Effect of process parameters to the characteristics of cassava rice sagon

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Abstract. Cassava rice sagon products were developed from modified enbal production technology. The ingredients were cassava rice flour, mung beans as a source of protein, and cassava flour as a comparison. This research aims to analyze the process characteristics of the cassava rice sagon produced. The research activities include three stages, namely (1) conducting research on the effect of roasting time on the physical characteristics of the cassava rice sagon produced; (2) optimizing the addition of protein sources to produce optimal textures and (3) characterizing the products. The research obtaining that cassava rice sagon with the addition of 30% of mung beans has the lowest moisture content, 6.12%. The formula also produced the highest levels of fat, protein and energy, namely 1.25%, 8.40%, and 372.73 kcal. Based on the results of the XRD analysis, the angle 2θ is almost the same, because the sagon product uses the same main raw material, namely from cassava rice (rasi) and cassava flour. While based on the results of SEM analysis, the use of 100% cassava flour is still relatively intact, while the use of cassava flour with the addition of 30% green beans as a source of protein has granules that have begun to break and merge with each other.

1. Introduction
Cassava is one of the important local carbohydrate sources in Indonesia. Cassava is easily cultivated and relatively resistant to various environmental conditions. Cassava tubers are rich in carbohydrates, so they are widely developed as local food sources in food diversification activities. Efforts to develop cassava as a food ingredient in food diversification have begun to be carried out. One that has been widely developed is processing cassava into cassava flour that is easier to use and formulated with other ingredients. Indigenous technology in processing cassava has also been developed in Indonesia. [1–5]

On Kei Island, Southeast Maluku, the production process of enbal is done by pressing grated cassava until the ingredients are dry half. Then enbal can be processed into dry enbal, which resembles roasted sago, which is consumed by the people of Buru Island as a staple food. [6–7]. Similar indigenous technology was also developed by the Cireundeu community in Cimahi, West Java. The Cimahi community processes cassava to be cassava rice (rasi). Cassava rice is obtained by grating, pressing (for starch extraction) followed by drying. Rasi can be consumed as a staple food by steaming or formulated with other ingredients into various snack products [8]

The opportunity to develop cassava as a nutritious processed product with good consumer preferences is a challenge to be developed. The dry enbal which has a high shelf life can be a benchmarking in the development of cassava processed products. Sagon which is also a solid dry product can be an option in developing this product. Cassava has low protein content. Therefore, the
development of food products from cassava needs to add a protein source to increase its nutritional value. One source of protein that can be used is mung beans. There are some research related to the development of cassava-based products i.e fish enbal [6] “sagon” and “kembang goyang” from cassava flour [9] and cake production [10]. Research on the use of mung beans in the production of food products has been carried out, including making cookies with the addition of mung bean flour. [11–12]. Mung bean flour also used as a material in food bar productions [13]

The aim of this study was to determine the effect of roasting time on the quality of cassava rice sagon, to optimize the addition of protein sources to produce optimal textures and to characterize cassava rice sagon that produced

2. Methods
This research was conducted at the Development Laboratory, Chemical Laboratory, Physical Laboratory, and Nanotechnology Laboratory of the Indonesian Center of Agricultural Postharvest Research and Development. The study was conducted in March-July 2019.

2.1. Materials
The material used is cassava flour obtained from the producer of cassava flour in Dramaga Bogor, cassava rice (rasi) flour, mung bean flour, natrium bicarbonate, powdered milk, granulated sugar, cane sugar, and vanilla flavour. The equipment that used were the following measuring cup, 80 mesh sieve, spatula, drying machine, spoon, Teflon pan, plastic bowl, gas stove, scales, blender.

2.2. Cassava rice sagon production
This research was conducted through three stages, first, to determine the effect of flour roasting duration on the texture and colour of cassava rice sagon, the second stage was conducted to determine the effect of mung bean flour to the physical characteristics of cassava rice sagon, then the characterization of selected product compared to control.

In the first stage of research, cassava rice flour and cassava flour were roasted according to the treatment, then added with Natrium bicarbonate 1%, and 70% v/w water and mixing until smooth. The ingredients are then baked for seven minutes with a waffle mold, after being removed from the mold then drying at 60°C for 2.5 hours. In this stage, there are four treatments, namely: cassava rice flour with 2 minutes roasting; cassava rice flour with 5 minute roasting; cassava flour with 2 minute roasting, cassava flour with 5 minutes roasting.

The second stage was the addition of mung bean flour as protein sources. There was a formula in the second stage (table 1).

| Formulas | Cassava flour (%) | Cassava Rice flour (%) | Mung bean flour (%) | White sugar (%) | Cane sugar (%) |
|----------|-------------------|------------------------|---------------------|----------------|--------------|
| 1        | -                 | 100                    | -                   | -              | -            |
| 2        | -                 | 85                     | 15                  | 10             | -            |
| 3        | -                 | 70                     | 30                  | 10             | -            |
| 4        | -                 | 85                     | 15                  | -              | 10           |
| 5        | -                 | 70                     | 30                  | -              | 10           |
| 6        | 100               | -                      | -                   | -              | -            |
| 7        | 85                | -                      | 15                  | 10             | -            |
| 8        | 70                | -                      | 30                  | 10             | -            |
| 9        | 85                | -                      | 15                  | 10             | -            |
| 10       | 70                | -                      | 30                  | 10             | -            |

The best formula in texture and colour is then optimized to obtain good organoleptic characteristics by adding 20% sugar, 10% milk and 1% vanilla.
In the first and second stages, the parameters observed were texture and colour. In the third stage, selected products were compared with controls on colour parameters, textures, proximate levels, and SEM and XRD analysis. This research was arranged in a Completely Randomized Design (CRD) with three replications.

Texture analysis using the Brookfield Model Texture Analyzer: CT-3 Brookfield. Colour analysis using AMT501 Colorimeter by measuring the parameters L, a, b and H. Proximate analysis were moisture, fat, protein, ash, carbohydrate and energy. Moisture content analysis using gravimetric method, ash analysis using gravimetric method, fat analysis by Soxhlet extraction method, protein analysis by Khjedal method, carbohydrate calculate by difference. Energy values are calculated based on fat, protein, and carbohydrate composition. Morphological characteristics of the product were evaluated by using a digital scanning electron microscope (SEM), (Model EVOLS10, ZEISS, Oberkochen, Germany). The data obtained were analyzed using Analysis of Variance, with a confidence interval of 95%. Processing data using the SPSS 20.

3. Result and discussion

3.1. Characteristics of cassava rice sagon from first stage texture
The parameters observed in this first stage were texture and colour. The texture of the cassava rice sagon ranged from 7.608 to 18.041 N. The lowest hardness was in the treatment of cassava flour with 5 minutes roasting. Furthermore, the adhesiveness value of the cassava rice sagon ranged from 2.85 to 3.07 mJ. The results of the variance analysis showed that the type of flour and length of roasting time had a significant effect on the hardness of the cassava rice sagon (table 2).

Table 2. Means of hardness and adhesiveness of cassava rice sagon in various treatments.

| Treatments                  | Hardness (N) | Adhesiveness (mJ) | Fractubility (mJ) |
|-----------------------------|--------------|-------------------|-------------------|
| Cassava rice flour, 2' roasting | 13.615\(^b\) | 2.850\(^b\)     | 2.703\(^a\)     |
| Cassava rice flour, 5' roasting | 18.041\(^c\) | 2.477\(^a\)     | 1.743\(^a\)     |
| Cassava flour, 2' roasting  | 13.829\(^b\) | 3.067\(^b\)     | 2.653\(^a\)     |
| Cassava flour, 5' roasting  | 7.608\(^a\)  | 2.950\(^b\)     | 4.603\(^a\)     |

Description: The same letter in the same column behind mean value showed no significant difference (\(p>0.05\))

When roasting flour, some starch will undergo gelatinization. At cassava rice flour, the longer the roasting time, the harder the texture of the product (increased Hardness value). According to Khan-Saini, the increase in hardness from products resulting from roasting was caused by case hardening during roasting.

3.2. Colour
Colour is an important parameter in product acceptance. The Lightness value (L) of the sagon ranges from 69.88 to 78.72. The highest brightness obtained from 2 minutes of flour roasting. Increased roasting time will reduce the brightness of the cassava rice sagon. While in a (redness index) and b (yellowness index) parameter, the increase in roasting time would increase the values of a, and b. (table 3).

Table 3. Means of colour parameters (L, a, b, H) of cassava rice sagon in various treatments.

| Treatments                  | L    | a    | b    | H    |
|-----------------------------|------|------|------|------|
| Cassava rice flour, 2' roasting | 78.72\(^a\) | 0.91\(^a\) | 4.97\(^a\) | 79.14\(^a\) |
| Cassava rice flour, 5' roasting | 69.88\(^b\) | 3.78\(^b\) | 14.14\(^b\) | 74.91\(^ab\) |
| Cassava flour, 2' roasting  | 72.23\(^b\) | 4.33\(^b\) | 16.25\(^b\) | 72.94\(^ab\) |
| Cassava flour, 5' roasting  | 70.54\(^b\) | 4.53\(^b\) | 16.38\(^b\) | 74.49\(^c\) |

Description: The same letter in the same column behind mean value showed no significant difference (\(p>0.05\))
Roasting will cause a Maillard reaction, the reaction between starch/protein that warms up to produce the brown-yellow colour. The polymerization of component oxidative during roasting also produces characteristic colours that are typical of the product [14].

3.3. Characteristics of cassava rice sagon with protein addition

From the result of previous stages, two minutes of roasting was chosen because it produces the best colour characteristics. The next stage was the addition of mung bean flour as a source of protein, as well as sugar to add taste. Then the products were analyzed for their colour and texture. The hardness of the products ranges from 6.59 to 24.065 N. The lowest hardness is the use of 100% cassava rice flour which is not significantly different from cassava rice flour: mungbean flour (70:30) formula. The addition of mung bean flour tends to increase the hardness of the product. Sagon made from cassava flour has a higher hardness compared to cassava rice flour. (table 4)

| Treatments                                      | Hardness (N) | Adhesiveness (mJ) |
|-------------------------------------------------|--------------|-------------------|
| Cassava rice flour 100%                         | 6.610a       | 0.110a            |
| Cassava rice flour: Mungbean flour (70:30), white sugar | 6.585a       | 2.260bc           |
| Cassava rice flour: Mungbean flour (85:15), white sugar | 21.720cd     | 0.613a            |
| Cassava rice flour: Mungbean flour (70:30), cane sugar | 16.459bc     | 2.950c            |
| Cassava rice flour: Mungbean flour (85:15), cane sugar | 23.666cd     | 1.373ab           |
| Cassava flour 100%                              | 14.364ab     | 0.263a            |
| Cassava flour: Mungbean flour (70:30), white sugar | 24.066d      | 0.837a            |
| Cassava flour: Mungbean flour (85:15), white sugar | 23.636cd     | 0.750a            |
| Cassava flour: Mungbean flour (70:30), cane sugar | 25.654d      | 0.097a            |
| Cassava flour: Mungbean flour (85:15), cane sugar | 24.087d      | 0.247a            |

*Description: The same letter in the same column behind mean value showed no significant difference (p> 0.05)*

The use of mung bean flour tends to increase the hardness of the sagon that produced. Cassava rice flour has lower starch content than cassava flour. The higher starch content can cause a harder texture because of the gelatinization process of starch during heating and retrogradation which causes the product's texture to become harder.

3.4. Characteristics of optimized product

Optimation process conducted based from the best basic formula obtained from the previous stage, namely (A) cassava rice flour: mung bean flour (70:30); (B) 100% cassava rice flour; (C) cassava flour: mung beans (70:30); (D) 100% cassava flour. The product is then analyzed organoleptically by the panelists. The results of the organoleptic analysis can be seen in table 5.
Table 5. Means of organoleptic parameters of cassava rice sagon in various treatments.

| Treatments | Colour          | Flavour         | Texture         | Taste           | Overall acceptance |
|------------|----------------|----------------|----------------|----------------|--------------------|
| A          | 3.30<sup>b</sup> (neutral-like) | 3.33<sup>b</sup> (neutral-like) | 3.63<sup>d</sup> (neutral-like) | 3.37<sup>c</sup> (neutral-like) | 3.70<sup>c</sup> (neutral-like) |
| B          | 3.67<sup>b</sup> (neutral-like) | 2.50<sup>a</sup> (rather like-neutral) | 1.67<sup>a</sup> (dislike-rather like) | 1.43<sup>a</sup> (dislike-rather like) | 2.00<sup>a</sup> (rather like) |
| C          | 2.63<sup>a</sup> (rather like-neutral) | 3.80<sup>c</sup> (neutral-like) | 2.83<sup>c</sup> (rather like-neutral) | 2.40<sup>b</sup> (rather like-neutral) | 2.87<sup>b</sup> (rather like-neutral) |
| D          | 3.23<sup>b</sup> (rather like-neutral) | 2.43<sup>a</sup> (rather like-neutral) | 2.13<sup>b</sup> (rather like-neutral) | 2.40<sup>b</sup> (rather like-neutral) | 2.17<sup>a</sup> (rather like-neutral) |

Description: The same letter in the same column behind mean value showed no significant difference (<i>p</i> > 0.05)

From table 5, it can be seen that the overall level of acceptance of the panelists towards the sagon range between 2.00–3.70 (rather like-like). In general, the use of mung bean flour increases panelists' acceptance of the flavour, texture and taste of the cassava rice sagon. Cassava rice flour: mung bean flour (70:30) formula produces the highest organoleptic value for texture, taste and overall acceptance. Mung beans contain protein, fat and starch. The presence of protein and fat in mung bean flour produces savory flavors and aromas in the sagon that produced. Furthermore, the results of colour analysis of the cassava rice sagon could be seen in table 6.

Table 6. Means of colour parameters (L, a, b, H) of cassava rice sagon with mung bean flour addition.

| Treatments | L<sup>a</sup> | a<sup>b</sup> | b<sup>c</sup> | H<sup>d</sup> |
|------------|--------------|--------------|--------------|-------------|
| A          | 62.190<sup>b</sup> | 2.613<sup>ab</sup> | 29.000<sup>c</sup> | 84.680<sup>c</sup> |
| B          | 83.680<sup>d</sup> | 1.743<sup>a</sup> | 12.020<sup>a</sup> | 81.737<sup>ab</sup> |
| C          | 59.823<sup>a</sup> | 2.877<sup>ab</sup> | 29.163<sup>c</sup> | 84.403<sup>c</sup> |
| D          | 70.710<sup>c</sup> | 3.947<sup>b</sup> | 20.160<sup>b</sup> | 78.887<sup>a</sup> |

Description: The same letter in the same column behind mean value showed no significant difference (<i>p</i> > 0.05)

From table 6 it could be seen that the addition of mung beans tends to decrease the Lightness of the cassava rice sagon, and increase redness and yellowness of the product. The white flour has high brightness, whereas the addition of mung bean has yellow colour that increases the yellowness of the product. Mung bean flour also contains proteins that can undergo Maillard reactions during roasting which produce a brownish-yellow colour to the resulting product. The selected product, namely A, then analyzed its proximate content, compared with the control (without the addition of mung bean flour). The proximate analysis results can be seen in table 7.
Table 7. Proximate analysis of cassava rice sagon.

| Treatments | Chemical Parameters |
|------------|---------------------|
|            | Moisture | Ash   | Fat     | Protein | Carbohydrat | Energy  |
| A          | 6.120     | 2.255 | 1.245   | 8.400   | 81.980      | 372.725 |
| B          | 7.485     | 1.130 | 0.235   | 0.890   | 90.260      | 366.715 |
| D          | 8.550     | 1.310 | 0.315   | 2.610   | 87.215      | 362.135 |

Description: The same letter in the same column behind mean value showed no significant difference ($p > 0.05$)

From table 7, it could be seen that the addition of mung bean flour can increase the protein and fat content of the cassava rice sagon. This is in line with the previous research [10] which states that the addition of mung bean flour produces biscuits with higher protein content than controls. Likewise the results of the study on cookies production which stated that the use of 25% mung bean flour to substitute wheat flour can increase protein levels of the product [12]. Protein is an important nutrient for the body, especially during growth. High protein content in cassava rice sagon with mung bean flour addition is expected to be one of the food products with good nutritional content.

Microstructure analysis using Scanning Electron Microscope is done to determine the quality of the structure of the product.

![Figure 1. Results of SEM Analysis of Cassava Rice Sagon (from top to bottom: sample A, B, C) (from left to right magnification of 50 x; 500x and 1000 x).](image)

From microstructure analysis, it can be seen that the three samples have different microstructures. Based on the results of SEM analysis, the use of 100% cassava flour is still relatively intact, while the use of cassava flour with the addition of 30% mung beans as a source of protein has granules that have begun...
to break and merge with each other. While Based on the results of the XRD analysis, the angle $2\Theta$ is almost the same, because the Sagon product uses the same main raw material, namely from cassava rice and cassava flour.

4. Conclusion

The roasting time of flour affects the parameters of the colour and texture of the cassava rice sagon that produced. The longer roasting times produce flour with a darker color. The best time for roasting flour was 2 minutes. The addition of mung bean flour to cassava rice sagon has a significant effect on the texture of the cassava rice sagon that produced. The proportion of cassava rice flour with 70:30 mung beans still produces a good sagon texture. The cassava rice flour with green beans 70:30 produced sagon that is favored by panelists. That sagon has 6.12% moisture content, 2.23% ash content, 1.25% fat content, 8.40% protein content, 81.98 carbohydrate and 372.73 Kcal energy. SEM analysis showed that granules begin to break apart and join each other.

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