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Effect of edible coating application by spraying method on the quality of red chili during storage

C Wibowo*, P Haryanti, and R Wicaksono

Department of Food Science and Technology, Faculty of Agriculture, Jenderal Soedirman University, Central Java Indonesia

* Email: condro.wibowo@unsoed.ac.id

Abstract After being harvested, fruits continue their physiological activity, such as transpiration and respiration, which leads to deterioration. The main problem on maintaining the quality of fresh fruit and vegetables is regarding the shelf life. They have short shelf life due to the metabolism still occurs. Therefore, additional treatments are required to prolong the shelf life. Application of edible coating is one of a promising treatments. The coating is known for its ability to prevent moisture loss and create a barrier for gas exchange to give protection from fruits decay by applying it directly to the fruit surface. This experimental study used Completely Randomized Design with two factors. The first factor is the type of starch used for coatings consisting Canna edulis starch, potato starch and sweet potato starch, and the second factor is the variation of nozzle diameter consisting 0.6 mm, 1.0 mm and 1.5 mm. The parameters observed in this study comprised of color parameter (L-, a-, and b- value), ascorbic acid and moisture content, and firmness. The result obtained from this study were analyzed using the F test and continued with the Duncan Multiple Range Test. The result showed that the main material for producing edible coating gave a contribution on the alteration of red chili during storage. Moreover, the differences of diameter of nozzle sprayer also influence the adhering of the edible coating on the surface of the agricultural product. Based on the present research, the selected treatment combination application of an edible coating for red chilies was using of edible film made from sweet potato starch that sprayed with a with a diameter of 0.6 mm nozzle sprayer.

1. Introduction

Due to the pandemic of COVID-19, many people aware regarding the healthy foods. Therefore, the demand of fresh fruit, vegetables and functional foods has been increasing. Fresh fruit and vegetables are beneficial for increasing the immunity of the body to inhibit the infection by the virus. The main problem on maintaining the quality of fresh fruit and vegetables is regarding the shelf life. They have short shelf life due to the metabolism after harvested. Additional treatments are required to prolong the shelf life.

Previous research explained that the use an appropriate packaging material [1], application of Modified Atmosphere Packaging (MAP) [2], and applying the low dose of Gamma irradiation [3] contribute on extending of shelf life of fruits and vegetables. Moreover, the combination between MAP and edible coating result longer shelf life of strawberry than the control and single treatment [3].

Edible coating is a thin layer of an edible material that can function as a barrier to moisture vapor, oxygen and the transfer of dissolved materials to food. Edible coating is applied directly over the surface of foodstuffs through various methods, such as dipping, spraying and bruising [4]. According to [5], the use of edible coating is beneficial for the environment because it is biodegradable and also is made of material that is suitable for consumption and has the benefit of maintaining the quality of food products. In addition to the application on to the surface of fresh commodities, edible coating can be applied on processed food as well to improve the quality of the product [4], [5], [6]. Edible coating can be applied to the products by dipping or spraying methods. Considering of using of natural resources, recently, the utilization tubers as raw material for producing edible coating is considered. The use of the tubers because they have high content of starch. Previous research reported the effect of utilization of starch produced from tubers as raw material of edible coating could contribute on improving quality of processed product [7]. A consideration of usage of plasticizer during the preparation of the edible coating plays an important role on determining the appropriateness of the coating [8].

Postharvest loss is one of the important factors that must be considered to maintain quality of agricultural commodities. Inappropriate strategies for handling of fruits can cause a significant decrease of their quality. Edible coating application is one of the strategies that can be used to maintain fruit or fresh-cut fruit quality after being harvested. At present, the consumption of fresh cut fruit increased because of the ease of consumption without the need to peel the fruit. However, because there is no protector over the fruit, the fruit is easily damaged [9]. Previous research by [4] stated that the use of edible coating on cut fruit can be useful for reducing weight loss, maintaining vitamin C level, delaying decay, and maintaining sensory quality especially color and firmness. Several previous studies stated that the use of edible coating on fresh fruit and vegetable can contribute to maintain their quality. The edible coating could be made from: chitosan [10], pectin [11], starch and protein [12], gelatin [13], and alginate [14].

The effectiveness of using edible coating to extend the shelf life of various types of fruit has also been reported by several previous researchers. It could be seen from the retention of ascorbic acid level, color, texture, freshness and taste that can still be accepted by consumers and there is no attack of microorganisms. Various types of fruit that have been studied are plums [15], tomatoes [16], strawberry [17], and cavendish banana [18]. In addition, edible coating is also useful in maintaining the quality of fresh-cut fruit, for example in watermelon [19], and preventing browning on mangoes [20].

Many kinds of fruits and vegetables are cultivated in Indonesia, the treatments during cultivation plays an important role on the characteristic of the harvested products [21]. In Indonesia, red chili is one of the important agricultural commodities because of high demand throughout the year. It is a perishable product that easily deteriorate at short period. Red chilies have a high moisture content, which is around 90%. The high moisture content causes transpiration to continue after harvesting so that red chilies are quickly damaged. The decrease in weight loss, change in color and decrease in vitamin C levels are caused by the respiration process which continues after harvesting. Therefore, fruit packaging and coating are needed which can reduce and suppress the rate of respiration and transpiration rate to inhibit damage to fruit. One potential way to reduce the level of damage to red chilies is by applying an edible coating. Edible coating forms a semi-permeable layer so that it is able to modify the internal atmosphere in the fruit, thereby delaying maturity and decreasing the transpiration rate of the fruits. Coating inhibits the release of gas, moisture and contact with oxygen, so the transpiration and respiration process can be slowed down [4]. This study aims to determine the effect of application of edible coating and the size of the nozzle sprayer for coating on chemical and physical characteristics of red chilies during storage.

2. Material and method

Red chili, variety of "OR TWIST 42", were harvested on the field from the farmers in the Limpakuwus, Banyumas regency, Central java. Therefore, the sample in this research were fresh product without any treatment after being harvested. The samples were sorted and cleaned in the laboratory before applying the treatments on the following day. Moreover, the starches (canna starch, potato starch and sweet potato starch) as raw material for producing edible coating were bought from the producer of starch. This company sell these starches in Indonesia and for export as well.

The factors studied were the type of edible coating (P) with 3 different sources of raw materials, edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3); the nozzle sprayer diameter with 3 different size of the diameter of the nozzle sprayer with 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3). Every treatment was performed 3 replications.

The parameters observed in this study comprised of color parameter (L-, a-, and b- value), ascorbic acid and moisture content, and firmness. The data that had been collected was analyzed using analysis of variance (F-test). Afterward, if the result showed that there was a difference, Duncan's Multiple Range Test (DMRT) should be done at a significance level of 5%.

3. Result and Discussion

3.1. Color parameter

In addition to spicy level of chili, appearances is one of the important factors influence the customers on consuming the chili. Therefore, color of chili plays an important role on customer's preference. Brightness is an essential attribute in the perception of the quality of red chilies. The average value of brightness in the combination of edible coating and nozzle sprayer type treatments during storage is presented in Figure 1. Figure 1 shows the change in surface brightness of red chilies that were treated with various types of edible coating and applied with various sizes of sprayer nozzles. This shows that all treatment combinations are able to maintain the brightness of red chilies. All samples do not appear to experience a significant increase in brightness values. Previous research by [22] also found that the brightness value of red chilies at the beginning of the harvest was 34.4.

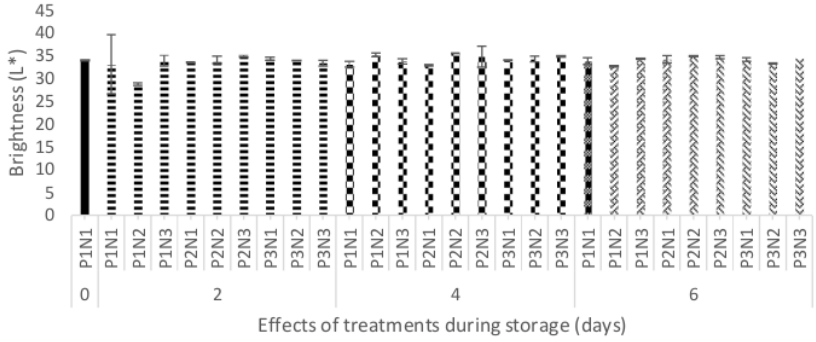

Figure 1. The effects of treatment on L-value of red chili during storage.
Edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3);
The nozzle sprayer diameter: 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3).

On day 2, the brightness of red chilies in each treatment combination was not significantly different. At day 4 and day 6 also did not have a significant difference between each treatment combination. What might happen is the ability of the coating to keep the red chilies evenly bright. When the coating is made, the coating is made with canna starch, which is clear in color with a little cloudiness.

The average value of a- and b-value in the combination of edible coating and nozzle sprayer type treatments during storage is presented in Figure 2 and Figure 3, respectively. Figure 2 and Figure 3 show that there is no significant differences found for the measurement of red chili for a- and b-value. Therefore, during storage until 6 days, the color of the red chili did not change intensely. Based on the visual observation, there were a tendency of the surface become darker. The initial color of red chili was red and during storage until the last day the color remain the same.

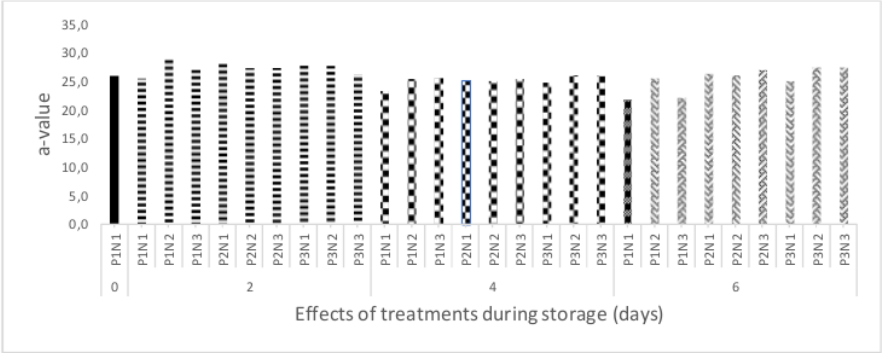

Figure 2. The effects of treatment on a-value of red chili during storage.
Edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3);
The nozzle sprayer diameter: 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3).

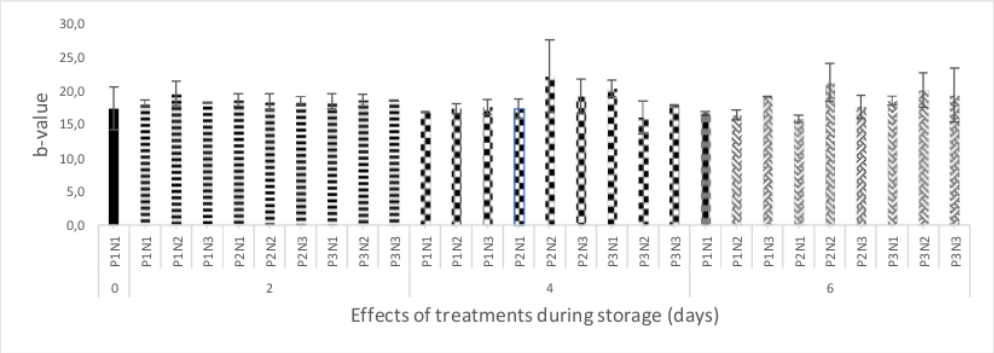

Figure 3. The effects of treatment on a-value of red chili during storage.
Edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3);
The nozzle sprayer diameter: 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3).

During the treatment with temperature and storage time, red chilies undergo physical changes, including changes in color and changes in texture. This happens where the color change is caused by the oxidation of chlorogenic acid by the enzyme polyphenoloksidase to melanoidin, so that a blackish brown color is formed. The longer storage time, chlorogenic acid oxidation is accelerated and the blackish brown color of the chilies is increasingly visible so that the color change that occurs is also faster. The ripening process of fruit is often associated with a series of visible changes including color, aroma, consistency and flavor (taste and smell). Likewise with color, the higher the level of fruit maturity, the higher the level of fruit color change.

3.2. Moisture content

Once harvested from the plant, the chilies still conducts the metabolism activities. Moisture loss during storage due to respiration and transpiration of chilies, which can cause a decrease in moisture content. The chilies that are just harvested are then stored and are still undergoing a development process, which is marked by a change in the color of the chilies and the occurrence of withering and wrinkling as a result of the respiration and transpiration processes. The average value of moisture content in the treatment of edible coating types during storage is presented in Figure 4.

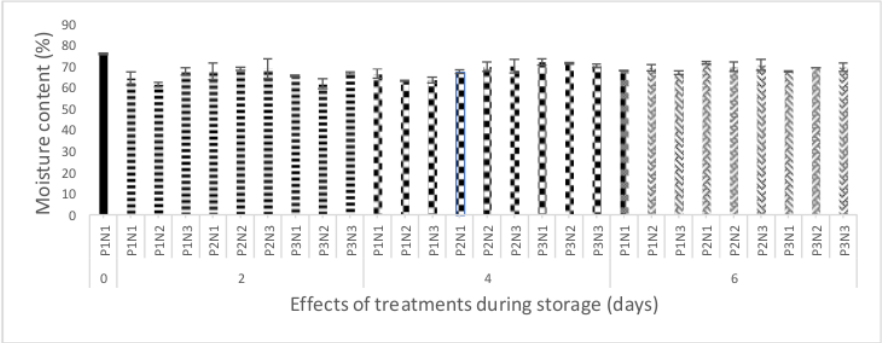

Figure 4. The effects of treatment on moisture content of red chili during storage.
Edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3);
The nozzle sprayer diameter: 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3).

Based on the results of the analysis of variance, it was found that the moisture content value did not have a significant effect except on the 4th day where the main coating factor had an effect on the moisture content. Based on Figure 4, it is obtained the average moisture content in red chilies. At the starting point of observation, the average moisture content of red chilies was 74%. Red chilies with the application of coatings of canna starch and sweet potatoes have relatively the same average moisture content, while potato starch has the highest moisture content of 68% on the second day. On the 4th day the coating made from canna starch showed the lowest moisture content with an average value of 64%, the coating with potato starch had an average moisture content of 69%, the coating of sweet potato starch had the largest average moisture content on the following day. On the 6th day of the potato starch coating treatment had the highest average moisture content of 70%.

Potato starch has quite high levels of amylose, about 23% amylose and 77% amylopectin. The amylose structure allows the formation of hydrogen bonds between glucose constituents and during heating is able to form a three-dimensional network that can trap moisture to produce a strong gel. This strong gel will

reduce the rate of water vapor transmission in food products so that the decrease in moisture content is inhibited.

Red chilies have a high moisture content so moisture loss will result in weight loss or shrinkage in the fruit. Moisture loss is closely related to weight loss. The coating material plays a role in slowing down the respiration process so that moisture loss from the fruit can be minimized and weight loss can be minimized [3].

3.3. Ascorbic acid

In addition to capsaicin, red chili also contain of ascorbic acid at relatively high concentration. At the beginning of the observation, the average level of ascorbic acid in red chilies was 23 mg/100 g. The second day, the level of ascorbic acid in the combination of sweet potato starch treatment with a nozzle sprayer measuring 0.6 mm had the highest average ascorbic acid, namely 19 mg/100 g. On the 4th day, the combination of edible coating types of sweet potato coated with a nozzle sprayer with a size of 1 mm had the highest average Ascorbic acid content with 15 mg/100 g, while the combination of edible coating types of potatoes with a nozzle sprayer measuring 0.6 mm had an average. On day 6, there was no significant effect between ascorbic acid levels and the factors tested. The possibility that what happened is on the 6th day all the starch ingredients that have been applied to red chilies have the same ability to maintain ascorbic acid levels in red chilies.

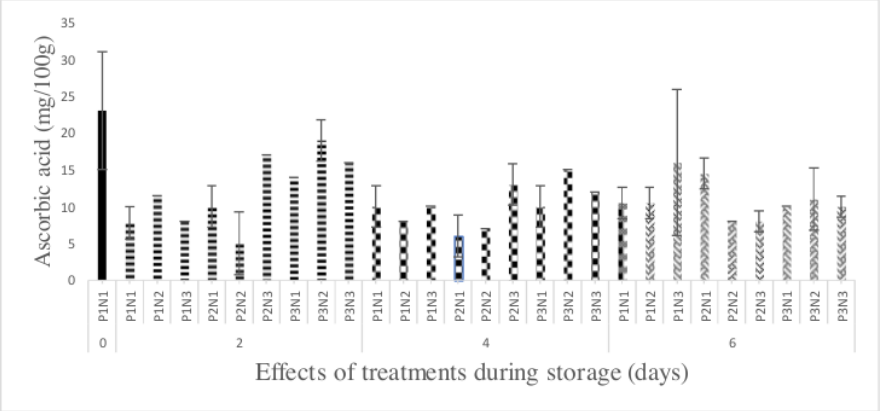

Figure 5. The effects of treatment on the ascorbic acid content of red chili during storage. Edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3); The nozzle sprayer diameter: 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3).

The decrease in ascorbic acid content can be affected by the process of respiration and transpiration which causes a decrease in fruit moisture content. Starch-based coating acts as a permeable membrane that is selective against the exchange of O_2 and CO_2 gases so that it can reduce respiration rates in fruits and vegetables.

3.4. Firmness

Texture changes are one of the physiological changes that occur as a direct result of moisture loss in horticultural products. The change in texture that can be used as an indication of damage to red chilies is a decrease in the firmness of red chilies so that they become soft during storage. The decrease in the firmness level of red chilies during storage is in accordance with the research of [23]. Based on the results of the analysis of the various treatments for the main coating material, it shows a significant difference on the second day, while the nozzle sprayer shows no significant difference. The highest firmness value was in the treatment of canna starch and a nozzle sprayer with a size of 0.6 mm.

On the 4th day the main coating material showed a significant difference, while the size of the sprayer nozzle did not show a significant difference. The coating treatment of potato starch and 1 mm nozzle sprayer had the highest average firmness of 0.201 kg / cm^2. Day 6 shows that there is no significant influence between the tested factors with fruit firmness. The coating treatment of sweet potato starch with a nozzle sprayer resulted the firmness with a value of 0.203 kg/cm^2.

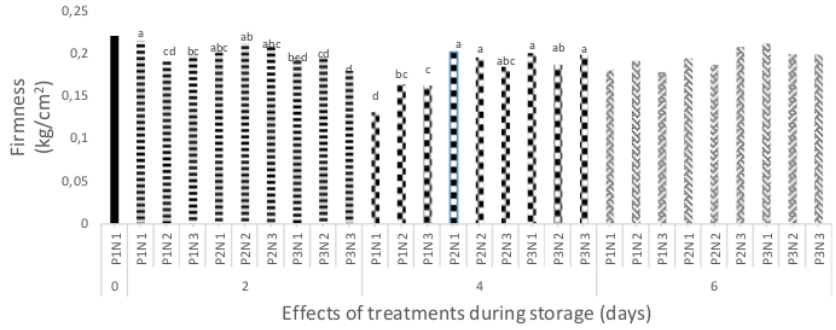

Figure 6. The effects of treatment on the firmness of red chili during storage.`
Edible coating made from canna starch (P1), potato starch (P2), and sweet potato starch (P3);
The nozzle sprayer diameter: 0.6 mm (N1), 1.0 mm (N2) and 1.5 mm (N3).

Chili peppers lose firmness rapidly during room temperature storage which contributes to a short post-harvest shelf life and susceptibility to fungal contamination. The texture of the fruit is influenced by the cell turgidity, structure and composition of the cell wall polysaccharides. Red pepper softening was associated with the degradation of the middle lamellae in parenchyma cortical cells, resulting in a dramatic increase in pectin solubilization, a slight change in pectin molecular weight and a slight reduction in hemicellulose content [23].

The firmness level of the fruit is related to the skin tissue system represented by the epidermis as the outer protector of the fruit. Gas exchange, moisture loss, mechanical damage, resistance to pressure and change in firmness all start at the surface of the fruit. Chemical changes also occur in the continuous cell wall of complex compounds from the structural carbohydrate group such as cellulose, hemicellulose, pectin and lignin.

Texture changes are one of the physiological changes that occur as a direct result of moisture loss in horticultural products. The change in texture that can be used as an indication of damage to red chilies is a decrease in the firmness of red chilies so that they become soft during storage. Reduction in the firmness level of red chilies during storage according to the study of [23]. The change in texture is due to the

respiration process which causes the breakdown of carbohydrates into simpler compounds, with the breakdown of these carbohydrates it will cause the breakdown of tissue in the fruits so that the fruit becomes soft. This respiration process leads to continued ripening of the fruit, at which time there is degradation of hemicellulose and pectin from the cell walls which results in changes in fruit firmness [23].

One of the changes in texture is caused by the presence of pectin, which is originally present in the form of protopectin in unripe fruits, but with the help of the pectin methylesterase and polygalacturonase enzymes, it causes pectin to dissolve in moisture and break down or break down pectin into other compounds. The breakdown or damage causes the texture of the hard plant to become soft.

4. Conclusions

The result of this research shows that the potential usage of edible coating produced from the local tubers, particularly starch made from sweet potato, potato and canna. The diameter of nozzle sprayer also contribute on determining the characteristic of edible coating on the surface of the product. The selected treatment combination for red chilies is the application of an edible coating made from sweet potato starch overlaid with a nozzle sprayer with a diameter of 0.6 mm.

Further research is needed on the application of coatings with a smaller sprayer nozzle and fogging system as a method for the applying of coating to examine the effect of other various method of edible coating application.

Acknowledgement

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