

Effectiveness of incorporating citric acid in cassava starch edible coatings to preserve quality of Martha tomatoes

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Abstract. Tomato as an agricultural product is extremely perishable. Coatings of tomatoes with edible starch extend quality and storage life of the fruits. Incorporation of citric acid as antimicrobial agent in the edible starch coatings is expected to preserve the quality of tomatoes during storage. The aim of this study was to verify the effectiveness of citric acid incorporated in cassava starch coating to preserve quality of tomatoes. The edible coatings formula consisted of cassava starch solutions (1; 2; 3%), citric acid (0.5; 1.0%) and glycerol (10%). Tomatoes were dipped to the coating solution for 10 seconds, then air-dried and stored at room temperature during 18 days. All the treatments were carried out in triplicates. Experimental data were analyzed using One Way ANOVA. The results showed that coating treatments did not affect the weight loss, moisture content, color characteristic, carotene and vitamin C content on Martha tomatoes. The low concentration of starch coating on Martha tomatoes are indicated to be the reason why there was no significant difference between coated and coated tomatoes for some parameters. However, incorporating citric acid in cassava starch-based coatings could prevent tomato fruits from firmness reduction and spoilage during storage.

Keywords: *edible coating, tomato, cassava starch.*

1. Introduction

Tomatoes are being one of the most important horticultural products in Indonesia because of their economic value and the nutrition. One medium sized tomato provides 57% of the recommended daily allotment (RDA) of vitamin C, 25% RDA of vitamin A, and 8% RDA of iron [1]. Besides consumed fresh, tomato can be baked, stewed, fried, juiced, or pickled and can be used in soups, salads, and sauces. Tomatoes are important agricultural product for food and beverage industries as well as pharmaceutical industry.

As climacteric fruits, tomato is highly perishable due to many processes affected to the loss quality after harvest and during storage including transpiration and respiration that will be followed by physiological changes such as softening tissues, reducing organic acids, color alteration, and volatile compounds losses [2, 3]. The deterioration of tomato's quality during storage and transportation is still becoming a serious post harvest problem for traders. Therefore, development of preservation technology is required to avoid postharvest losses and deterioration of tomatoes.



The use of edible coatings to preserve quality of fruits is well known. Edible coatings offer some advantages such as edibility, biocompatibility, aesthetic or glossy appearance, barrier properties, non-polluting and having low cost [4, 5]. Moreover, edible coatings act as a barrier to external elements, protect the products, extend the storage life, and prevent microbial spoilage, which is extremely important to perishable fruits [6, 7].

Polysaccharide-based coatings such as starch provide favorable functional properties that enable development of edible coatings for use in the food industry [8]. Starch edible coatings exhibit similar physical characteristics to synthetic polymers such as transparent, odorless, tasteless, semi-permeable to CO₂ and resistant to O₂ passage [9]. One of the important sources of starch in Indonesia is cassava. Cassava starch edible coating is cheap, tasteless, odorless, colorless, non-toxic, biodegradable, safe, and have low permeability to oxygen [10].

Based on some researches, the effectiveness of starch as an edible coating should be blend with other biopolymers, hydrophobic substances and/or antimicrobial compounds [11-14]. One of the chemical compounds that were potential to use as an antimicrobial agent in edible coating formulation is citric acid. Citric acid is generally recognized as safe chemical preservatives that can acts as antimicrobial agents. The addition of citric acid in edible coatings formula inhibited browning reaction and reduced losses because this acid acts as antimicrobial agent [15]. Compared to other organic acids, citric acid is relatively cheap and easily obtained.

Until now, the application of edible coating on Indonesian fruits is still limited. The utilization of materials that was easy to obtained and inexpensive is expected to increase the farmer interest to develop this technology on their commodities. The aim of this study was to evaluate the effect of citric acid incorporation in cassava starch edible coating on preserving the quality of Martha tomatoes during storage. The evaluation of tomato quality changes were based on their physicochemical properties such as weight loss, moisture content, vitamin C, carotene content, fruit firmness, color, as well as the percentage of fruit decay.

2. Materials and Methods

2.1. Sample preparation

Uniform and healthy tomatoes cv. Martha from a farmer in Boyolali, Central Java was selected as samples. The fruits were classified according to their size and maturity (based on their external color and firmness). Upon arrival at the laboratory, the tomatoes were washed in tap water and cleaned with a sterilized cloth to remove physical dirt from the surface. The tomatoes were treated within 3 hours of arrival time.

Edible coatings were prepared from cassava starch with additions of citric acid as antimicrobial agent and glycerol as plasticizer. The purpose of glycerol addition in the treatments was to enhance the coatings flexibility, since glycerol has low molecular weight that enables macromolecules interaction to increase mobility of the polymer chains and reduce the glass transition temperature of the system [16].

Experimental treatments in this study refer to Chiumarelli *et al.* [17] method, which was using cassava starch and citric acid in coating fresh-cut mango. Combination of cassava starch (1, 2, and 3% w/v solution) and citric acid (0.5 and 1.0% w/v solution) were tested as coatings. Glycerol 10% was added in all combinations as the standard treatment. All materials were mixed in distilled water and boiled at 80-90 °C for 15 minutes with a constant agitation. Edible coating solution was left until its temperature reached the room temperature (approximately 25 °C). Tomatoes were immersed in the edible coating solution for 10 seconds and air-dried using a fan. Each treatment contained 15 tomatoes and the experiment was replicated three times. Uncoated tomatoes were used as control. Tomatoes were stored at room with air conditioner at temperature 25 °C before further observation.

2.2. Data collection and analysis

The physicochemical observations were done after 18 days storage when the fruits reaching softened. The physical analysis included their weight loss (the percentage weight lost from the original weight), surface color (Hunter Lab Scan Spectrocolorimeter), textural degradation (Instron Universal Testing Machine Instron Corporation, Canton, MA), as well as the percentage of decayed fruit. The decay percentage of tomato fruit was calculated as the number of decayed fruit divided by initial number of all fruit multiplied by 100 [18]. Chemical analysis consisted of moisture content [19], vitamin C [19], and total carotene [20]. All the experiments were carried out in triplicates. Each replication was consisting 15 tomatoes.

2.3. Statistical analysis

Experimental data were analyzed statistically using one-way analysis of variance (One Way ANOVA). Detailed examinations for significant differences were done using a Duncan Multiple Range Test at $p \leq 0.05$. SPSS 17.0 statistical software (SPSS Inc., Chicago, IL, USA) was used in all statistical analysis.

3. Results and discussion

3.1. Weight loss

In this study, there were no statistically differences in weight loss among all treatments (Figure 1). The low concentration level of cassava coatings in this experiment lead to a formation of thin layer on tomatoes surface that still enable respiration activities, engendering no difference on weight loss between coated and uncoated tomatoes. Moreover, tomatoes naturally covered by a continuous wax layer that provides high resistance to water movement across the cuticle [21].

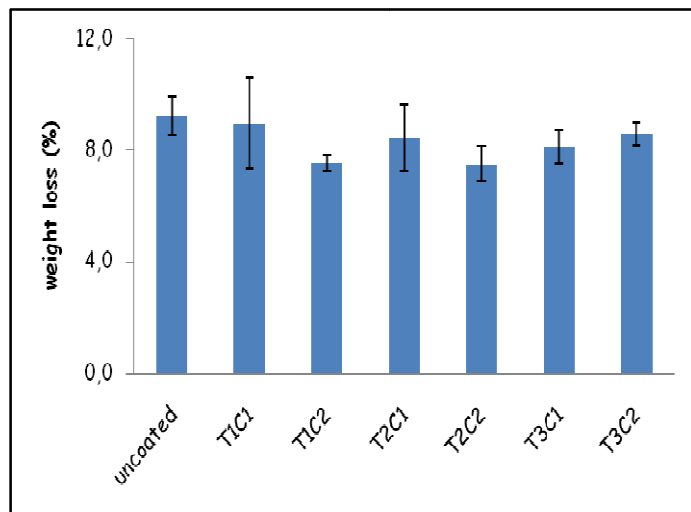


Figure 1. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on tomatoes weight loss after 18 days storage at room temperature.

The transpiration process as well as respiration rate triggers the weight loss on fruits during storage [22]. The basic mechanism of weight loss from fresh fruits and vegetables is by vapor pressure at different locations [23]. When the vapor pressure inside the fruit is higher than outside then the moisture will discharge resulting in the fruit weight loss. Furthermore, the respiration activity on fruits engenders fruit ripening causing reduction of fruit weight [22].

3.2. Moisture content

Moisture content is one of degradation parameter quality of tomatoes that related to weight loss. Moisture contents of coated tomatoes after 18 days storage were relatively the same (95.16 - 95.37%) (Figure 2). There were no significant differences among all treatments (uncoated and coated

tomatoes). Some researchers [24, 25] suggested that polysaccharide based coatings do not behave well as moisture barriers because of their hydrophilic nature. Other research has also reported that the use of citric acid in cassava starch formulation coating could slightly increased the dehydration of fresh-cut mango during storage, due to the cell turgidity loss [17, 26].

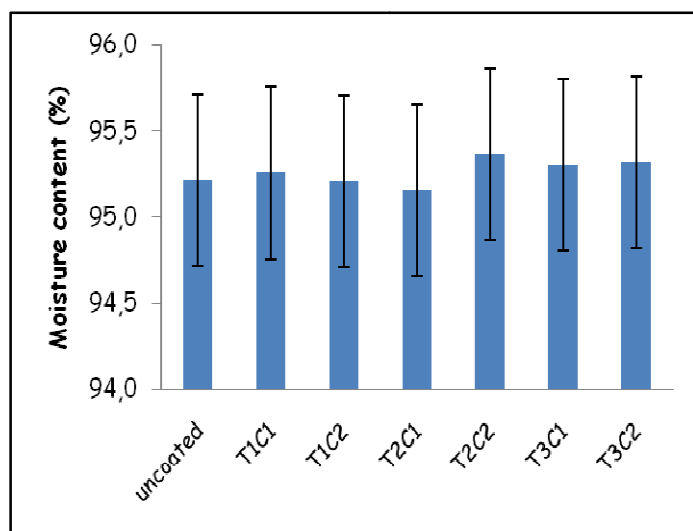


Figure 2. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on the moisture content of tomatoes after 18 days storage at room temperature.

3.3. Vitamin C

Tomato is rich in vitamin C. The results showed that vitamin C on coated tomatoes after 18 days storage varied between 12.24 to 15.25 mg/100 g sample (Figure 3). The low vitamin C on tomatoes samples is probably due to the decreasing of tomatoes vitamin C during storage. The vitamin C of tomato fruits tends to decrease with the time of storage [27]. Once fruit reach the full ripe stage, vitamin C content starts to decline [28]. The loss of vitamin C can be attributed to the stress caused by the operations involved in processing, resulting in greater weight loss and juice leakage during storage [29].

In this study, there were no significant differences on vitamin C between all treatments of tomatoes during 18 days storage. This condition indicated that the coating formulation in this study is inadequate for maintaining the environment around the samples, thus enabling for the respiration activity and metabolic process. Hence, the vitamin C contained on coated and uncoated tomatoes was not significantly different.

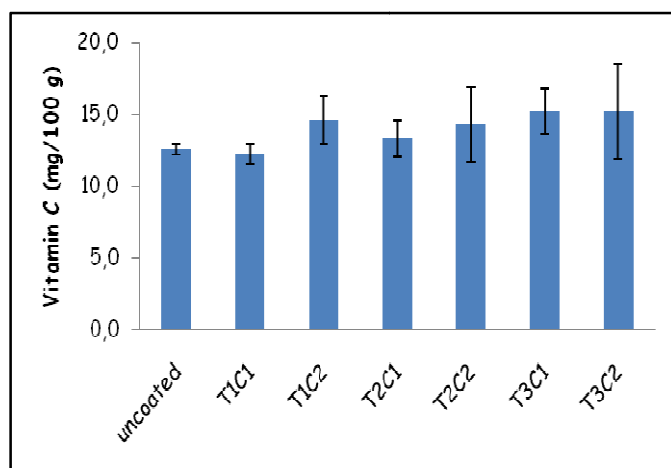


Figure 3. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on the vitamin C of tomatoes after 18 days storage at room temperature.

3.4. Carotene content

During fruit ripening, chlorophyll decomposition raises and chloroplast transform into chromoplasts, and then generates carotenoid formation [30]. The evaluation results showed that edible coating treatments have no significant effects on carotene content of tomatoes during 18 days storage (Figure 4). This result is consistent with Chiumarelli *et al.* [17], which worked on fresh-cut mango showed that cassava starch coating incorporated with citric acid has no influence on β -carotene content of fruits during storage 15 days. The possible explanation is that the low concentration of coating was not effective, thus allowing the activities of carotenoid biosynthesis in the tomatoes.

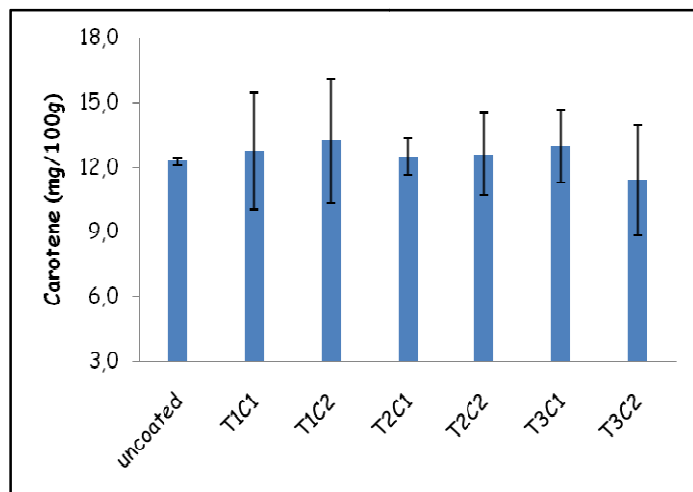


Figure 4. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on the carotene content of tomatoes after 18 days storage at room temperature.

3.5. Fruit firmness

Texture transformation is one of the obvious physical characteristic changes on tomatoes during storage. Throughout storage, a loss of mechanical properties was observed for all treatments. The observation exhibited that the coatings affected the firmness significantly. The application of 1% cassava starch coating blend with 0.5% citric acid was the most effective treatment for hindering the firmness reduction of tomatoes during 18 days of storage (Figure 5).

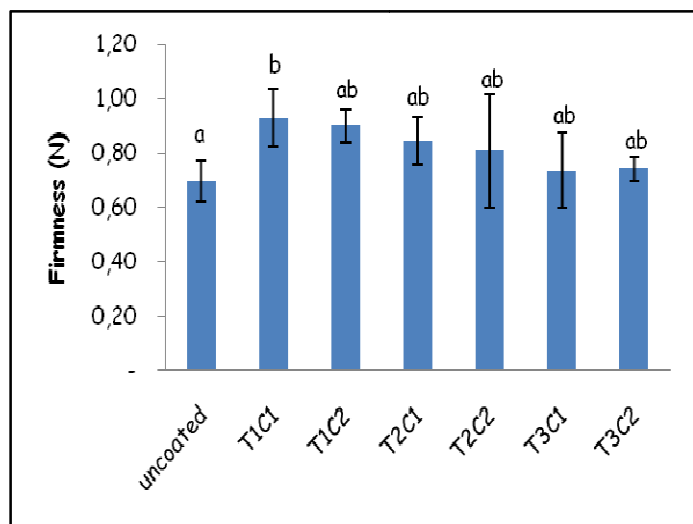


Figure 5. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on tomato firmness after 18 days storage at room temperature.

The higher concentration of cassava starch causing the greater firmness reduction on tomatoes. It was presumed that higher concentration of cassava starch resulted in lower O_2 concentrations and

excessive CO₂ concentrations, yielding ethanol production that was triggering greater firmness reduction [31].

The fruit softening is due to deterioration in the cell structure, cell wall composition and intracellular materials [32] and a biochemical process involving the hydrolysis of pectin and starch by enzymes [28]. Edible coating enable to inhibit respiration rate thus postpone the ripening process and texture degradation during storage [33]. Low respiration rate can limit the activities of hydrolysis enzymes that triggering firmness retention on tomatoes [3, 28, 34].

3.6. Color index

The color of fresh products is one of the most significant quality factors for its acceptance. Figure 6 showed that coated tomatoes did not present significant changes on color properties when compared with control sample during 18 days storage. The similar condition was occurred on fresh-cut pineapple and strawberries where application of cassava starch edible coatings did not affect the fruit natural color characteristic [29, 35]. Other research also showed that coating application has no influences on color parameters of cherry tomatoes after 15 days of storage [21].

During ripening, the green chlorophyll pigment is degraded and there is accumulation of carotenoid, particularly lycopene giving the red color to the ripe tomato [28]. In this study, the influence of respiration rate and volatile changes on tomatoes might have been insufficient to raise a significant effect on peel color parameters of coated Martha tomatoes. It was possible that the coatings were not providing a sufficient barrier against ethylene production and gas exchange between inner and outer environment, thus there was no increasing in carotenoid synthesis. Therefore, the coated tomatoes have no different color with uncoated tomatoes. Furthermore, tomatoes that was used were selected with the uniform external color (full-developed red color), which could also explain there is no changes observed in color during storage.

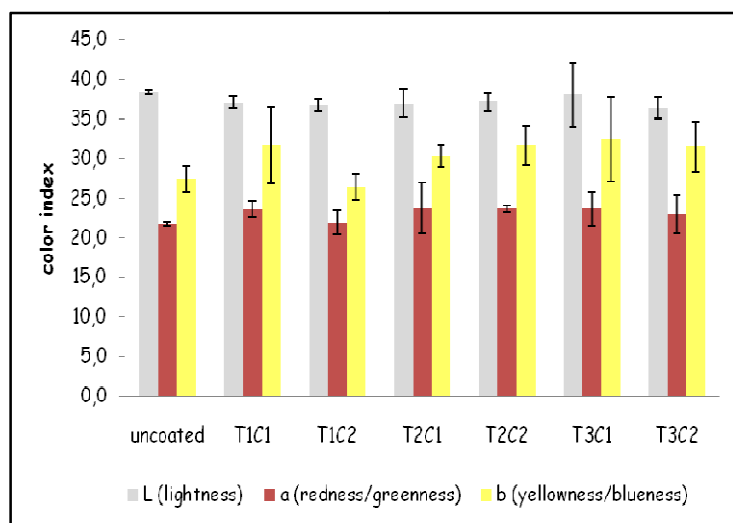


Figure 6. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on tomato color after 18 days storage at room temperature.

3.7. Fruit decay

Effectiveness of coating treatments on maintaining tomatoes quality can also be observed from its spoilage incidences level during storage. The results indicated that an addition of citric acid as an antimicrobial agent in coating formulation is effective on preventing decay on tomatoes. The percentage of decay level after 18 days storage on coated tomatoes was less than 5%, while on uncoated tomatoes was more than 25% (Figure 7). *Botrytis cinerea* Pers. and *Alternaria alternata* (Fr.) Keissl. are the most common fungal pathogens responsible for postharvest decay on tomato fruit, causing gray mold and black spot, respectively [36].

The decrease in decay percentage was probably due to the effect of the coating on delaying senescence, which makes the commodity more susceptible to pathogenic infection as a result of loss of

cellular or tissue integrity [37]. Other research has also reported that the use of starch based coatings without antimicrobial agent in their formulation was unable to control the development of yeast and molds [38]. Starch coating material was a carbohydrate source and may have been used as a substrate for microbial growth.

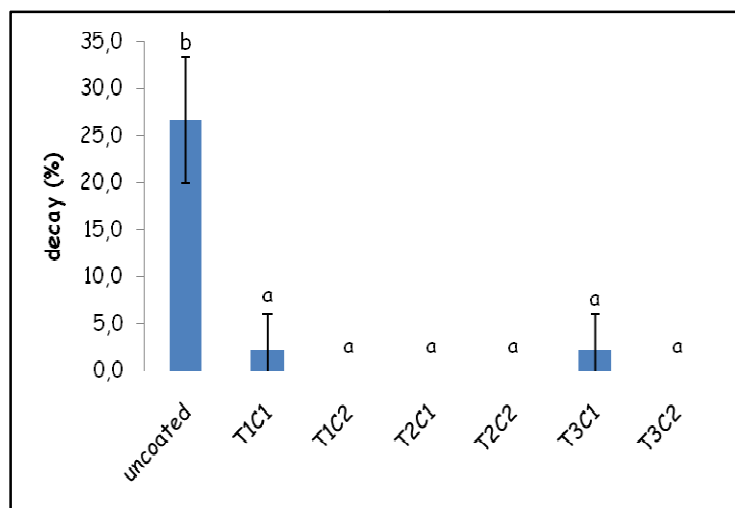


Figure 7. The effect of incorporating citric acid in cassava starch coating (T1C1 = 1% starch + 0.5% acid, T1C2 = 1% starch + 1% acid, T2C1 = 2% starch + 0.5% acid, T2C2 = 2% starch + 1% acid, T3C1 = 3% starch + 0.5% acid, T3C2 = 3% starch + 1% acid) on the percentage of tomato decay after 18 days storage at room temperature.

4. Conclusion

The coatings of cassava starch (1, 2, and 3%) with an addition of 0.5 and 1.0% citric acid did not provide sufficient barrier to transpiration, respiration activity, as well as metabolic processes of tomatoes cv. Martha. The coating treatments in this study did not affect the weight loss, fruit color, moisture, carotene, and vitamin C of Martha tomatoes as compared to uncoated tomatoes. However, an addition of citric acid on cassava starch coating was effective in maintaining the firmness reduction and microorganism growth on tomatoes during 18 days of storage

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