*International Journal of Research in Engineering and Science (IJRES)*
*ISSN (Online): 2320-9364, ISSN (Print): 2320-9356*
*www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 437-444*

# Effect of Edible Coating with Raw Materials from Cassava Starch and Yellow Sweet Potato on Physicochemical Changes of Strawberry Fruit (*Fragaria x ananassa* Var. Rosalinda) at Different Storage Temperatures

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***Abstract***
*Strawberries are a very popular fruit in Indonesia and have a high selling price. The main problem with strawberries is that strawberries are classified as non-climacteric fruits and are easily damaged commodities. This study aims to determine the best edible coating for starch raw materials and storage temperature to maintain the physical and chemical properties of strawberries during storage. This study was arranged according to a randomized block design with split plots using two factors and three replications. The main factor is storage temperature with room temperature ($S_1$), air conditioning refrigerated temperature ($S_2$), and refrigerator temperature ($S_3$). An additional factor is the provision of edible coating with three levels, namely without the provision of edible coating ($P_0$), the provision of edible coating for cassava starch ($P_1$) and the provision of edible coating for yellow sweet potato starch ($P_2$). There is a significant effect on the interaction of the physicochemical properties of strawberries in weight loss and water content. On the main factor, refrigerator temperature gave the best physicochemical properties with the lowest weight loss, the highest water content value, the lowest decrease in fruit hardness, the lowest total solids value, and the lowest decrease in vitamin C content. In the additional factor, the provision of edible coating as raw material for yellow sweet potato starch gave the best physicochemical properties with the lowest weight loss, the highest fruit moisture content, the lowest fruit hardness decrease, the lowest total soluble solids value, and the lowest vitamin C content reduction.*

***Keywords:*** *edible coating, physiochemistry, starch, strawberry, temperature*

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Date of Submission: 02-05-2023 Date of acceptance: 14-05-2023

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## I. INTRODUCTION

Strawberry (*Fragaria x ananassa* Var. Rosalinda) is a fruit that is very popular with people in Indonesia and has a high selling value [11]. The high content of strawberries in 100 g of strawberries has 32 calories of energy, 0.67 g protein, 0.3 g fat, 7.68 g carbohydrates, 16 mg calcium, 24 mg phosphate, 0.8 mg iron, vitamin A 12 IU, 0.0047 mg of B vitamins, 58.8 mg of vitamin C and 90.95 g of water. [16]. The number of processing industries based on strawberries affects the potential for developing strawberries. However, the main problem with strawberries is that strawberries are classified as non-climacteric fruit and are included in perishable commodities. This is because the water content of strawberries is relatively high, namely 90.0% per 100 g.

Cold temperatures ranging from 6-10˚C are relatively good temperatures for the storage of horticultural products [17]. However, cold temperature storage is not enough to maintain fruit quality. Therefore, appropriate postharvest technology is needed which can be combined with storage temperature [12]. By utilizing technology, one of which is the use of edible coatings. The edible coating is a method by applying a thin layer on the surface of the fruit to inhibit the release of gas, and moisture and avoid contact with oxygen, so that the process of cooking and browning of the fruit can be slowed down [1].

In the manufacture of edible coatings there are three natural biopolymer materials, namely derived from proteins, lipids, and polysaccharides [4]. Starch is a polysaccharide compound that is capable of bonding with oxygen bonds and is one of the natural polymers obtained from plant extraction that can be used to produce biodegradable materials because it is environmentally friendly, easily degraded, abundantly available, and affordable. Starch has good mechanical properties, oxygen barrier properties, renewable, biodegradable, biocompatibility, low processing costs and is usually used in food additives [6]. The starch content varies based on the type of tuber. Cassava potato (*Manihot esculenta*) contains 17% amylose and 83% amylopectin [3] while yellow sweet potato starch (*Ipomoea batatas* L.) contains 22.9% amylose and 77.1% yellow sweet potato starch amylopectin.[7]. Based on this, it is necessary to conduct research on the effect of the type of starch as an edible coating material and storage temperature on the physicochemical changes of strawberries. The application of edible coating combined with storage temperature is expected to be an alternative to be able to provide the best physical and chemical properties during storage.

## II. RESEARCH METHOD

### 2.1 Tools and Materials

The tools used are hot plates, analytical scales, trays, thermometers, texture analyzers, hand refractometers, ovens, refrigerators, desiccators, pens, plastic wrap, plastic cups, funnels, aluminum cup, beaker glass, Erlenmeyer, magnetic stirrer and other chemical tools.

The material used in this research is strawberry fruit. Fresh strawberries were obtained from the farmer's garden in Pancasari Village, Sukasada District, Buleleng Regency. Other ingredients are starch, carboxymethyl cellulose (CMC), glycerol, stearic acid, ascorbic acid, starch, 0.01 N iodine, and distilled water.

### 2.2 Harvesting and sorting

Strawberry fruit samples were taken from the farmer's strawberry garden in Pancasari Village, Sukasada District which had a uniform level of ripeness, namely having a red color reaching 75% -80% and being fresh. Then the strawberries are put into the storage container that has been provided before and then transported to Denpasar.

### 2.3 Storage

Storage of strawberry fruit samples was carried out within 6 days with observations on days 0,2,4, and 6 days during storage. Fruit samples are stored according to the level of treatment consisting of fixed samples and destructive samples. Fixed samples are used to determine weight loss, while destructive samples are crushed samples to observe water content, fruit hardness, total dissolved solids, and vitamin C content.

### 2.4 Research procedures

a. The procedure for making cassava potato starch and yellow sweet potato starch is carried out as follows.

1. Sweet potatoes are cleaned from the remaining soil that sticks using running water
2. Peel the skin of the sweet potato
3. then grated to get sweet potato porridge
4. Sweet potato puree then add water with a ratio of 1:3
5. The sweet potato pulp is then kneaded so that the starch comes out
6. The sweet potato pulp is then filtered to get water from the sweet potato feeling
7. Then the feeling water is deposited for 6-12 hours
8. The clear liquid that is at the top of the squeeze that has been precipitated is discarded while the precipitated-feeling water is transferred to the tray
9. The precipitate that is in the tray is then dried in the sun to dry

b. Making red galangal feeling the water as follows.

1. The skin of the red galangal is peeled
2. Red galangal that has been peeled and then grated
3. The galangal pulp is squeezed and filtered to take the feeling of water
4. The red galangal juice obtained is then stored

c. Make edible coating soluble

The process of making edible coatings is as follows:

1. Put 1,000 ml of distilled water (equates) into a container and stir at temperatures up to 70˚C
2. Carboxymethyl cellulose (CMC) (0.4% (w/v)) is dissolved in distilled water while stirring for ± 6 minutes
3. Then added starch (3% (w/v)) and stirred for ±3 minutes
4. Glycerol (5% (v/v)) was added to increase the elasticity of the coating and stirred for ± 3 minutes
5. Add red galangal water (3% (v/v)) then stirred for ± 3 minutes
6. Added stearic fatty acid (0.5% (w/v) and stirred for ± 3 minutes until homogeneous

d. Edible coating application on strawberries

The application procedure is as follows:
1. Strawberries are dipped into the edible coating solution for 5 seconds.
2. Drained and dried with a fan.
3. Furthermore, after the edible coating layer is dry, the strawberries are placed in the tray and then labeled.
4. After that, the strawberries are wrapped and stored.
5. Strawberries that were not coated with edible coating were kept for control

**2.5 Variable Observation**

Observational variables are observed as follows.

1. Weight loss. Changes in fruit shrinkage were measured by calculating the difference in the weight of the initial sample and the final sample compared to the initial sample weight. Weighing of the fruit weight loss was carried out by using a digital scale every two days of observation.
2. Water content. Calculation of fruit water content with the AOAC method. Samples were crushed and weighed as much as 5 g then put into an aluminum cup whose weight was known then heated at 105˚C for 4 hours, then cooled in a desiccator until cold then weighed. Heating and cooling were repeated until a constant weight was obtained.
3. Fruit Hardness Level. Fruit hardness can be measured with a texture analyzer. You do this by turning on the computer and opening the texture analyzer software on the computer. After that, the fruit is placed in the place to be stabbed automatically and then the maximum value is recorded.
4. Total dissolved solids. Total dissolved solids (˚brix) were measured using a hand refractometer. The fruit to be observed is grated first and then squeezed using gauze. Drop the fruit onto the surface of the reaction prism with three repetitions. Point the tool at the light source and look at the distance where the line on the lens passes.
5. Vitamin C content. Measurement of fruit vitamin C content by using the method of iodine titration. Observations were made on days 4 and 6 days after storage. Fruit that has been crushed, weighed 5 g. Then dissolved into 100 ml by adding distilled water, and filtered using filter paper. Then extract the strawberry, take 10 ml and drip with 0.1 ml of starch solution, then titrate with 0.1 N iodine until the blue color does not disappear for 30 seconds.

**2.6 Data Analysis**

Observational data were analyzed using analysis of variance (Anova) at a significant effect level of 5% and 1%. If there is a significant effect on the interaction, then it is continued with Duncan's test. If one of the factors has a significant effect, then it is continued with the LSD test at the 5% level.

## III. RESULT AND DISCUSSION

**3.1 Weight loss**

The highest weight loss was obtained in the combination of treatments without edible coating at room storage temperature ($S_1P_0$) with a weight loss at 4 days after storage of 44.16%. While the lowest increase in weight loss was obtained in the combination of giving edible coating from starch raw materials from yellow sweet potatoes at refrigerator storage temperature ($S_3P_2$) with weight loss at 4 days after storage of 8.07% (Table 3). The percentage difference in fruit weight between the two combinations was 36.09% (Figure 1). This is in accordance with Sembiring [13] which states that weight loss will increase during the storage period which indicates an increase in respiration and transpiration processes which result in the loss of substrate and water so that changes in weight loss occur.

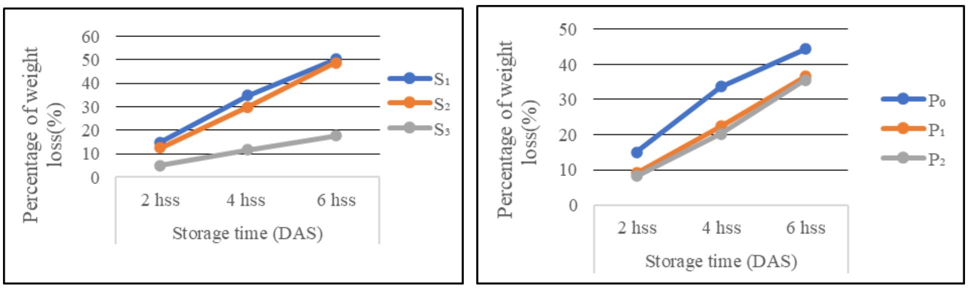


**Figure 1. Effect of storage temperature and edible coating on weight loss**

**Table 1. The interaction between storage temperature and edible coating treatment on the percentage of fruit weight loss at various shelf life**

| Storage temperature | Provision of edible coatings | | |
|---|---|---|---|
| | $P_0$ | $P_1$ | $P_2$ |
| | .......Weight loss at 2 hss (%)...... | | |
| $S_1$ | 19,68 a | 13,02 b | 12,04 bc |
| $S_2$ | 18,24 a | 9,80 cd | 9,30 cd |
| $S_3$ | 7,28 d | 4,56 e | 3,42 e |
| | .......Weight loss at 4 hss (%)...... | | |
| $S_1$ | 44,16 a | 31,31 b | 29,19 bc |
| $S_2$ | 40,55 a | 25,63 cd | 23,45 d |
| $S_3$ | 16,40 e | 10,38 f | 8,07 f |

Description: Numbers followed by the same letter at the same shelf life are not significantly Different Duncan's 5% multiple spaced test.

**Table 2. Effect of storage temperature and edible coating on the percentage of fruit weight loss at shelf life**

| Treatment | Weight loss (% hss) |
|---|---|
| | 6 |
| Storage temperature | .............score.............. |
| $S_1$ | 50,21 a |
| $S_2$ | 48,70 a |
| $S_3$ | 17,58 b |
| LSD 5% | 5,49 |
| Provision of edible coatings | .............score.............. |
| $P_0$ | 44,53 a |
| $P_1$ | 36,58 b |
| $P_2$ | 35,53 b |
| LSD 5% | 2,36 |

Description: Numbers followed by the same letter in the same treatment and column indicate no difference in the 5% level of low significant difference test (LSD).

### 3.2 Water content

The highest fruit water content was obtained in the combination of the treatment of giving edible coating for yellow sweet potato starch raw materials at refrigerator storage temperature ($S_3P_2$) at 6 days after storage with a value of 87.93% while the lowest water content value was obtained in the combination without giving edible coating to room temperature ($S_1P_0$) of 79.67% (Table 3). The percentage difference in fruit moisture content of the two combinations is 8.26%. The lowest water content value occurs at room temperature. Water content is closely related to fruit weight loss, where the higher the water loss, the higher the weight loss. [15]. This is by the literature which states that the loss of weight loss in fruit during the shelf life is caused by water loss [8].

**Table 3. Interaction between storage temperature and edible coating treatment on fruit moisture content at shelf life**

| Storage temperature | Provision of edible coatings | | |
|---|---|---|---|
| | $P_0$ | $P_1$ | $P_2$ |
| $S_1$ | 79,67 f | 83,73 d | 84,33 cd |
| $S_2$ | 81,87 e | 83,33 de | 84,93 cd |
| $S_3$ | 85,67 bc | 87,33 ab | 87,93 a |

Description: Numbers followed by the same letter at the same shelf life are not significantly different Duncan's 5% multiple spaced test.

**Table 4. Effect of storage temperature and edible coating treatment on fruit moisture content of various shelf life**

| Treatment | Fruit water content during storage (% hss) | |
|---|---|---|
| | 2 | 4 |
| Storage temperature | .............score.............. | |
| $S_1$ | 88,29 a | 85,67 b |
| $S_2$ | 88,67 b | 86,20 b |
| $S_3$ | 90,6 c | 88,89 a |
| LSD 5% | 0,27 | 1,04 |
| Provision of edible coatings | .............score.............. | |
| $P_0$ | 87,96 b | 85,62 b |
| $P_1$ | 89,42 a | 87,4 a |
| $P_2$ | 90,18 a | 87,3 a |
| LSD 5% | 1,24 | 0,87 |

Description : Numbers followed by the same letter in the same treatment and column indicate no difference in the 5% level of low significant difference test (LSD).

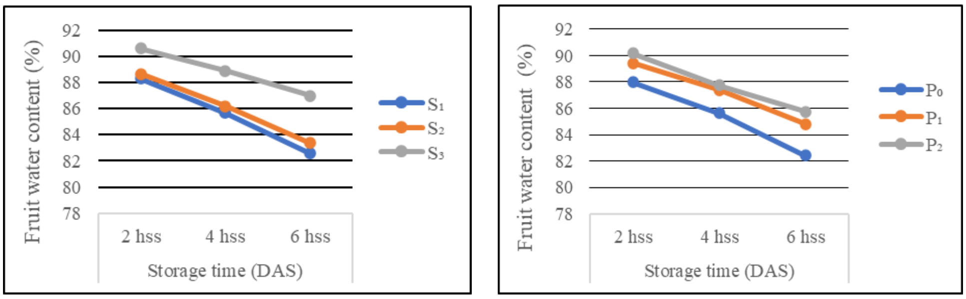


**Figure 2. Effect of storage temperature and edible coating on fruit water content**

### 3.3 Fruit hardness level

The level of fruit hardness decreased at the storage temperature treatment until 6 days after storage (Table 5). $S_1$ gave the highest reduction of 71.43%, while $S_2$ and $S_3$ respectively amounted to 52.43% and 31.19%. According to Panda et al. [9] Refrigerator temperature can reduce excessive respiration in strawberries so that the degradation of pectate, cellulose lignin, and hemicellulose caused by the activity of the enzyme pectin methyl esterase and polygalacturonate which work as a cell wall breakdown can be inhibited so that the fruit does not soften quickly. In the treatment of giving edible coating fruit hardness decreased. The highest decrease was at $P_0$ which was 58.36% while at $P_1$ and $P_2$ 43.27% and 41.31% respectively (Figure 3). This is in accordance with the research by Miskiyah et al. [5] that edible coating treatment on red peppers was effective in maintaining hardness.

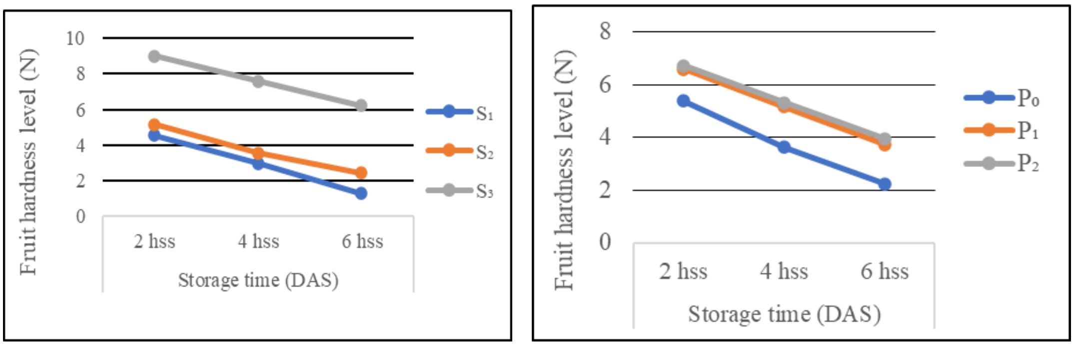


**Figure 3. Effect of storage temperature and edible coating on fruit hardness**

**Table 5. Effect of storage temperature and edible coating treatment on fruit hardness levels of various shelf life**

| Treatment | Fruit hardness level on storage time (N hss) | | |
|---|---|---|---|
| | 2 | 4 | 6 |
| Storage temperature | | .............score.............. | |
| $S_1$ | 4,55 b | 2,98 b | 1,3 c |
| $S_2$ | 5,15 b | 3,56 b | 2,45 b |
| $S_3$ | 9,01 a | 7,60 a | 6,2 a |
| LSD 5% | 0,89 | 1,27 | 0,42 |
| Provision of edible coatings | | .............score.............. | |
| $P_0$ | 5,38 b | 3,64 b | 2,24 b |
| $P_1$ | 6,61 a | 5,16 a | 3,75 a |
| $P_2$ | 6,73 a | 5,33 a | 3,95 a |
| LSD 5% | 0,85 | 1,02 | 0,56 |

Description: Numbers followed by the same letter in the same treatment and column indicate no in the 5% level of low significant difference test (LSD).

### 3.4 Total dissolved solids

Total dissolved solids increased with storage time. In the storage temperature treatment, the percentage of $S_1$ gave the highest increase, namely 5.21%, while $S_2$ and $S_3$ were 5.09% and 4.6%, respectively (figure 4). In the treatment of giving edible coating the percentage increase in $P_0$ gave the highest increase of 5.99% while $P_1$ and $P_2$ were 4.35% and 4.33%. This is following the opinion of Pujimulyani [10] which states that the high total dissolved solids in control strawberries are caused by a fast transpiration process. Coating the fruit with an edible coating can cover the lenticels and cuticles of the strawberries and then can inhibit respiration and transpiration activities in the fruit.

**Tabel 6. Effect of storage temperature and edible coating treatment on total soluble solids of various fruit shelf life**

| Treatment | Total dissolved solids (˚brix) during storage (hss) | | |
|---|---|---|---|
| | 2 | 4 | 6 |
| Storage temperature | | .............score.............. | |
| $S_1$ | 7,48 a | 8,77 a | 7,87 a |
| $S_2$ | 7,27 a | 8,47 a | 7,64 ab |
| $S_3$ | 6,95 a | 7,14 b | 7,27 b |
| LSD 5% | ns | 1,2 | 0,43 |
| Provision of edible coatings | | .............score............. | |
| $P_0$ | 7,67 a | 8,75 a | 8,13 a |
| $P_1$ | 7,12 a | 7,89 b | 7,43 ab |
| $P_2$ | 6,92 a | 7,74 b | 7,22 b |
| LSD 5% | ns | 0,39 | 0,82 |

Description: Numbers followed by the same letter in the same treatment and column indicate no difference in the 5% level of low significant difference test (LSD); ns: not significantly different.

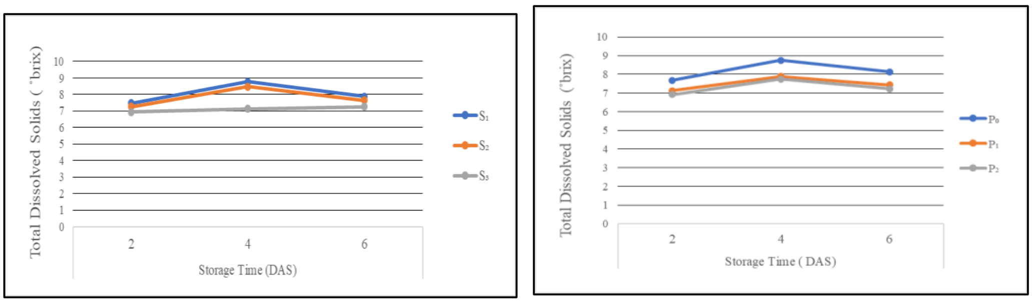


**Figure 4. Effect of storage temperature and edible coating on total dissolved solids**

### 3.5 Vitamin C content

The content of vitamin C during storage decreased from 4 days after storage to 6 days after storage (Table 7). The lowest decrease was in $S_3$ which was 6.28% and was significantly different from $S_1$ and $S_2$. The content of vitamin C also decreased in the provision of edible coatings. The lowest percentage decrease was in $P_2$ at 46.35% while in $P_0$ and $P_1$ respectively 48.86% and 46.7% (Figure 5). The degradation of vitamin C causes a decrease in the content of vitamin C in fruit. This indicates that the presence of an edible coating layer with yellow sweet potato starch as raw material can inhibit the entry of oxygen into the fruit tissue and the oxidation reaction that causes damage to vitamin C. According to Annisa et al. [2]. stated that ascorbic acid is very easily oxidized to L-dehydroascorbic acid which still has the activity of vitamin C and undergoes further changes to L-diketogulonic acid which functions optimally as an antioxidant. This is following Siti research [14], vitamin C red chili with no edible coating (control) had a low vitamin C content of 17.36 mg/100 g, while red chili coated with an edible coating to preserve ginger (*Zingiber offinale*) was 22.19 mg/100 g.

**Table 7. The effect of storage temperature and edible coating treatment on the vitamin C content of various fruit shelf life**

| Treatment | Vitamin C content (mg/100 g) | |
|---|---|---|
| | 4 | 6 |
| Storage temperature | ..............score.............. | |
| $S_1$ | 45,56 a | 13,49 b |
| $S_2$ | 44,00 ab | 15,84 b |
| $S_3$ | 43,61 b | 40,87 a |
| LSD 5% | 1,88 | 11,5 |
| Provision of edible coatings | ..............score.............. | |
| $P_0$ | 43,22 a | 22,10 a |
| $P_1$ | 44,39 a | 23,66 a |
| $P_2$ | 45,56 a | 24,44 a |
| LSD 5% | ns | ns |

Description: Numbers followed by the same letter in the same treatment and column indicate no difference in the 5% level of low significant difference test (LSD); ns: not significantly different.

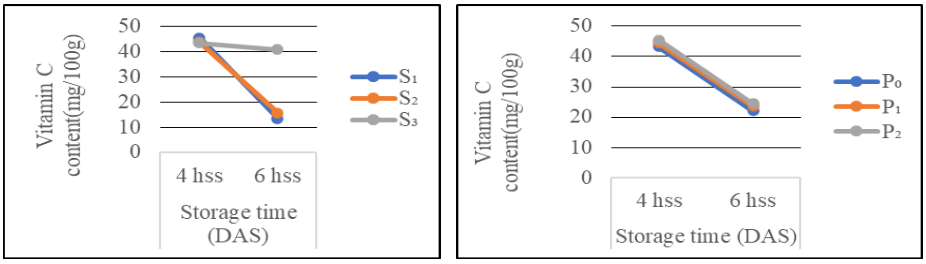


**Figure 5. Effect of storage temperature and edible coating on vitamin C content**

## IV. CONCLUSION

The provision of edible coating with yellow sweet potato starch ($P_2$) gave the lowest increase in weight loss with a value of 35.53%, the highest water content was 87.93%, the lowest decrease in hardness was 41.31%, the lowest value was the lowest total dissolved solids and the lowest percentage decrease in vitamin C content was 46.35%. Storage temperature $S_3$ gave the lowest increase in weight loss with a value of 17.58%, the highest water content value was 87.93%, the lowest hardness reduction was 31.19%, the lowest total dissolved solids value, and the lowest decrease in vitamin C content was 6.28%. There is a significant effect on the interaction on the physicochemical properties of strawberries in combination with the provision of edible coating with starch from yellow sweet potato at refrigerator storage temperature ($S_3P_2$) which gives the lowest weight loss and the highest water content value

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