Santo-11. Wibowo_2023_IOP_Conf._Ser.__Earth_Environ._Sci._1155_012014

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IOP Conference Series: Earth and Environmental Science

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To cite this article: C Wibowo *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1155** 012014

Application of Starch-based Edible Coating on Tomato and Its Effect during Storage

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Abstract. The appropriate postharvest treatment is required for the tomato (*Solanum lycopersicum* L.) because it is a perishable commodity. Common procedures for maintaining quality and extending its shelf life is applying storage at low temperatures. Another alternatif is an application of coating on the tomatoes. Starch-based coating is widely used due to its positive effects on the agricultural commodities. The aim of this research is to determine the effect of various coating materials and sprayer nozzle size on the physical and chemical characteristics of tomatoes during storage. This study used an experimental method with a completely randomized design method with 2 factors, namely variations in the type of main coating material (P): canna starch (P1), potato starch (P2), sweet potato starch (P3) and variations in sprayer nozzle size. (N): 0.6 mm (N1); 1.0 mm (N2); 1.5 mm (N3). Each treatment was performed three times. The findings of the research show that the type of main coating material and variations in the diameter of the sprayer nozzle can maintain the brightness level and total soluble solids value of tomatoes on day 6 observation. The selected treatments are tomato fruit samples coated with sweet potato starch, and the sprayer nozzle diameter is 1.0 mm.

Keywords: coating, quality, starch, spraying, tomato

1. Introduction

Tomato (*Solanum lycopersicum* L.) is one of the horticultural commodities which is perishable, therefore, it is important to handle the postharvest process properly. Common procedures for maintaining quality and extending the shelf life of tomatoes are: cleaning, storage at low temperature, and applying packaging for the distribution. Another alternatives is an application of coating on the tomatoes. Starch-based coating is widely used due to its positive effects on the agricultural commodities. Edible coating is one of the methods that can increase the shelf life of a product during storage. Three groups of based coating materials, notably hydrocolloids, lipids, and their combinations, can be utilized to create coatings. Edible coating also can be made from polysaccharides such as chitosan, natural gum, alginate, carrageenan and starch, which can be renewable biopolymer material [1].

Starch consists of two kinds of polysaccharides, amylose and amylopectin. Amylose is necessary for the production of films and firmness of gels. Starch is the most widely used as a biopolymer because of the acceptable properties, biodegradability, and thermoplastic properties [1]. Many researchers have studied polysaccharide-based coatings, including polysaccharide from banana cellulose [2], cactus [3], and soybean [4], various kinds of seeds [5], tapioca [6], jicama [7], sago starch [8]. The edible coating could maintains the quality of commodities such as on banana [9], strawberry [10]. Moreover, previous study reported that starch-based coating is also contribute on reducing oil content of fried potato chips [11].

Starch based coating solutions usually have low water resistance and water vapor barrier [12]. The poorness of water resistance property on starch based coating solutions are the result of hydrophilic components [13]. Therefore, a plasticizer is required for creating starch based coating solutions. Because it can reduce the intermolecular pressures on the polymer chain. Plasticizer is a substance that is added to a film-forming material to increase its flexibility [14] and improve its mechanical properties [15]. In addition to plasticizers, cross-linker could be introduced to improve the properties of edible film [16], [17]. To provide better preservation, active substances could be added to give antimicrobial effect of the coating, including extract of clove [18], ginger [19]. Another alternatives is using the extract of neem leaf [20].

Three different forms of starch, including potato, sweet potato, and canna starch, were employed in this study due to the high amylose content. Because all three forms of starch are present in tubers with high levels of amylose content, it is known that it has the ability to serve as foundational components for edible coating. Commonly, coating solutions are applied into products by dipping, however there is an alternative, spraying method that is more efficient and waste-less.

Spraying method in the coating process has been used in many studies including beef, whole and fresh-cut fruits, vegetables, and fruit-based salad coating [21]. The primary principle behind the spraying method is to modify the coating-dipping formula into a thinner liquid that is applicable to sprayed. Nozzle sprayer is one of the factors that affect coating spray qualities. Nozzles impacted the size of coating solutions droplets [22]. Since there are limited reports about the application of coating on tomato by spraying with various size of sprayer nozzle, thus, there is a need for further study about sprayer nozzles used. In this study, sprayer nozzles with diameters of 0.6 mm, 1.0 mm, and 1.5 mm were used to coat tomato fruit.

Starch based coating with sorbitol addition as plasticizer and spraying method used in this work are expected to slow down the transpiration process and maintain the quality of tomatoes, notably the physical appearance and chemical content. The aim of this research is to determine the effect of various coating materials and sprayer nozzle size on the physical and chemical characteristics of tomatoes during storage.

2. Material & Methods

2.1. Material

The materials used in this study were tomatoes variety of Servo that obtained from farmers in the Purwokerto Central Java area. The specifications of tomatoes are being yellowish red, oval in shape, and having a diameter of 3.5-3.8 cm. Canna starch, sweet potato starch were bought from the producers in Yogyakarta, potato starch, sorbitol, and other chemicals obtained from chemical store in Purwokerto.

2.2. Experimental Design

This study used an experimental method with a completely randomized design (CRD) method with 2 factors, namely variations in the type of main coating material (P): canna starch (P1), potato starch (P2), sweet potato starch (P3) and variations in sprayer nozzle size. (N): 0.6 mm (N1); 1.0 mm (N2); 1.5 mm (N3). Each treatment was performed for three times.

2.3. Coating Preparation and Application

Coating solution were made by 3 grams of each Cana starch, potato starch, and sweet potato starch then added 6% (w/v) of sorbitol for each Canna starch, potato starch, and sweet potato starch solution then each solution were heated at 67 - 83℃ for 8 - 9 minutes and cooled down until 35 - 37℃. The solution then sprayed using 3 different nozzles as stated on experimental design. Tomatoes were sprayed for about 20 seconds until all of the surfaces were coated. The samples were stored at Styrofoam tray and wrapped with the plastic. For each treatment, there were 3 trays and for each tray consists of 6 tomatoes.

2.4. Physical Analysis

2.4.1. Measurement of Tomato Firmness Firmness on tomatoes was analyzed using a fruit hardness tester (Model GY-3 Analogue, China). The working principle of this tool is to determine the amount of pressure needed to insert the pressure device into the tomato fruit.

2.4.2. Measurement of Tomato Brightness Tomato skin color was measured using a chromameter (Konica Minolta CR-400, Japan). The chromameter detector released a light to read fruit skin color value. Measurements were obtained from 3 points, the top (near the stalk), middle, and bottom on 2 sides of fruit. In total there are 6 data were collected from each sample, values were reported as the mean of six points color measurement. The displayed value of the tool is L*/Lightness that indicates the brightness of the sample, between 0 (black) to 100 (white).

2.5. Chemical Analysis

2.5.1. Measurement of Vitamin C The sample used approximately 200-300 grams and crushed with a blender. The slurry was weighed between 10-30 grams, then put into a 100 ml volumetric flask and then added with distilled water up to the mark. Then the filtrate was homogenized and filtered with filter paper. The filtrate obtained was taken 25 ml and put into a 100 ml Erlenmeyer then 1 ml of 1% starch was added to it. The filtrate that has been added with starch is titrated with 0.01 N standard iodine solution until a color change occurs. Vitamin C levels are calculated by the formula:

$$Vitamin\ C\ (\%) = \frac{v\ iodium\ x\ 0{,}01\ N\ x \frac{100}{25}\ x\ 88\ x\ 100}{sample\ weight\ (mg)}$$

2.5.2. Measurement of Moisture Content Moisture content were calculated using gravimetric method according to AOAC (2000) it begins with drying the empty cup in the oven (Memmert, Germany), then cooled in a desiccator, weighs a sample of 5 grams of the mashed material, put it into the cup which is then put into the oven at a temperature of 105°C. Heating was carried out for 6 hours, after which it was cooled in a desiccator and weighed again. Work is stopped when a constant weight is obtained. The moisture content is calculated by the formula:

$$Moisture\ Content = \frac{Weight\ loss\ (g)}{Sample\ Weight\ (g)}\ x\ 100\%$$

2.6. Data Analysis
The data were analyzed ANOVA followed by Duncan's Multiple Range Test with significance level of 0.05.

3. Results & Discussion

3.1. Physical Analysis
3.1.1. Tomato Fruit Firmness The average of the firmness of the tomatoes with the treatment shows in Figure 1. The results of the analysis of variance showed that the effect of the main coating material (P) had no significant effect on tomato firmness at all observation. Whereas, the variations of size sprayer

nozzle (N) had a significant effect on day 6 based on analysis of variance tests. The DMRT test on day 6, showed that the size of the nozzle sprayer with a diameter of 0.6 mm and 1.0 mm were significantly different with a 1.5 mm diameter sprayer nozzle. This could be an indication that the nozzle sprayer with 0.6 mm diameter that has 0.20 kg/cm^2 of hardness value and nozzle sprayer with 1.0 mm diameter that has 0.19 kg/cm^2 of hardness, can inhibit decrease of tomato firmness until 6 day of storage time.

The interaction between the type of main coating material and the size of the sprayer nozzle (PxN) showed a significant effect on firmness, especially samples on day 4. Edible coating provides barrier properties against moisture loss and gasses transpiration, subsequently preventing enzymatic reactions that could lead to change of texture in fresh produce. Viscosity of the coating, spray nozzle shape and design affect spraying efficiency of coating solution, thus making the coating solution to spread more evenly [23].

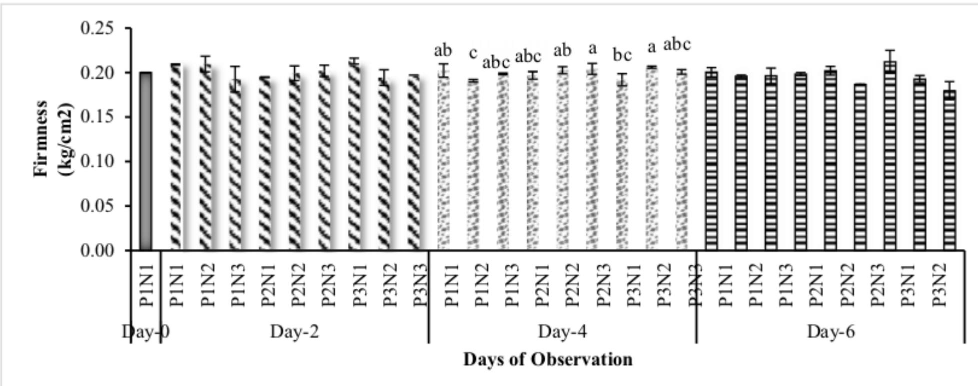

Figure. 1. Firmness of the tomatoes after the treatments

Note: P1: canna starch; P2: potato starch; P3: sweet potato starch; N1: sprayer nozzle size 0.6 mm; N2: sprayer nozzle size 1.0 mm; N3: sprayer nozzle size 1.5 mm.
Average of the results at the same day of observation with different letters shows the significant differences (P<0.05).

Based on the statistical analysis, on the 4th day of observation, the combination of P1N2 and P3N1 treatments resulted in the lowest tomato fruit hardness value. This explains that the interaction between the type of the main coating material and the size of the sprayer nozzle cannot stop the rate of decreasing the hardness of tomatoes. Fruit that is given a coating, less oxygen enters the tissue, so that the enzymes involved in respiration and tissue softening are quickly minimized.

3.1.2. Tomato Fruit Brightness Level The average value of the brightness level in the tomato fruit samples with the treatment shows in Figure 2. The results of the analysis of variance (α = 0.05) indicated that the effect of the main type of coating material had a very significant effect on day 4 and day 6. L* value of tomatoes on day 6 observation coated with canna starch showed on 39.73, potato starch on 38.87, and sweet potato starch on 39.88. The further DMRT test showed that tomatoes coated with canna starch and sweet potato starch were significantly different from potato starch coated, which is effective in maintaining the brightness of tomatoes.

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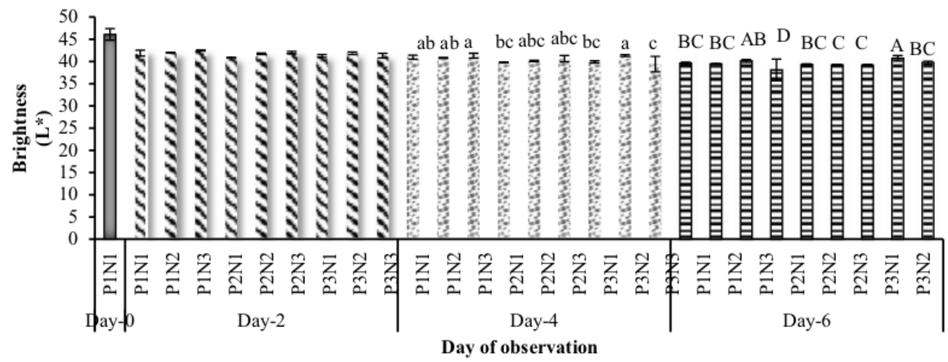

Figure. 2. Brightness level of the tomatoes after the treatments

Note: P1: canna starch; P2: potato starch; P3: sweet potato starch; N1: sprayer nozzle size 0.6 mm; N2: sprayer nozzle size 1.0 mm; N3: sprayer nozzle size 1.5 mm.
Average of the results at the same day of observation with different letters shows the significant differences (P<0.05).

The nozzle sprayer size based on the results of the analysis of variance, had a significant effect on the tomato fruit samples observed on day 2 and 6. Further DMRT test on day 6 showed the size of the nozzle sprayer brightness level with a diameter nozzle of 1.0 mm (N2) that has brightness level at 39.82 and 1.5 mm (N3) that has brightness level of 39.71 significantly different from the nozzle diameter of 0.6 mm (N1).

The interaction between the type of the main coating material and the size of the sprayer nozzle (PxN) on the measurement of the brightness level (L) in tomatoes based on the results of the analysis of variance showed a significant effect on the tomato fruit samples observed on day 4 and day 6. Based on the DMRT further test, the interaction of the effect of the main type of coating and the size of the nozzle sprayer on the brightness level of tomatoes on day 6 which had significantly different was the combination of canna starch and 1.5 mm nozzle spray used with a brightness value of 40.13 then the combination treatment of sweet potato starch and the using of 1.0 mm nozzle sprayer with a brightness value of 40.70. Brightness level of tomato is an important factor of acceptability and nutrition indication of fruit. The color of tomato indicated the freshness and nutrient properties of tomatoes, and also one of the factors for choosing products by consumers [24]. The color of tomatoes represent the antioxidant and lycopene content [25].

3.2. Chemical Analysis

3.2.1. Tomato Fruit Vitamin C The average value of the moisture content in the tomato fruit samples with the treatment shows in Figure 3. The results of the analysis of variance (α = 0.05) showed that the effect of the main coating material (P) had a significant effect on vitamin C levels of tomato samples on day 2 and on day 6, and on observation of tomato samples on day 4 made a real impact. Based on the DMRT further test on observations at day 6, the type of main ingredient for coating canna starch (P1) was significantly different from the type of main material for coating potato starch (P2) and also the type of main material for coating sweet potato starch (P3). This indicates that canna starch (P1) can maintain vitamin C levels in tomato samples. Coating with starch is able to maintain vitamin C levels because it can inhibit the diffusion of O_2 into fruit tissue and the oxidation reaction can be slowed down. The same result from another research shows that the edible coating can give effective retention of ascorbic acid contained in fresh cut kiwi, thus edible coating effectively slows respiration rate and decreases oxygen diffusion [26]. Same result also occurred in previous study of coating solution made from corn starch able to maintain vitamin C content in tomato due to its ability to inhibit O_2 diffusion into the tissue [27].

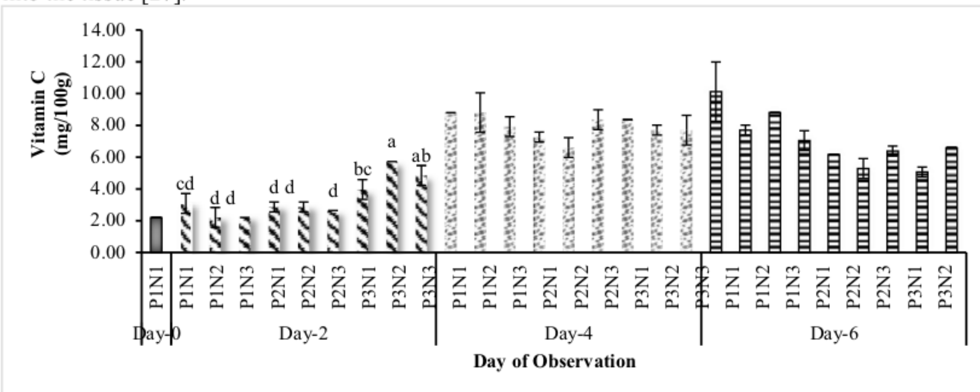

Figure. 3. Vitamin C content of the tomatoes after the treatments

Note: P1: canna starch; P2: potato starch; P3: sweet potato starch; N1: sprayer nozzle size 0.6 mm; N2: sprayer nozzle size 1.0 mm; N3: sprayer nozzle size 1.5 mm.
Average of the results at the same day of observation with different letters shows the significant differences ($P<0.05$).

While the sprayer nozzle size (N) based on the results of the analysis of variance showed a significant effect on the observation of tomato fruit samples on day 6 significantly on the size of the nozzle sprayer with a diameter of 1.0 mm (N2) and a nozzle size of 1.5 mm (N3). The size of the nozzle sprayer with a diameter of 0.6 mm (N1) can maintain the value of vitamin C levels in tomato fruit samples.

The interaction between the type of main coating material and the size of the sprayer nozzle (PxN) on the measurement of vitamin C levels in tomatoes based on the results of the analysis of variance showed a significant effect on the observation of tomato samples on day 2. From the DMRT further test on the observation of tomatoes on day 2, the combination of P3N2 treatments was a significantly different combination and had the highest vitamin C value of 5.7 mg/100g when compared to other treatment combinations. The presence of an edible coating can inhibit the entry of oxygen into the fruit which causes damage to vitamin C through oxidation reactions.

3.2.2. Tomato Fruit Moisture Content The average value of the moisture content in the tomato fruit samples with the treatment shows in Figure 4. The results of the analysis of variance showed that the effect of the main coating material type (P), the sprayer nozzle size (N), and the interaction between the coating main material type and the sprayer nozzle size (PxN) on the measurement variables of the water content contained in tomatoes showed no effect significantly on the observation of tomato fruit samples on day 2, day 4 and day 6 and even on control at day 0. This can be indicated that the coating effectively maintains the vapor and gas transpiration.

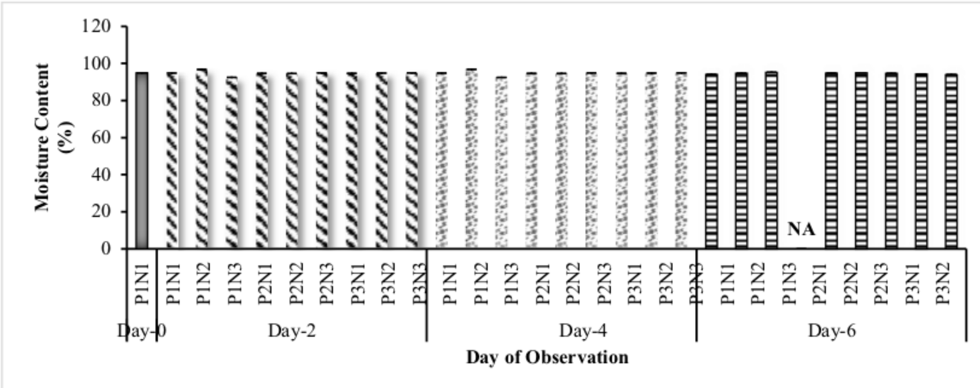

Figure. 4. Moisture content of the tomatoes after the treatments

Note: P1: canna starch; P2: potato starch; P3: sweet potato starch; N1: sprayer nozzle size 0.6 mm; N2: sprayer nozzle size 1.0 mm; N3: sprayer nozzle size 1.5 mm.
Average of the results at the same day of observation with different letters shows the significant differences (P<0.05).

The capability of coating on inhibiting the gas and vapor transpiration related to moisture content of the samples [28]. Generally, moisture content decreases along with the storage duration which can lead to the product deterioration [29]. The loss of moisture content mostly caused by water vapor transpiration during storage.

4. Conclusion

The findings of the research show that the type of main coating material and variations in the diameter of the sprayer nozzle can maintain the brightness level of tomatoes on day 6 observation. Meanwhile, the interaction of the treatments does not result significant differences at day-6 on other parameters, firmness, Vitamin C content and moisture content.
Moreover, the recommended treatment for application of starch-based coating on tomato is application of coating produced from sweet potato starch, and the sprayer nozzle diameter is 1.0 mm.
In the present report, limited properties of tomato were observed, therefore, more comprehensive analysis should be done to provide better understanding the effect of coating on the quality of tomatoes during storage.

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