Implementation of carrageenan and xanthan gum in “raja” banana (Musa sapientum) for coating application

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Abstract. “Raja” banana (Musa sapientum) is a type of banana that is often consumed in Indonesia. Raja bananas provides several benefits due to nutrients content, such as bioactive phenolics, antioxidants, potassium, vitamin C and also high carbohydrate content that changes color and texture during ripening. Preservation method was used to suppress this physical changes. This research was done to analyze color in “Raja” bananas and its shelf life after the treatment using iota carrageenan and xanthan gum as coating material. The four formulas of coating were applied in banana by full surface coating in banana and stored in room temperature. The color change and texture of banana peel were observed for 5 days. As result, the best coating composition was iota carrageenan since the coating using this material provided moist appearance during ripening process, indicating the inhibition in banana’s ripening. As conclusion, iota carrageenan may be applied as coating material in “Raja” banana that enable to suppress the physical changes on color and texture during ripening.

1. Introduction
Bananas has been known as native fruit from tropical climates, including Indonesia so that this production contributes to the country's economy dominantly because they are classified as a leading fruit commodity with a large production level of more than 7 million tons in Indonesia [1]. “Raja” banana is a type of banana that is often consumed by Indonesian people with very cheap price and readily available daily [2]. Bananas have many benefits because they contain many nutrients such as bioactive phenolics, antioxidants and potassium and high level in vitamin C [3]. However, bananas may experience changes in color and texture during the ripening process quickly due to high carbohydrate content as one of the consideration. Furthermore, bananas are classified as climacteric fruit because their respiration rate increases sharply during the ripening period which affects the change in its color and texture [4].
Based on previous research [5], it was found that carrageenan plus xanthan gum provided a good barrier to the diffusion of \( \text{O}_2 \) and \( \text{CO}_2 \) gases that might be applied to inhibit color and textural change in banana. Giving xanthan gum may reduce ethylene production but the coating fruit which results in spoilage [6]. Carrageenan has been widely known as biocompatible and non-toxic polymer that may be used to compose elastic hydrogel [7]. Hydrogel is a hydrophilic gel containing about 95% moisture and may cover whole surface [8]. The utilization of additional substance such as enzyme may extend the shelf life of coated-food and agricultural products [9][10][14]. Addition of calcium chloride may provide extra firmness that was caused by the chelation effect of Ca ions on amino acids [11]. Other substances such as glycerol, may be used as an additive for coating as antimicrobial agent that may be utilized in gel formation [12]. Since less data on carrageenan coated banana were found, therefore this research was focused on analyzing the appearance coated bananas with hydrogel and determining its shelf life. This research may open the knowledge of utilization carrageenan as readily available material in bananas.

2. Materials and Methods
This research was conducted in Central Laboratory for Research and Services Diponegoro University (CORESDU), Semarang. “Raja” banana was used in this research and collected from banana plantation in Jabungaran district, Semarang-Indonesia. Iota carrageenan was provided from carrageenan manufacture in Semarang. Glycerol, \( \text{CaCl}_2 \), and xanthan gum were purchased from Sigma Aldrich, USA.

2.1 Hydrogel Preparation
Hydrogel preparation referred to the previous method [13] with modification in its concentration. The main ingredient for making hydrogel was iota carrageenan, glycerol, \( \text{CaCl}_2 \), and xanthan gum. Hydrogel was composed of 2 % iota carrageenan and xanthan gum with same concentration in ratio. As much as 2% glycerol and 0.2% \( \text{CaCl}_2 \) were also used as the material. The absence of xanthan gum or glycerol was standardized by additional of water. Iota carrageenan was dissolved in distilled water using hot-plated magnetic stirrer initially, then followed by dilution glycerol and gum. This solution was stored in aseptic condition until it achieved the temperature of 30°C.

2.2 Banana Preparation
Banana sample preparation referred to the method that has been done previously [14]. The banana that used was an immature green banana that was harvested from local plantation at the 6 month of plantation. The best appearance of banana was then selected using visual determination and based on uniformity of shape, color and size. Banana was separated into one piece using a aluminum coated-knife, then was cleaned using aseptic cloth.

2.3 Hydrogel Application
The application of hydrogel coating on bananas followed a previously existing method with modification [15]. The hydrogel was sprayed in all surface of the banana and let the coated banana in laminar airflow. Bananas that have been coated with hydrogel were then labeled and stored in a aseptic box with controlled air circulation in room temperature.

2.4 Visual Observation of Bananas
Banana observation was carried out following pre-existing methods [16]. Observations were made on day 0 until the bananas showed indicator of ripening (at day 5). Visual observations were made by determining the color change of the banana from green to yellow while the texture of hydrogel was identified as the moisture appearance (wet feeling) and fungus appearance in the banana surface.
2.5. Data Analysis
The data were analyzed descriptively by describing the appearance of color, surface moisture, and fungus during ripening period. The color change was described using photo, moisture of coating surface was explained using wetness level, and fungus appearance was described using the visual detection of fungus contamination in the surface during ripening.

3. Result and Discussion
Hydrogel was successfully applied in banana without any problem on the coating process. The achieved formula was provided proper gel conformation. Proper hydrogel was successfully obtained resulting in the high moisture in surface of banana peels. No fungus was detected in the banana during preparation and the first day of ripening. It has been stated in the method section, this hydrogel was composed from iota carrageenan, xanthan gum, glycerol and CaCl$_2$ that might provide best formula in forming hydrogel. This may be explained due to carrageenan ability to form gels [17] while glycerol was able to bind hydrogel due to its hydrophilicity or has several –OH bonds that provided low permeability [18]. A good hydrogel showed wet appearance, soft, flexible that was allowed permeable mechanism to various biomolecules, minerals, and ions transportation. This mechanism is useful to keep freshness of fruit [19]. The freshness of banana was indicated by the remaining green color in banana as can be seen at Table 1. The hydrogel made of carrageenan, xanthan gum and glycerol provided best formula to keep freshness of banana while the carrageenan hydrogel unable to suppress the ripening process.

After being applied to bananas, the hydrogel made of carrageenan, xanthan gum and glycerol might hinder the growth of fungi compared to only iota carrageenan of hydrogel as can be seen at Table 2. The dry appearance was also could be detected in the iota carrageenan-only hydrogel. The composition of iota carrageenan and glycerol from day 0 to day 5 were detected as wet by visual analysis. However, the fungal growth could be detected on day 4 of ripening. In other treatments the fungus starts to grow on day 3. This may be explained because the water content in several parts of banana that may accelerate the growth of the fungus [20,22,23]. This also explain that xanthan gum might increase the susceptibility of coating from fungal contamination. It has been widely known that final ripening banana might be achieved by 2 days of ripening in the market [21], thus by coating with hydrogel, the final ripening of banana could be prevented. This strategy may be used as preservative effort in order to prolong the shelf life of food product [22,24].
**Table 1.** Photo of Hydrogel Coated Bananas during Ripening Process

| Sample                  | Storage | Day-0 | Day-1 | Day-2 | Day-3 | Day-4 | Day-5 |
|-------------------------|---------|-------|-------|-------|-------|-------|-------|
| Iota-carrageenan        |         | ![Image](image1.png) | ![Image](image2.png) | ![Image](image3.png) | ![Image](image4.png) | ![Image](image5.png) | ![Image](image6.png) |
| Iota-carrageenan + Glycerol |       | ![Image](image7.png) | ![Image](image8.png) | ![Image](image9.png) | ![Image](image10.png) | ![Image](image11.png) | ![Image](image12.png) |
| Iota-carrageenan + Glycerol + Xanthan gum | | ![Image](image13.png) | ![Image](image14.png) | ![Image](image15.png) | ![Image](image16.png) | ![Image](image17.png) | ![Image](image18.png) |

**Table 2.** Observation of Wetness Level and Fungal Growth in Coated Banana using Hydrogel during Ripening Process

| Hydrogel                          | Storage | Wetness Level | Fungal Growth |
|-----------------------------------|---------|---------------|---------------|
| Iota-carrageenan                  | Day-0   | Wet           | -             |
|                                   | Day-1   | Semi Dry      | -             |
|                                   | Day-2   | Dry           | -             |
|                                   | Day-3   | Dry           | -             |
|                                   | Day-4   | Dry           | +             |
|                                   | Day-5   | Dry           | +             |
| Iota-carrageenan + Glycerol       | Day-0   | Wet           | -             |
|                                   | Day-1   | Wet           | -             |
|                                   | Day-2   | Wet           | -             |
|                                   | Day-3   | Wet           | -             |
|                                   | Day-4   | Wet           | +             |
|                                   | Day-5   | Wet           | +             |
| Iota-carrageenan + Glycerol + Xanthan gum | Day-0 | Wet | - |
|                                   | Day-1 | Wet | - |
|                                   | Day-2 | Wet | - |
|                                   | Day-3 | Wet | + |
|                                   | Day-4 | Wet | ++ |
|                                   | Day-5 | Wet | ++ |

Notes: symbol of -, +, ++ indicates no fungal, initiation of fungal growth, and fungal grow in several spot in banana surface, respectively.
4. Conclusion
The best hydrogel conformation was successfully achieved using the formula made of iota carrageenan, xanthan gum, glycerol with CaCl$_2$ as an additive. Hydrogel that was made of iota carrageenan and glycerol provided proper hydrogel coating based on the appearance of fungal detection in banana.

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