. For some types of food, temperature control during storage is necessary.

Research results or surveys show that the percentage of fresh horticultural yield loss reaches 40% to 50%. This is supported by the physiological properties of fresh horticultural products, which are easily damaged. Therefore, these products require better handling from harvest to post-harvest. Variations in harvest and postharvest handling procedures are strongly influenced by the characteristics of horticultural crop products so that they require different handling,

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storage, transportation, and human resource competencies (Cahyono, 2008).

Based on Winarti (2012), edible coatings can be made from polysaccharides (carbohydrates), proteins, lipids, and composites. Polysaccharides are widely applied as edible coatings for fruits and vegetables because they act as selectively permeable membranes for the exchange of CO_2 and O_2 gases so that the rate of respiration will decrease. The use of starch as an edible coating has been widely developed due to its abundant sources and low price. Starch has properties that make it suitable for use as an edible coating because it can form a strong layer (Winarti, 2012). According to Fatah & Bachtiar (2004), apart from using edible coatings on food, calcium chloride ($CaCl_2$) can also be added to products to slow down the decline in the quality of cut fruit. $CaCl_2$ can also be used to remove the brown color that sometimes appears on fruit after peeling or soaking it in chemicals. The addition of calcium chloride salt to food products can maintain a firmer texture. This can happen because calcium ions will react with pectic acid to support tissue and improve product texture (Fennema et al., 2017).

Exogenous $CaCl_2$ is not only relatively inexpensive but also easy to obtain. $CaCl_2$ treatment with post-harvest immersion of the fruit will not leave residue after washing the fruit with water (Pantastico, 1986; Rahmawati et al.,2011). But, in some cases, edible coatings were not successful. The success of edible coatings for fresh products totally depends on the control of internal gas composition. Park et al., (1994) reported that tomatoes coated with 2.6-mm zein film produced alcohol and off-flavors internally due to low oxygen and high carbon dioxide concentrations. (Smith et al., 1987) summarized that use of coatings results in disorders like core flush, flesh breakdown, accumulation of ethanol, and alcoholic off-flavors, which are due to modification of the internal atmosphere. Based on this description, the purpose of this study was to determine the effect of calcium chloride concentration ($CaCl_2$) and the type of starch used as an edible coating material on the inhibition of tomato chilling injury.

Method

Tools and materials

The materials used in this study consisted of tomatoes obtained from Parompong District, West Bandung Regency; sweet potatoes, cassava and canna yams obtained from Ciroyom Market Bandung; carboxylmethyl cellulose (CMC), glycerol and calcium chloride ($CaCl_2$).

The materials used for the analysis were aquadest, starch, and 0.1 NI_2. The tools used in this study consisted of a digital scale, knife, plastic container, grater, waring cloth, heat-resistant plastic, ziplock plastic, tray, tunel dryer, measuring cup, vibratory screen, blender, beaker glass, hot plate, magnetic stirrer, spoon, stopwatch, clamp, stayrofoam, plastic warp, and refrigerator. The tools used for analysis were digital scales; refractometer; penetrometer; mustard and pastle; funnel; filter paper; burette; 100 mL measuring cup; 5 mL pipette; and 250 mL erlenmeyer.

Preliminary Research

This preliminary study was intended to determine the best drying temperature and time in the drying process of sweet potato starch. The drying temperatures and times used were 50 °C for 6 hours and 60 °C for 5 hours, and a hedonic quality test was carried out on the color attribute of starch. The process of making starch includes sorting tubers (sweet potato, cassava and sweet potato), stripping, washing, weighing, size reduction (grating) plus water with added water ratio (3:1), filtering, settling for 12 hours at room temperature, decantation, drying (T = 50 °C, t =6 hours and T = 60 °C, t =5 hours), milling, sieving (100 mesh) and hedonic quality test analysis was performed on the color attribute of starch.

Main Research

The main research was conducted to test cherry tomatoes soaked in calcium chloride ($CaCl_2$) and edible coatings with different concentrations and types of edible ingredients. The research method consisted of treatment design, experimental design, analysis design, and response design. In the main study, the treatment design was based on two factors: the amount of calcium chloride (A) and the type of starch used as an edible coating (B). The first factor had three levels, while the second factor had four levels. A calcium chloride concentration factor (A) consists of:

a1 = 1%
a2 = 2%
a3 = 3%

The type of starch as an edible coating material (B) consists of:

b1 = No Edible Coating
b2 = Sweet Potato Starch
b3 = Cassava Starchb
b4 = Pati Ganyong

In this study, the experimental design was a factorial pattern (3x4) in a Randomized Block Design (RAK) with two repetitions. This gave us 24 experimental units. Observation criteria include chemical response, physical response, and organoleptic response. Observations were made on days 5 and 10. Chemical responses carried out were vitamin C levels (Iodimetry) (Lathifa, 2013) and total dissolved solids (Refractometer) (Mawardi, 2005). Physical responses taken were weight loss (Mawardi, 2005) and hardness

(Penetrometer) (Apriyantono et al., 1989 in Nanda, 2016). Using the hedonic test method and 30 panelists, the organoleptic response was evaluated based on color and appearance (Soekarto, 1985).

The Process of Making CaCl2 Solution

The process of making a solution of calcium chloride ($CaCl_2$) consists of three concentrations, including $CaCl_2$ 1%, 2%, and 3%. The material was weighed according to the weight of each concentration (5 grams, 10 grams, and 15 grams), then diluted to 500 ml in a measuring flask and homogenized.

Edible Manufacturing Process

The process of making edible coatings consists of weighing starch, mixing I (4% starch with distilled water), mixing II (CMC 0.2%), mixing III (glycerol 5%) and heating at 80 °C for 15 minutes. The Cherry Tomato Edible Coating Process. The process of edible coating of cherry tomatoes, namely, sorting of cherry tomatoes, washing, draining, soaking in a solution of calcium chloride (1%, 2%, and 3%) for 10 minutes, then draining, immersing the edible coating at a temperature of 40°C for 120 seconds, then drained to dry edible, stored at a temperature of 5°C and carried out chemical, physical, and organoleptic analysis on days 5 and 10.

Result and Discussion

Preliminary Research

Based on the results of organoleptic responses using hedonic quality tests on color attributes, preliminary research was conducted to determine the temperature and drying time for the process of making sweet potato starch.The results of the analysis can be seen in table 1.

Table 1. Results of Preliminary Analysis of Sweet Potato Starch Color

Temperature and Time	Value Average	Real Level 5%
T = 50°C, t = 6 hours	2.29	a
T = 60°C, t = 5 hours	2.43	b

Description: Each different letter indicates a significant difference at the 5% level of Duncan's Advanced Test.

Based on the results of the preliminary analysis, it can be seen that the temperature treatment of 60 °C for 5 hours was the selected treatment for use in the main study. It is suspected that the drying time will result in browning of the starch, which is called the Maillard reaction. The Maillard reaction is a browning reaction that occurs between carbohydrates, especially reducing sugars with primary amine groups. The result of this reaction produces a brown material, which is often undesirable or an indication of a decrease in quality (Winarno, 1992). Susanto and Suneto (1994) in Martunis (2012) added that the effect of drying on the quality of the material depends on the type of material being dried, pre-treatment, drying time, type of drying process, and others.

Main Research

The main research is a continuation of the preliminary research. The main research was conducted to determine the effect of the concentration of calcium chloride and the type of starch as an edible coating on the inhibition of chilling injury in cherry tomatoes. Chemical responses include analysis of vitamin C levels and total dissolved solids; physical responses include weight loss and hardness; as well as organoleptic responses using hedonic tests on color and appearance attributes carried out on days 5 and 10.

Chemical Response

Vitamin C

Day 5

The results of the analysis of vitamin C levels carried out on tomatoes showed that the type of starch as an edible coating material (B) had a significant effect on vitamin C levels in tomatoes. Tomato fruit can be inhibited according to the statement of Lathifa (2013); the presence of an edible coating on the surface of the tomato fruit can inhibit the rate of respiration. As the calcium chloride concentration factor (A) is suspected, the calcium chloride concentration used in this study was not appropriate. The interaction between the two factors did not affect the chemical response of vitamin C in tomatoes because the two factors did not work synergistically in providing differences in each sample treatment. In Duncan's further test of the effect of starch as an edible coating material (B), can be seen in Table 2.

Table 2. Effect of Types of Starch as Edible Coating Material (B) on Vitamin C Levels of Tomatoes on Day 5

Types of Starch as Edible Coating Material (b)	Average Value of Vitamin C Content (mg/100 g ingredient)	Real Level 5%
No edible coating (b_1)	20.555	a
Sweet Potato Starch (b_2)	22.156	b
Cassava Starch (b_3)	22.251	b
Canna Starch (b_4)	22.439	b

Description: Each different letter indicates a significant difference at the 5% level of Duncan's Advanced Test.

Based on the results of the analysis in Table 2, it shows that the edible coating treatment (b2, b3, b4) has higher vitamin C levels than the treatment without edible coating (b1). This shows that the edible coating (B) can inhibit the diffusion of O2 into the fruit tissue and the oxidation reaction that causes damage to vitamin C can be slowed down. Whereas in tomatoes that are not coated with an edible coating, the diffusion of O2 into the tissue cannot be inhibited, which results in the degradation of vitamin C, which will continue (Lathifa, 2013).

Day 10

The results of the analysis of vitamin C levels carried out on tomatoes showed that the type of starch as an edible coating material (B) had a significant effect on vitamin C levels in tomatoes. Tomato fruit can be inhibited according to the statement of Lathifa (2013); the presence of an edible coating on the surface of the tomato fruit can inhibit the rate of respiration. As the calcium chloride concentration factor (A) is suspected, the calcium chloride concentration used in this study was not appropriate. The interaction between the two factors did not affect the chemical response of vitamin C in tomatoes because the two factors did not work synergistically in providing differences in each sample treatment. In Duncan's further test of the effect of starch as an edible coating material (B), can be seen in Table 3.

Table 3. Effect of Types of Starch as Edible Coating Material (B) on Levels of Vitamin C Tomato Fruit on Day 10

Types of Starch As Edible Coating Materials (b)	Average Value of Vitamin C Content (mg/100 g ingredient)	Real Level 5%
No *edible coating* (b_1)	19.523	a
Sweet Potato Starch (b_2)	21.005	b
Cassava Starch (b_3)	21.138	bc
Canna Starch (b_4)	21.562	c

Description: Each different letter indicates a significant difference at the 5% level of Duncan's Advanced Test.

Based on the results of the analysis in Table 3, it shows that the Sedible coating treatment (b2, b3, b4) had higher vitamin C levels than the treatment without edible coating (b1). This shows that the edible coating (B) can inhibit the diffusion of O_2 into the fruit tissue and the oxidation reaction that causes damage to vitamin C can be slowed down. Meanwhile, in tomatoes that are not coated with an edible coating, the diffusion of O_2 into the tissue cannot be inhibited, which causes the degradation of vitamin C to continue. Because of this, the amount of vitamin C in fruit goes down (Lathifa, 2013).

Tomato fruits with an edible coating of canna starch have a higher vitamin C content than tomatoes with an edible coating of sweet potato starch and cassava starch. This is presumably because canna starch has a higher amylose content, so it has a higher density than sweet potato starch and cassava starch. According to Baldwin, Hagenmaier, & Bai (2011), amylose has low transparency, strength, and elasticity properties but high density. The respiration rate will be held by the film matrix better the more amylose is in it.

According to Rudito (2005), the coating on tomatoes can inhibit the rate of respiration. In the process of respiration, in addition to sugar, organic acids can also be oxidized. So, if the respiration rate of a product is high, the rate of reduction of organic acids will also be faster.

Vitamin C is also easily oxidized when exposed to air containing oxygen and sunlight containing ultraviolet light, as well as mild heating (slightly above room temperature). So that dehydroascorbic acid is produced, which causes its ability as an antioxidant to decrease, and even if it is hydrolyzed to 2,3-diketogluconate, its antioxidant activity will disappear (Tampubolon, 2017).

A graph of the vitamin C levels of tomatoes on days 5 and 10 can be seen in Figure 1. Based on the graph in Figure 1, it can be seen that vitamin C levels on day 10 decreased from vitamin C levels on day 5 because, during the ripening process, there will be a decrease in organic acids. This decrease in organic acids is thought to be caused by the use of organic acids in the respiration process. It undergoes conversion into sugar (Pujimulyani, 2009).

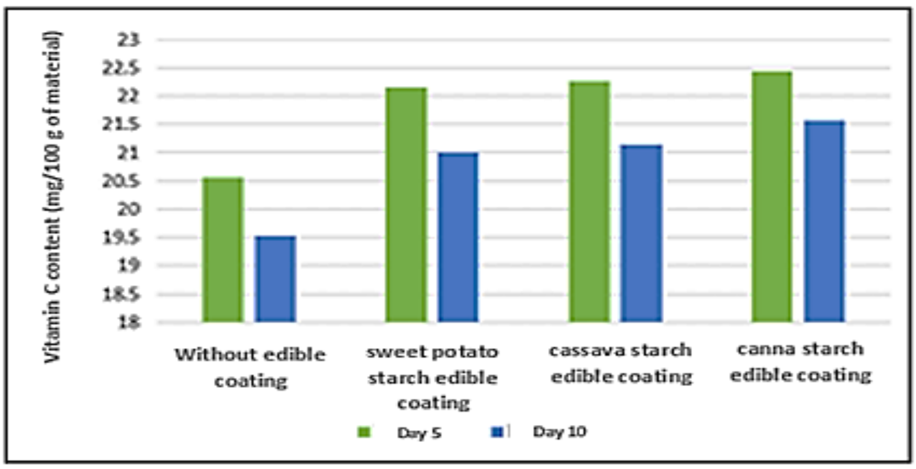

Figure 1. Graph of Vitamin C Levels in Tomatoes on Days 5 and 10.

Total Dissolved Solids (TDS)

Day 5

The results of the analysis of the total dissolved solids content showed that the type of starch as an edible coating material (B) had a significant effect on the total dissolved solids content of tomatoes because with the edible coating, the respiration process ran slower and the ripening phase of tomatoes could be suppressed. The concentration of calcium chloride (A) had no effect on the total dissolved solid content of tomatoes. This is presumably because the concentration of calcium chloride used in this study was not appropriate. The interaction between the two factors did not affect the total soluble solids content of tomatoes because the two factors did not work synergistically in providing differences in each sample treatment. In Duncan's further test of the effect of starch as an edible coating material (B), can be seen in Table 4.

Table 4. The Effect of Types of Starch as an Edible Coating Material (B) on the Total Dissolved Solids Content of Tomato Fruit on Day 5

Types of Starch As Edible Coating Materials (b)	Average Value of Vitamin C Content (mg/100 g ingredient)	Real Level 5%
No edible coating (b1)	5.357	c
Sweet Potato Starch (b2)	5.043	b
Cassava Starch (b3)	5.063	b
Canna Starch (b4)	4.856	a

Description: Each different letter indicates a significant difference at the 5% level of Duncan's Advanced Test.

Based on the results of the analysis in Table 4, it shows that the edible coating treatments (b2, b3, b4) had a lower total dissolved solids content than the treatment without edible coating (b1). This means that the edible coating is able to form a layer that is good enough to suppress the rate of respiration and transpiration processes so that it can inhibit the increase in total dissolved solids levels. In accordance with Pujimulyani (2009), which states that when fruit ripens, the dissolved solids will increase. This increase is sharper if there is very fast transpiration.

Day 10

The results of the analysis of the total dissolved solids content showed that the type of starch as an edible coating material (B) had a significant effect on the total dissolved solids content of tomatoes because with the edible coating, the respiration process ran slower and the ripening phase of tomatoes could be suppressed. The concentration of calcium chloride (A) had no effect on the total dissolved solids content of tomatoes. This is presumably because the concentration of calcium chloride used in this study was not appropriate. The interaction between the two factors did not affect the total soluble solids content of tomatoes because the two factors did not work synergistically in providing differences in each sample treatment. In Duncan's further test of the effect of starch as an edible coating material (B), can be seen in Table 5.

Table 5. Effect of Types of Starch as Edible Coating Material (B) on Total Dissolved Solids Content of Fruit

Types of Starch As Edible Coating Materials (b)	Average Value of Total Dissolved Solids Content (Brix)	Real Level 5%
No edible coating (b1)	6.177	c
Sweet Potato Starch (b2)	5.796	b
Cassava Starch (b3)	5.782	b
Canna Starch (b4)	5.550	a

Desvription: Each different letter indicates a significant difference at the 5% level of Duncan's Advanced Test.

Based on the results of the analysis in Table 5, it shows that the edible coating treatments (b2, b3, b4) had a lower total dissolved solids content than the treatment without edible coating (b1). This means that the edible coating is able to form a layer that is good enough to suppress the rate of respiration and transpiration processes so that it can inhibit the increase in total dissolved solids levels. In accordance with Pujimulyani (2009), which states that when fruit ripens, the dissolved solids will increase. This increase is sharper if there is very fast transpiration.

Tomato with canna starch edible coating treatment had a lower total dissolved solids content than sweet potato and cassava starch edible coating treatments. This is presumably because canna starch has a higher amylose content of 18.9% (Richana and Sunarti, 2004 in Lathifa, 2013) compared to the amylose content of sweet potato starch at 15% (Eliasson, 2004 in Putri & Nisa, 2014) and the amylose content of cassava starch at 17% (Richana and Sunarti, 2004 in Lathifa, 2013), so that the edible coating of canna starch has a higher density level.

The measurement of total dissolved solids is expressed in degrees of sucrose brix. The chemical changes are mainly in the sweet taste of the fruit, which is indicated by the dissolved solids. Most of the total dissolved solids are in the form of sugar, which is found in fruit. Sucrose gives a sweet taste to the fruit, so the higher the total dissolved solids value, the sweeter the fruit (Badriyah, 2011).

Winarno (1981) say that during respiration, complex materials like carbohydrates are broken down by oxidation, which lowers the amount of starch and makes simple sugars. The hydrolysis of starch produces the same concentration of glucose and fructose with a small amount of sucrose. With longer storage, the content of the three types of sugar is reduced. The graph of the total dissolved solids content of tomatoes on days 5 and 10 can be seen in Figure 2.

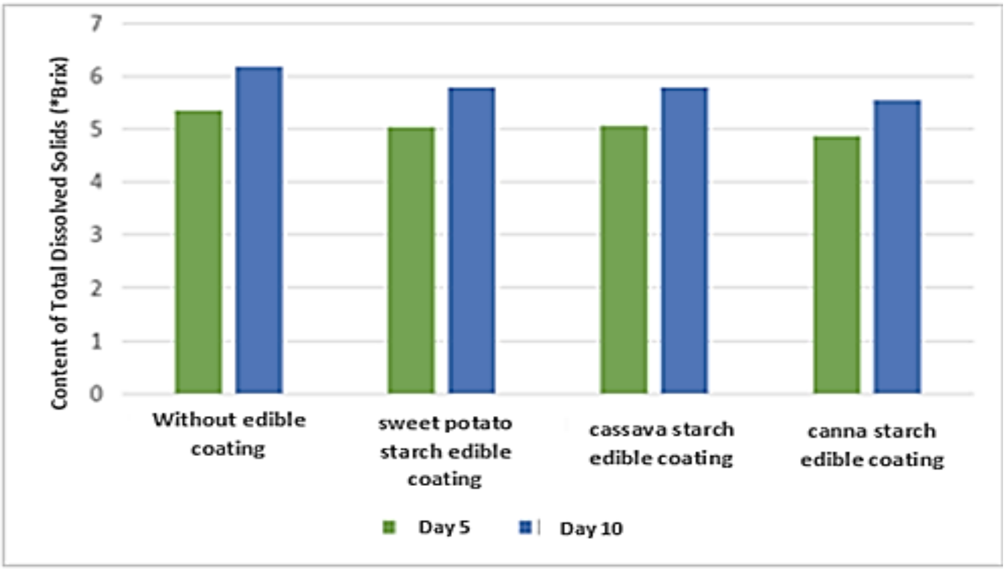

Figure 2. Graph of Total Dissolved Solids Content of Tomato Fruit on Days 5 and 10.

Based on the graph above, it can be seen that the total dissolved solids content on day 10 increased from the total dissolved solids content on day 5. This is a characteristic of fruit in a climacteric state. The increase in total dissolved solids with the main content of simple sugars may be due to the increased rate of respiration, resulting in the oxidative breakdown of complex materials such as carbohydrates. This causes the starch content of tomatoes to decrease and simple sugars (sucrose, sugar, and fructose) are formed (Hutabarat, 2007).

Physical Response

Day 5: Weight Loss

The results of the weight loss analysis showed that the type of starch as an edible coating material (B) had an effect on the weight loss of tomatoes. This was because the edible coating was a good barrier to water and oxygen so as to control the respiration rate. The interaction between the two factors affects the weight loss of tomatoes because they work synergistically to provide differences in each sample treatment. The concentration factor of calcium chloride (A) had no effect on the weight loss of tomatoes. A further test of the interaction effect of calcium chloride (A) and the type of starch as an edible coating material (B) can be seen in Table 6.

Based on the results of the analysis in Table 6, it shows that with increasing concentration of calcium chloride on stiffening without edible coating, edible coating of sweet potato starch, and cassava starch, there is no significant difference in the weight loss of tomatoes. However, this does not happen with the edible coating of canna starch. The weight loss decreased at concentrations of 1% and 2% calcium chloride with different types of starch as edible coating materials. However, this did not happen at a concentration of 3% calcium chloride.

Table 6. The Effect of Calcium Chloride Concentration (A) and Starch Type as Edible Coating Material (B) on Tomato Fruit Weight Loss on Day 5

Concentration of CaCl2 (A)	Types of Starch As Edible Coating Materials (b)			
	b1	b2	b3	b4
	A	A	A	B
a1	2.159	1.480	1.801	1.480
	b	a	a	a
	A	A	A	A
a2	2.387	1.593	1.904	1.069
	c	b	b	a
	A	A	A	B
a3	2.180	1.309	1.930	1.450
	b	a	b	a

Description: The average value marked with the same letter shows no significant difference at the 5% level according to Duncan's further test. Lowercase letters are read horizontally while capital letters are read vertically.

Day 10

The results of the weight loss analysis showed that the type of starch as an edible coating material (B) had an effect on the weight loss of tomatoes. This was because the edible coating was a good barrier to water and oxygen so as to control the respiration rate. The interaction between the two factors affects the weight loss of tomatoes because they work synergistically to provide differences in each sample treatment. The concentration factor of calcium chloride (A) had no effect on the weight loss of tomatoes. In Duncan's further test of the interaction effect of calcium chloride (A) and the type of starch as an edible coating material (B) can be seen in Table 7.

Table 7. Interaction of Concentration of Calcium Chloride (A) and Type of Starch as Edible Coating Material (B) Against Weight Loss of Tomato Fruit on Day 10

Concentration of $CaCl_2$ (A)	Types of Starch As Edible Coating Materials (b)			
	b1	b2	b3	b4
	A	A	A	B
a1	2.395	1.640	1.921	1.597
	c	a	b	a
	A	A	A	A
a2	2.620	1.758	2.036	1.175
	d	b	c	a
	A	A	A	B
a3	2.414	1.554	2.058	1.517
	c	a	b	a

Description: The average value marked with the same letter shows no significant difference at the 5% level according to Duncan's further test. Lowercase letters are read horizontally while capital letters are read vertically.

Based on the results of the analysis in Table 7, it shows that with increasing concentration of calcium chloride on stiffening without edible coating, edible coating of sweet potato starch, and cassava starch, there is no significant difference in the weight loss of tomatoes. However, this does not happen with the edible coating of canna starch. At concentrations of calcium chloride of 1, 2% and 3% with different types of starch as an edible coating material, fluctuating results were obtained.

The treatment without edible coating (b1) had a higher weight loss value than the treatment with edible coating (b2, b3, b4). This is because in tomatoes without edible coating treatment, there is no barrier that can reduce water loss due to transpiration and the breakdown of glucose into CO_2 and H_2O, which can result in increased weight loss. According to Pantastico (1986), the increase in weight loss was largely due to high transpiration. The opening and closing of the skin determines the amount of water loss, resulting in weight loss. The same statement was reported by Santoso & Purwoko (1995). Apart from having a direct effect on quantitative loss, transpiration also causes quality loss (withering and shrinking).

Weight loss is one of the factors that indicates the quality of tomatoes. Changes will occur during storage time, where the longer the tomatoes are stored, the weight loss decreases. The factor that affects weight loss is relative air humidity (RH) in the storage room. If the storage room has a high RH, the weight loss experienced will be lower when compared to the storage room that has a low RH (Ryall and Lipton, 1982 (Broto, 1998).

The graph of tomato fruit weight loss on days 5 and 10 can be seen in Figure 3.

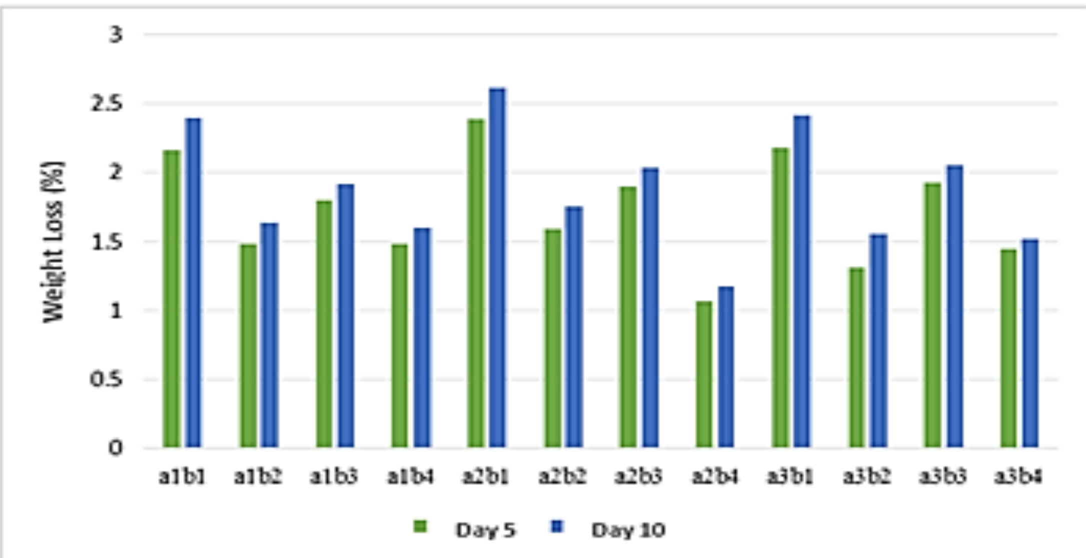

Figure 3. Graph of Tomato Fruit Weight Loss on Days 5 and 10.

Based on the graph above, it can be seen that the weight loss of tomatoes has increased. This is due to the process of transpiration and respiration. This is similar to research by Hutabarat (2008), which states that the increase in weight loss is largely due to water loss due to transpiration and the breakdown of glucose into CO_2 and H_2O during the respiration process, although the amount is small.

Violence

Day 5

The results of the hardness analysis showed that the concentration factor of calcium chloride (A), the type of starch as an edible coating material (B), and the interaction between the two factors did not significantly affect the hardness response of tomatoes. The instrument used made a mistake.

The level of hardness in fruits will generally decrease during the storage process. The softer the skin of the fruit, the more it can be said that the fruit has been damaged and is not liked by consumers. The hardness value is expressed in mm/second/gram. The lower the hardness value, the harder the tomatoes. This is indicated by the shallower the needle penetration in the tomatoes.

In general, chemically, the cell wall in fruit is composed of compounds such as cellulose, pectin, hemicellulose, and lignin, which will undergo changes during the ripening process. The cell wall and middle lamella layer, with a weight of 1-3% of the weight, form a solid structure with a mixture of mostly water (Bourne, 1981).

The longer the fruit is stored, the softer it will be because insoluble propectin is converted into pectin, which is soluble in pectic acid (Winarno, 1981). Propectin is a form of pectin that is insoluble in water where the breakdown of propectin into substances with low molecular weight results in weak cell walls and decreased cohesion that binds cells to one another (Pantastico 1986). The destruction of the carbohydrate polymers that make up the cell wall, especially pectin and hemicellulose, will weaken the cell wall and network cohesion bonds, so that the fruit texture becomes softer (Wills, Lim, & Greenfield, 1986).

Day 10

The results of the hardness analysis showed that the concentration factor of calcium chloride (A), the type of starch as an edible coating material (B), and the interaction between the two factors did not significantly affect the hardness response of tomatoes. The instrument used made a mistake. The level of hardness in fruits will generally decrease during the storage process. The softer the skin of the fruit, the more it can be said that the fruit has been damaged and is not liked by consumers. The hardness value is expressed in mm/second/gram. The lower the hardness value, the harder the tomatoes. This is indicated by the shallower the needle penetration in the tomatoes.

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Organoleptic Response

Color

Day 5

Based on the results of the ANOVA calculation, it shows that the concentration of calcium chloride (A), the type of starch as an edible coating material (B), and the interaction between the two factors significantly affect the color attribute of tomatoes. In Duncan's further test of the interaction effect of the concentration of calcium chloride (A) and the type of starch as an edible coating material (B) can be seen in Table 8.

The average value marked with the same letter shows no significant difference at the 5% level according to Duncan's further test. Lowercase letters are read horizontally while capital letters are read vertically.

Table 8. Effect of Calcium Chloride Concentration (A) and Starch Type as Edible Coating Material (B) on Tomato Fruit Color on Day 5

Concentration of CaCl2 (A)	Types of Starch As Edible Coating Materials (b)			
	b1	b2	b3	b4
	A	A	A	A
a1	4.300	4.117	4.367	4.200
	ab	a	b	ab
	A	A	B	B
a2	4.350	4.217	4.767	4.400
	ab	a	c	b
	A	B	A	AB
a3	4.250	4.600	4.383	4.233
	a	b	a	a

Based on the results of the analysis in Table 8, it shows that the a2b3 treatment has the highest average compared to the other treatments, so it can be seen that the a2b3 treatment is preferred by the panelists because it has a higher percentage of pink color.

Day 10

Based on the results of the ANOVA calculation, it shows that the concentration of calcium chloride (A), the type of starch as an edible coating material (B), and the interaction between the two factors significantly affect the color attribute of tomatoes. In Duncan's further test of the interaction effect of calcium chloride (A) and the type of starch as an edible coating material (B) can be seen in Table 9.

Table 9. Effect of Calcium Chloride Concentration (A) and Starch Type as Edible Coating Material (B) on Tomato Fruit Color on Day 10

Concentration of $CaCl_2$ (A)	Types of Starch As Edible Coating Materials (b)			
	b1	b2	b3	b4
	A	A	A	A
a1	4.217	4.150	4.600	4.317
	a	a	b	a
	A	A	A	A
a2	4.333	4.333	4.833	4.400
	a	a	b	a
	A	B	A	A
a3	4.250	4.733	4.650	4.317
	a	b	b	a

Description: The average value marked with the same letter shows no significant difference at the 5% level according to Duncan's further test. Lowercase letters are read horizontally while capital letters are read vertically.

Based on the results of the analysis in Table 9, it can be seen that the a2b3 treatment has the highest average compared to other treatments, so it can be seen that the a2b3 treatment is preferred by the panelists because it has a bright red color. Tests on color attributes have fluctuating results. This is probably due to psychological errors from the panelists, namely central tendency errors. The characteristic of this central tendency error is that the panelists give the middle value on the existing value scale and are hesitant to give the highest score (Kartika, Hastuti, & Supartono, 1988). Because of this mistake, the panelists think that all of the samples that were tested are almost the same.

Color is one of the factors that determine the quality of food before other factors are considered visually. A food that is nutritious and has a good texture will not be good if it has a color that deviates from the color it should be. Food ingredients are considered nutritious and taste good but are not eaten if they have an unsightly color or give the impression of deviating from the proper color (Winarno, 1992).

During storage, the color of the tomatoes changes from green to yellow to red. Tomato fruit is harvested in the turning phase and the longer the storage time, the color gradually turns yellow and then red. This statement is supported by Winarno (1981), stating that the color change of tomatoes begins with the loss of green color where the chlorophyll content of ripe fruit gradually decreases. At the start of the ripening process, the yellow pigment xanthophyll is produced. Then, at the next stage of maturity, the red pigment (lycopene) will accumulate. This study shows that storage at low temperatures can slow down the chlorophyll breakdown process and, at the same time, slow down the lycopene formation process. This is supported by the opinion of Winarno (1981), which states that temperature has an important role in the formation of pigments.

Sightings

Day 5

Based on the results of ANOVA calculations, it shows that the concentration of calcium chloride (A), the type of starch as an edible coating material (B), and the interaction between the two factors significantly affect the appearance attributes of tomatoes. In Duncan's further test of the interaction effect of calcium chloride (A) and the type of starch as an edible coating material (B) can be seen in Table 10.

Table 10. Effect of Calcium Chloride Concentration (A) and Starch Type as Edible Coating Material (B) on Tomato Fruit Appearance on Day 5

Concentration of $CaCl_2$ (A)	Types of Starch As Edible Coating Materials (b)			
	b1	b2	b3	b4
	A	A	A	A
a1	4.233	4.317	4.583	4.367
	a	ab	c	b
	A	A	B	AB
a2	4.333	4.300	4.783	4.400
	a	a	b	a
	A	B	AB	B
a3	4.283	4.467	4.667	4.500
	a	b	c	b

Description: The average value marked with the same letter shows no significant difference at the 5% level according to Duncan's further test. Lowercase letters are read horizontally while capital letters are read vertically.

Based on the results of the analysis in Table 10, it shows that the a2b3 treatment has the highest average compared to other treatments, so it can be seen that the a2b3 treatment is preferred by the panelists because it has a better appearance.

Day 10

Based on the results of ANOVA calculations, it shows that the concentration of calcium chloride (A), the type of starch as an edible coating material (B), and the interaction between the two factors significantly affect the appearance attributes of tomatoes. In Duncan's further test of the interaction effect of calcium chloride (A) and the type of starch as an edible coating material (B) can be seen in Table 11.

Based on the results of the analysis in Table 11, it shows that the a2b3 treatment has the highest average compared to other treatments, so it can be seen that the a2b3 treatment is preferred by the panelists because it has a better appearance. The organoleptic test on the appearance attribute has fluctuating results. This is probably due to a psychological error from the panelists, namely a central tendency error. The characteristic of this central tendency error is that the panelists give the middle value on the existing value scale and are hesitant to give the highest score. Because of this mistake, the panelists think that all of the samples that were tested are almost the same.

Table 11. Effect of Calcium Chloride Concentration (A) and Starch Type as Edible Coating Material (B) on Tomato Fruit Appearance on Day 10

Concentration of $CaCl_2$ (A)	Types of Starch As Edible Coating Materials (b)			
	b1	b2	b3	b4
a1	A 4.267 b	A 4.050 a	A 4.617 c	A 4.283 B
a2	A 4.250 A	B 4.417 b	A 4.683 c	A 4.283 A
a3	A 4.217 A	B 4.500 b	A 4.617 b	A 4.300 a

Description: The average value marked with the same letter shows no significant difference at the 5% level according to Duncan's further test. Lowercase letters are read horizontally while capital letters are read vertically.

Appearance is a product trait that most influences consumers' desire to buy a product because appearance is often the only trait that can be tested by consumers before buying a product. The appearance of fresh food ingredients is influenced by the shrinkage of cells, especially the skin of the fruit, as a result of the transpiration process.

Conclusion

Based on the results of the research that has been done, we can say that: (1) The preliminary study's hedonic quality test results: the temperature and drying time of the selected starch were 60 °C for 5 hours; (2) The concentration of calcium chloride ($CaCl_2$) affected the color and appearance on day 5 and day 10, but had no effect on vitamin C content, total dissolved solids content, weight loss, or hardness on day 5 and day 10; (3) The type of starch as an edible coating material has an effect on vitamin C levels, total dissolved solids content, weight loss, color, and appearance on day 5 and day 10, but has no effect on hardness on day 5 and day 10; (4) The interaction between the concentration of calcium chloride ($CaCl_2$) and the type of starch as an edible coating material has an effect on weight loss, color, and appearance on day 5 and day 10, but has no effect on vitamin C content, total dissolved solids content, and hardness on day 5 and the 10th day; (5) Based on the results of weight loss analysis, the color and appearance of the 2% calcium chloride concentration had better results than the 1% and 3% calcium chloride concentrations; (6) Based on the analysis of vitamin C content, the total soluble solids content and specific gravity loss of canna yam starch had better results than sweet potato and cassava starch.

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