Effect of cassava starch-based edible coating incorporated with lemongrass essential oil on the quality of papaya MJ9

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Abstract. Edible films and coatings have emerged as an alternative packaging in food applications and have received much attention due to their advantages. The incorporation of essential oils in film matrices to give antimicrobial properties had been observed recently, and could be used as promising preservation technology. In this study, cassava starch-based edible coating incorporated with lemongrass essential oil (1%) was applied by spraying and dipping methods to preserve papaya MJ9 during storage at room temperature. The quality of papaya MJ9 was analyzed based on its physicochemical and microbiological properties. The addition of lemongrass essential oil (1%) significantly inhibited the microbial growth on papaya MJ9 by reducing the value of total yeast and mold as compared to the control. This study also showed that for parameters of weight loss, total soluble solid, vitamin C, and total titratable acid, papaya MJ9 with cassava starch-based edible coating incorporated with lemongrass essential oil (1%) had the lower values than control, however, they had the higher value than control on firmness parameter. These results indicate that cassava starch-based edible coating incorporated with lemongrass essential oil (1%) can be used as an alternative preservation for papaya MJ9.

1. Introduction
Tropical fruits have been received much attention on international trade in recent years, because of consumer preferences for experiencing different, exotic, and diversified products [1]. Papaya is one tropical fruits which occupies a prominent place among the most important tropical fruits [2]. Indonesia as one of tropical countries has been producing papaya 840,000 tons in 2014, while Central Java province has been producing 105,624 tons in 2014 [3]. Papaya MJ9 is one of papaya varieties that cultivated in Indonesia especially by farmers' groups in Boyolali, Central Java province, Indonesia. The importance of papaya from the economy perspectives is shown by its substantial production. However, papaya is a perishable fruits and postharvest diseases caused by microorganisms, particularly fungi, reduce the shelf-life and market value of papaya [2].

Among the available preservative treatments to control fungi decay, edible coatings has been remarked to be used to prolong the shelf-life and prevent the quality loss of papaya. Edible coatings is a method to maintain the original appearance of products, inhibit the release of gas, water vapor, and avoid directly contact with oxygen by providing a thin layer that is safe to be eaten and environmentally friendly [4] [5]. The materials used for edible coating could be proteins, lipids, and polysaccharides that can be utilized individually or as mixed composite blends [6] [7]. Several studies have shown that edible coatings made of different coating materials could maintain quality and prolong the shelf-life of fruit products such as fresh-cut pineapple [8] and apples [9]. Moreover,
Cassava starch is one of potential edible coatings materials due to its properties, including isotropic, odorless, tasteless, colorless, non-toxic, biologically degradable, have good flexibility, and low water permeability [10].

Edible coatings incorporated with essential oils also have been used in food preservation since addition of some active substances have been useful to improve edible coatings properties and enhance the protective purposes [11]. Cinnamon oil incorporated on chitosan coating improved the storage quality of frozen rainbow trout [12]. Essential oils of *Alpinia purpurata* and *Kaempferia rotunda* enrichment on cassava starch-based edible coating could maintain refrigerated patin fillets for several days [11] [13] [14]. However, the addition of lemongrass essential oil on cassava starch-based edible coatings have limited found to extend papaya fruits shelf-life. Thus, this study aimed at evaluating the effect of cassava starch-based edible coating incorporated with 1% lemongrass essential oil on the quality of papaya MJ9.

2. Experimental

Papaya MJ9 were obtained from farmers' groups in Mojosongo, Boyolali (Central Java province, Indonesia) and the characteristics of them were as follows, weight range of 950-1250 g, clean, with no diseases and bruises, and the homogeneity of maturity level that were shown by orange stripe on the surface of papaya. Essential oil of lemongrass was produced by water-vapor distillation for 4 hours [15]. Prior to distillated, lemongrass (purchased from local market) was sliced (10 mm) and air dried. Cassava starch "Rose Brand" was obtained from local market and other supporting materials, including chemicals for analysis were supplied by local distributor and were analytical grade.

The preparation of cassava starch-based edible coating solution followed previous procedure [14]. Briefly, coating formula were 5 g cassava starch, 150 ml of distilled water, and 2 ml glycerol. 1% (v/v) lemongrass essential oil and 0.1% (v/v) tween 80 were mixed after the last heating of the solution. Edible coating solution was applied to papaya by two methods (dipping and spraying methods). For the dipping method, coating solution was put into boxes, furthermore, papaya MJ9 was dipped into a solution of edible coating for 2 minutes, and drained, while for the spraying method, a solution of edible coating (± 40 ml) was sprayed on papaya MJ9 with a pressure of 3-4 bar by sprayer gun and compressor [16]. Samples were then dried with a hair dryer to dry the coating layer and kept at room temperature for examining the quality parameters of papaya during storage. Samples were analyzed microbiologically and chemically, including weight loss analysis [9], firmness analysis [9], pH analysis [17], vitamin C analysis [18], Total Soluble Solids analysis (TSS) [9], Total Titratable Acid analysis (TTA) [18], and Total Molds and Yeasts analysis [19] at 0, 3, 6, 9, and 12 days of storage at room temperature. All samples and all analysis were made in duplicates. A completely randomized design (CRD) with one factor was used in this study. There were five treatment variations, F1 (control, without coating), F2 (cassava starch-based edible coating, dipping method), F3 (cassava starch-based edible coating, spraying method), F4 (cassava starch-based edible coating + 1% lemongrass oil, dipping method), and F5 (cassava starch-based edible coating + 1% lemongrass oil, spraying method). The data were then statistically analyzed by one way analysis of variance (ANOVA) at 0.05 significance level and differences in the mean values were determined with Duncan’s (DMRT) test (p < 0.05) to determine the differences among concentration treatment and differences among storage time at room temperature. SPSS Statistics 16 program was used for statistical analysis.

3. Results and discussion

3.1. Weight loss

Weight loss of all formulas were increased significantly (p < 0.05) in line with the storage time at room temperature, however edible coating treatment could inhibit the occurrence of weight loss on comparison to the control (Table 1). Polysaccharides-based edible coating acts as a permeable membrane that is selective for the exchange of O₂ and CO₂ gases, therefore can reduce the level of respiration in fruits and vegetables [20]. Lemongrass essential oil acted as hydrophobic component in
the layer edible coating, so that the weight loss of papaya MJ9 on the treatment of F4 and F5 are smaller \((p < 0.05)\) than the treatment of F2 and F3, and control.

### Table 1. Weight loss of papaya MJ9 during storage (%)

| Formula | Storage (Days) | 0 | 3 | 6 | 9 | 12 |
|---------|----------------|---|---|---|---|----|
| F1      |                | 0.00 \(\pm 0.000\) | 4.51 \(\pm 0.132\) | 14.78 \(\pm 0.078\) | 25.69 \(\pm 0.049\) | 31.48 \(\pm 0.651\) |
| F2      |                | 0.00 \(\pm 0.000\) | 3.44 \(\pm 0.417\) | 12.21 \(\pm 0.431\) | 18.04 \(\pm 0.240\) | 24.72 \(\pm 0.813\) |
| F3      |                | 0.00 \(\pm 0.000\) | 4.27 \(\pm 0.011\) | 13.22 \(\pm 0.205\) | 19.14 \(\pm 0.368\) | 25.28 \(\pm 2.164\) |
| F4      |                | 0.00 \(\pm 0.000\) | 4.23 \(\pm 0.176\) | 11.16 \(\pm 0.545\) | 14.28 \(\pm 0.665\) | 18.08 \(\pm 0.205\) |
| F5      |                | 0.00 \(\pm 0.000\) | 4.23 \(\pm 0.099\) | 11.32 \(\pm 0.587\) | 16.64 \(\pm 0.997\) | 20.31 \(\pm 0.057\) |

- Mean with different letter within each column are significantly different \((P < 0.05)\)
- Mean with different letter within each line are significantly different \((P < 0.05)\)

#### 3.2. Firmness

Table 2 shows that during the 12 days of storage at room temperature, the firmness of papaya decreased significantly \((p < 0.05)\), however coatings treatment can maintain the firmness of papaya MJ9 compared to control, as reported in the study of strawberry [21]. Other study showed that fruit without treatment (or control) was less able to withstand the metabolic processes occur during storage, thus the reform process protopectin into soluble pectin would become faster, [22] this means that edible coating can prevent softening of the fruit [23].

It has been reported that the firmness of papaya treated with gum arabic coating incorporated with 0.05% lemongrass essential oil could maintain the firmness better value compared to the control and treatment of gum arabic coating alone \((p < 0.05)\) [19]. For firmness parameter, coating methods (dipping and spraying) did not show any significant difference.

### Table 2. Firmness of papaya MJ9 during storage (N)

| Formula | Storage (Days) | 0 | 3 | 6 | 9 | 12 |
|---------|----------------|---|---|---|---|----|
| F1      |                | 38.97 \(\pm 1.598\) | 31.68 \(\pm 3.274\) | 27.62 \(\pm 3.387\) | 24.84 \(\pm 0.297\) | 21.74 \(\pm 0.169\) |
| F2      |                | 38.87 \(\pm 2.079\) | 31.72 \(\pm 2.679\) | 30.69 \(\pm 1.689\) | 25.29 \(\pm 0.283\) | 22.99 \(\pm 0.289\) |
| F3      |                | 37.63 \(\pm 4.441\) | 35.33 \(\pm 2.199\) | 28.76 \(\pm 2.136\) | 25.23 \(\pm 0.085\) | 23.27 \(\pm 0.021\) |
| F4      |                | 38.41 \(\pm 0.806\) | 33.18 \(\pm 2.956\) | 29.15 \(\pm 2.758\) | 27.87 \(\pm 1.329\) | 25.52 \(\pm 0.028\) |
| F5      |                | 37.57 \(\pm 0.177\) | 33.95 \(\pm 3.253\) | 30.08 \(\pm 1.039\) | 26.98 \(\pm 2.029\) | 25.02 \(\pm 0.417\) |

- \(\text{A-A}^\text{a-e}\) Mean with different letter within each column are significantly different \((P < 0.05)\)
- \(\text{a-e}^\text{a-e}\) Mean with different letter within each line are significantly different \((P < 0.05)\)

#### 3.3. Total soluble solid (TSS)

Table 3 shows an increasing rate of TSS during storage at room temperature that is caused by the hydrolysis of starch into simple sugars [24]. Coating treatment either with or without the incorporation of 1% lemongrass oil had a significant effect \((p < 0.05)\) on TSS of papaya after 9 days of storage compared with control. It is in line with the other study about papaya treated with gum arabic coating [19]. The results also showed that the incorporation of 1% lemongrass oils had a significant effect on the TSS value of papaya after 12 days of storage, whereas dipping or spraying methods did not show any significant difference for TSS parameter.
treatment with the incorporation of 1% lemongrass essential oil could inhibit a decrease in the pH or spraying methods of coatings did not show any significant difference for this parameter.

Table 3. Total soluble solid (TSS) of papaya MJ9 during storage (°Brix)

| Formula | 0            | 3            | 6            | 9            | 12           |
|---------|--------------|--------------|--------------|--------------|--------------|
| F1      | 6.88±0.459   | 8.40±0.424   | 9.60±0.283   | 10.38±0.035  | 11.05±0.071  |
| F2      | 7.00±0.884   | 8.30±0.707   | 9.43±0.601   | 10.00±0.000  | 10.78±0.035  |
| F3      | 6.60±0.424   | 8.10±0.141   | 9.70±0.141   | 10.10±0.141  | 10.73±0.035  |
| F4      | 6.83±0.530   | 8.55±0.106   | 9.13±0.177   | 10.05±0.071  | 10.45±0.141  |
| F5      | 7.05±0.212   | 8.00±0.141   | 9.70±0.141   | 10.10±0.000  | 10.55±0.141  |

A-E Mean with different letter within each line are significantly different (P < 0.05)
a-e Mean with different letter within each column are significantly different (P < 0.05)

3.4. pH
Table 4 shows the decreasing rate of pH value in all treatments (p <0.05) in line with the storage time at room temperature. The decreasing rate of pH value is possibly because of the production of organic acids, such as malic acid and citric acid during storage as a result of biochemical reactions [25]. Increased levels of total acid is accompanied by a decrease in pH during storage indicating that the organic acid in releasing hydrogen ions contributed on lowering the pH during storage period [26]. Starting on the storage days of 6th, F1 treatment showed the smallest value of pH although it did not show any significant differences to the coating treatment. Further, on the 12th days of storage, coating treatment with the incorporation of 1% lemongrass essential oil could inhibit a decrease in the pH value, while dipping or spraying methods did not show any significant difference for pH parameter.

Table 4. pH of papaya MJ9 during storage

| Formula | 0            | 3            | 6            | 9            | 12           |
|---------|--------------|--------------|--------------|--------------|--------------|
| F1      | 7.08±0.035   | 6.63±0.035   | 5.70±0.424   | 5.08±0.106   | 4.90±0.000   |
| F2      | 7.08±0.248   | 6.58±0.106   | 6.15±0.071   | 5.70±0.000   | 5.48±0.035   |
| F3      | 6.70±0.000   | 6.53±0.248   | 6.20±0.000   | 5.70±0.283   | 5.20±0.071   |
| F4      | 6.90±0.071   | 6.60±0.141   | 6.13±0.035   | 6.03±0.035   | 5.96±0.000   |
| F5      | 6.85±0.141   | 6.45±0.141   | 6.25±0.071   | 5.95±0.071   | 5.75±0.064   |

A-E Mean with different letter within each column are significantly different (P < 0.05)
a-e Mean with different letter within each line are significantly different (P < 0.05)

3.5. Vitamin C
Table 5 shows that cassava starch-based edible coating treatments (with or without incorporation of 1% lemongrass oil) could inhibit the increase in value of vitamin C in papaya. A papaya ripening is characterized by impairment of firmness, increased dissolved solids and the amount of vitamin C [27]. Edible coatings treatment on the surface of the papaya acts as a barrier to water vapor transmission, so that the respiration process is inhibited and the increasing value of vitamin C is also inhibited. Dipping or spraying methods of coatings did not show any significant difference for this parameter.

Table 5. Vitamin C of papaya MJ9 during storage (%)

| Formula | 0            | 3            | 6            | 9            | 12           |
|---------|--------------|--------------|--------------|--------------|--------------|
| F1      | 0.055±0.0031 | 0.084±0.0000 | 0.097±0.0125 | 0.121±0.0093 | 0.184±0.0078 |
| F2      | 0.053±0.0062 | 0.073±0.0031 | 0.086±0.0093 | 0.097±0.0031 | 0.123±0.0187 |
| F3      | 0.046±0.0000 | 0.059±0.0031 | 0.067±0.0078 | 0.079±0.0062 | 0.125±0.0156 |
| F4      | 0.046±0.0031 | 0.064±0.0093 | 0.086±0.0031 | 0.092±0.0000 | 0.133±0.0140 |
| F5      | 0.055±0.0031 | 0.062±0.0062 | 0.086±0.0093 | 0.101±0.0125 | 0.143±0.0093 |

A-E Mean with different letter within each column are significantly different (P < 0.05)
a-e Mean with different letter within each line are significantly different (P < 0.05)
3.6. Total titratable acid (TTA)

Based on Table 6, the coating treatments could inhibit the increasing value of TTA on papaya during storage at room temperature, while dipping or spraying methods of coatings did not show any significant difference for this parameter. It is in line with other studies that reported an increasing value of TTA in control was greater (p < 0.05) than papaya treated with coating of gum arabic 5% and 10% [19]. Other study showed that pectin-based edible coating can maintain the integrity of the cell wall thereby slowing the release of acid and inhibit the increase TTA [26].

![Table 6. Total titratable acid (TTA) of papaya MJ9 during storage (%)](image)

| Formula | 0          | 3          | 6          | 9          | 12         |
|---------|------------|------------|------------|------------|------------|
| F1      | 0.29±0.057 | 0.25±0.000 | 0.49±0.000 | 0.53±0.000 | 0.70±0.057 |
| F2      | 0.21±0.064 | 0.25±0.000 | 0.35±0.028 | 0.37±0.000 | 0.49±0.000 |
| F3      | 0.21±0.064 | 0.25±0.000 | 0.29±0.057 | 0.33±0.000 | 0.54±0.064 |
| F4      | 0.37±0.057 | 0.37±0.057 | 0.41±0.000 | 0.49±0.057 | 0.56±0.354 |
| F5      | 0.25±0.000 | 0.25±0.000 | 0.29±0.057 | 0.33±0.000 | 0.49±0.000 |

**Mean with different letter within each column are significantly different (P < 0.05)**

**Mean with different letter within each line are significantly different (P < 0.05)**

3.7. Yeast and mold

As seen in Table 7, coating treatments without the incorporation of 1% lemongrass oil can suppress the growth of molds and yeasts up to 0.455 log CFU/g after 12 days of storage at room temperature, while the coating treatment with the incorporation of 1% lemongrass oil can suppress the growth of molds and yeasts up to 1.48 log CFU/g. Dipping or spraying methods of coatings did not show any significant difference for this parameter. Other study showed that total mold and yeast of fresh-cut pineapple treated with coating incorporated with 1% peppermint oil (1.11 log CFU/g) was smaller than control and coating without incorporation of essential oil [28].

![Table 7. Total yeast and mold of papaya MJ9 during storage (log CFU/g)](image)

| Formula | 0          | 3          | 6          | 9          | 12         |
|---------|------------|------------|------------|------------|------------|
| F1      | 1.35±0.071 | 2.76±0.078 | 3.77±0.078 | 4.24±0.120 | 4.99±0.169 |
| F2      | 1.24±0.085 | 2.64±0.219 | 3.26±0.057 | 3.80±0.177 | 4.44±0.078 |
| F3      | 1.15±0.212 | 2.59±0.262 | 2.96±0.021 | 3.63±0.134 | 4.34±0.219 |
| F4      | 1.24±0.085 | 2.10±0.141 | 2.57±0.028 | 3.02±0.092 | 3.40±0.014 |
| F5      | 1.15±0.212 | 2.42±0.021 | 2.72±0.106 | 3.29±0.064 | 3.73±0.049 |

**Mean with different letter within each column are significantly different (P < 0.05)**

**Mean with different letter within each line are significantly different (P < 0.05)**

4. Conclusion

The incorporation of lemongrass essential oil (1%) on cassava starch-based edible coating significantly inhibited the microbial growth on papaya MJ9 by reducing the value of total yeast and mold, weight loss, total soluble solid, vitamin C, and total titratable acid as compared to the control, however, they had the higher value than control on firmness parameter, suggesting that cassava starch-based edible coating incorporated with lemongrass essential oil (1%) could be used as an alternative preservation for papaya MJ9.

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