Physico-chemical properties of gathot (fermented cassava) flour applied on edible film

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Abstract. The objective of this research is to examine the physicochemical properties of gathot and its potential as an edible film. The materials used included dried gathot, carrageenan, and glycerol with 4 levels of treatment and 5 repetitions. The treatment was in the form of variation of gathot flour’s concentration (0.00; 0.75; 1.00; 1.25 %). The test was conducted on gathot flour, covering scavenging ability, bulk density, water absorbency, color brightness, proximate analysis and crude fiber with descriptive analysis. Gathot flour-derived edible film’s characteristics were tested for tensile strength and water vapor transmission rate (WVTR) to examine whether gathot flour-derived edible film was able to compete with commercial bioplastics through quantitative statistical analysis and Completely Randomized Design (RAL) and processing with SPSS 23.0. The results of physicochemical test on gathot flour were scavenging ability 49.37%; bulk density 0.57 g/mL; water absorbency 2.37 g/g; color brightness 17.42; water content 9.32%; protein content 4.76%; fat content 0.13%; ash content 0.09%; carbohydrate 85.70%; and crude fiber 3.54%. The average results of edible film’s characteristics test with a variation of gathot flour’s concentration were tensile strength 1.41-3.00 N/mm² and water vapor transmission rate (WVTR) 5.42-6.99%. From the perspective of physicochemical properties, it is concluded that gathot flour is almost equal to wheat flour and tapioca flour. In addition, gathot flour-derived edible film at up to concentration level 1.25% has met the criteria for the edible film with moderate properties and complied with the standard bioplastic packaging.

Keywords: gathot (fermented cassava), edible film, physicochemical properties, flour

1. Introduction

Plastic packaging is often used for food products. Plastic containing easily migrating compounds such as vinyl chloride, acrylonitrile, metacrylonitrile, vinyldiene chloride, and styrene will quite easily migrate into foodstuff, particularly one with high-fat content such as livestock yields [1] since they are influenced by food or storage temperature, processing and storing duration [2]. Contamination and altered quality because of packaging and content in sausage may lead to non-fulfillment of food safety criteria.

Food safety is important and needs to be noted by all producers of food products. Food packaging is one important factor to reach the food safety of a product. The migration process of a hazardous compound in plastic packaging may be prevented by replacing the packaging with one safer, more...
environmentally friendly and consumable together with the product [3]. Such packaging is commonly called edible film. The edible film must have a good thickness, attractiveness as well as elongation percentage and water transmission rate and comply with the standard food packaging. To meet the criteria, the edible film is commonly created by combining one polysaccharide with the other, one protein with the other, or polysaccharide with protein [4]. One source of polysaccharide that has not been well utilized is gathot.

Gathot is an Indonesian local product derived from spontaneously fermented cassava with blackish patches almost on its entire surface. Fungus Acremonium charticola which causes blackish patches on gathot contains high tannin and phenol and good probiotic for the digestive tract, while the other fungus on gathot, Rhizopus oryzae, contains high flavonoid [5]. Gathot is commonly known as a traditional snack served with grated coconut, while the other processed products are for livestock feed. Gathot may be served as gathot flour for an extended storage period. Gathot flour contains amylose 33.8% and amylopectin 39.41% [6]. Amylose is the edible film that contributes to the compactness of its matrix, that the high content of amylose in the material will result in the strong and compact edible film. Likewise, amylopectin contributes to stability [7].

Gathot utilization in society is still limited to traditional food with its not really long period of storage, while gathot may potentially be processed into other processed products by utilizing amylose and amylopectin in gathot’s polysaccharide. In some researches, with regard to gathot utilization as food product, it has been processed into steamed-sponge cake [6], analog rice in the utilization of gathot’s gel-forming capability [8], and gluten-free noodle proving that gathot flour’s antioxidant activity is able to decrease blood sugar level in consumer’s body [9]. Based on the foregoing, gathot may with its polysaccharide potentially be processed into an edible film that is safe for consumers and to extend its storage period.

2. Materials and methods

2.1. Materials
The materials included commercial dried gathot from dried gathot producers in Gunungkidul, Yogyakarta, carrageenan and glycerol. The instruments employed included a grinder, 80-mesh screen, dry sterilization oven, analytical balance and desiccator.

2.2. Methods
The method in this study is an experimental method and data were analyzed using RAL for the physical test of edible film. The data resulting from the test or analysis were analyzed statistically using Duncan Multiple Range Test (DMRT) at a significance level of 5% [10]. All of the data analyses were calculated with the assistance of the SPSS 23.0 program, while the data gathot flour’s physicochemical characteristics were analyzed descriptively [11].

First, dried gathot was inserted into the grinder, ground for about 30 seconds several times until fine powder was resulted, and screened using an 80-mesh screen that it became gathot flour with moisture content 9.32%. Then, gathot flour was analyzed for scavenging ability test [3], bulk density [12], water absorbency [13], color [14], proximate analysis [15] and crude fiber content [16].

Second step is edible film making, which referred to the earlier method with some modifications, starting with 2 g carrageenan and gathot flour as per treatments (0.0, 0.75, 1.0 and 1.25% (b/v)) inserted into the beaker and added with 50 ml distilled water, initial stirring was then performed until they were mixed, re-added with 50 ml distilled water and re-stirred until it truly became sample solution. The sample solution was then stirred in water bath until 60°C for ± 6-8 minutes, aiming to mix and homogenize the sample solution. After the sample solution reached 60°C, it was added with glycerol for 1.5 ml and re-stirred for 30 minutes.

The sample solution was then poured into plastic molds in size of 10x10 cm for 18 ml solution per container. The plastic molds were put into the oven at 70°C for 6 hours [17]. The finished edible film
layer was then chilled and removed from plastic molds and physically tested such as tensile strength [18] and water vapor transmission rate (WVTR) [19].

3. Result and Discussion

3.1. Gathot flour’s physicochemical characteristics
Flour may be called a foodstuff when its physical and chemical contents meet the requirements for commercial standard flour. Gathot flour’s physical and chemical characteristics may be observed in Table 1.

| Parameter                              | Content |
|----------------------------------------|---------|
| Free Radical (scavenging ability) (%)  | 49.37   |
| Bulk Density (g/mL)                    | 0.57    |
| Water absorption (g/g)                 | 2.37    |
| Color                                  | 17.42   |
| Water (%)                              | 9.32    |
| Protein (%)                            | 4.76    |
| Fat (%)                                | 0.13    |
| Carbohydrate (%)                       | 85.70   |
| Crude Fiber (%)                        | 3.54    |
| Ash (%)                                | 0.09    |

3.1.1. Scavenging ability. The result of test on gathot flour shows that 100 g gathot flour processed from dried gathot has a scavenging ability of 49.37%. This value is lower than gathot flour in the earlier research of 90.33% [9]. The low level of scavenging ability is caused by different processing of gathot flour. Cassava drying process into gathot requires uncertain time, depending on the weather and sunlight condition. Cassava drying into gathot will be deemed complete when there are blackish patches on its surface. In addition, gathot storing place and temperature before processing into flour are also important with regard to gathot flour’s antioxidant content. The stability of antioxidant content in a food product is influenced by storing temperature and duration as well as pH [20].

3.1.2. Physical characteristics. The result of the physical test on gathot flour shows that gathot flour 100 g has a bulk density of 0.57 g/mL. Gathot flour’s bulk density is deemed high compared to that of tempeh flour of soybean sprout 0.42 g/mL and tempeh flour of soybean 0.39 g/mL [21], indicating that gathot flour product is more compact since it does not require a wide place for storage. Bulk density is also related to gathot flour’s low water content. Lower water content indicates more water to vaporize during heating, causing a declining volume of flour granules, causing higher bulk density value [22].

Gathot flour’s water absorbency of 2.37 g/g has equal value to that of cassava flour 2.36 g/g and wheat flour 2.5 g/g [23]. This shows that gathot flour has met the requirements as flour since it is equal to commercial flour. The difference is on gathot flour’s brightness value. The result of the color brightness test is 17.42, far lower than the color brightness of wheat flour and tapioca flour, which is a minimum of 91 [24]. The reason is that gathot is initially black and flour making process cannot alter gathot’s color. The brownish color of tuber-derived flour is caused by its polyphenol content [25]. The polyphenol content in that is derived from fungi’s activity that causes blackish patches, in conformance to the earlier research that black fungi in some conditions may produce phenol components [26].

3.1.3. Chemical characteristics. The result of the chemical test shows that 100 g of gathot flour contains water content 9.32%, protein 4.76%, fat 0.13%, carbohydrate 85.70%, ash 0.09%, and crude fiber 1.54%. According to the Indonesian National Standard (SNI), the requirement for the quality of tapioca flour is to contain maximum water content of 14% and maximum crude fiber 0.4% [24]. Gatot flour’s water content has met the requirements, but the gathot flour’s crude fiber content is far higher than the
prevailing standard. The crude fiber in gathot flour is actually lower than that in cassava 6.15% [27]. Compared to the United State Department of Agriculture, the water, protein, fat and ash contents of gathot flour are lower than those of commercial flours, but with higher carbohydrate. The standard is water content 11.92%; protein content 10.33%; fat content 0.98%, carbohydrate 76.31% and ash 0.47% [28]. Cassava flour contains protein content 0.10% and fat content 0.56% [29]. The difference in chemical content between gathot flour and cassava, cassava flour, tapioca flour and wheat flour is caused by fermentation in gathot processing. Fermentation may alter the chemical and physical contents of food product. Enzymatic process during fermentation may degrade carbohydrate component, including fiber, into simpler compound because of hydrolysis [43].

From the perspective of gathot flour’s physicochemical properties, this flour may be processed into food product, particularly in utilization of polysaccharide content therein.

3.2. Gathot flour derived edible film’s physical characteristics

Edible film is plastic, flexible and thin layer wrapping food product safely. To meet the safety criteria, physical test needs to be conducted. Gathot flour derived edible film’s physical characteristics may be observed in Table 2.

### Table 2. Gathot flour derived edible film’s physical characteristics.

| Parameter                                    | Treatment | P Value |
|----------------------------------------------|-----------|---------|
| Tensile strength (N/mm²)                     | Gatot 0.00% | 2.72 ± 0.024 | 3.00 ± 0.032 | 2.14 ± 0.017 | 1.41 ± 0.015 | 0.001 |
| Water Vapour Transmission Rate (WVTR) (g/m²/day) | Gatot 0.75% | 5.42 ± 0.068 | 5.74 ± 0.043 | 6.79 ± 0.012 | 6.99 ± 0.011 | 0.001 |
|                                              | Gatot 1.00% | 4.10 ± 0.010 | 4.32 ± 0.012 | 4.54 ± 0.014 | 4.76 ± 0.016 | 0.001 |
|                                              | Gatot 1.25% | 3.80 ± 0.012 | 4.02 ± 0.014 | 4.24 ± 0.016 | 4.46 ± 0.018 | 0.001 |

Note: Different superscript letter shows significant difference (P<0.05).

3.2.1. Tensile strength. Tensile strength shows a film’s maximum limit of stretching ability before it is broken in withdrawal. The result shows that variation of gathot flour’s concentration in edible film significantly (P<0.01) influences tensile strength value. Gathot flour contains polysaccharide with amylose and amylopectin that will cooperate with carrageenan and glycerol to form film tissue. Carrageenan and glycerol, which serve as plasticizer, will dissolve and fill all empty space in each polymer chain, increasing transition temperature. Solution’s increasing temperature during edible film making process will form film’s polymer which gets harder, thus the tensile strength value produces increases [30]. This is also related to amylase and amylopectin content in gathot flour. Whether or not film is strong is influenced by the ration of amylase and amylopectin in tapioca flour, that the higher the amylose, the higher the tensile strength is [25]. Gathot flour, according to the earlier research contains amylase 33.8% and amylopectin 39.41% [6]. It is this higher content of amylopectin which influences the low value of tensile strength of gathot flour derived edible film since amylopectin is hydrophilic. Apart from amylopectin, the use of glycerol as plasticizer also contributes to the low value of tensile strength since it can reduce hydrogen bond in the edible film’s tissue formed. This conforms to the earlier research, that plasticizer may serve to reduce molecule attraction between tapioca flour and carrageenan by weakening hydrogen bond between polysaccharide chains [31].

The tensile strength of edible film with gathot flour ranges from 1.41 – 3.00 N/mm². Edible film with gathot flour concentration 0.75% (3.00 N/mm²) is higher than that of control edible film (gathot 0%) of 2.72 N/mm². The criteria of tensile strength in an edible film is within the standard moderate properties of 1-10 N/mm² [32], thus gathot flour derived edible film up to level 1.25% meets the requirements.

3.2.2. Water Vapor Transmission Rate (WVTR). The result shows that variation of concentration of gathot flour in edible film significantly (P<0.01) influences WVTR of edible film. The higher gathot’s concentration, the higher the WVTR value is. The WVTR value of edible film with gathot flour ranges
from 5.74–6.99 g/m²/day, in which the WVTR value is higher than that of control edible film (5.42 g/m²/day). According to the JIS standard, a good WVTR value is maximum 7 g/m²/day [33]. WVTR value in gathot flour derived edible film up to level 1.25% has met the requirements, although it is deemed high.

WVTR value is related to film’s ability to restrain water vapor’s movement. Packaging’s permeability means its ability to have gas and water vapor particles permeating at a certain condition [34]. The reason of high WVTR value is that all materials contained therein are hydrophilic. Hydrophilic compound will bind more water or water vapor during storage. Hydrophilic compound has a large number of hydrogen bonds, which will increase water absorption at high humidity, which will disturb molecule chain interaction, followed with increased diffusion, making water vapor in the surrounding air get absorbed [35]. Factors which influence WVTR include material’s chemical properties, test condition and properties of material that will diffuse and solution’s polymer structure [25].

4. Conclusion
According to the explanation above, it is concluded that edible film made of gathot flour up to concentration level 1.25% has met the criteria for edible film with moderate properties and complied with the standard bioplastic packaging. Tapioca flour derived edible film indeed has some weaknesses, one of which is its low mechanical properties.

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