Influence of Glycerol Mono Stearate and Guar gum on Quality Characteristics of Gluten Free Macaroni from Cassava

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Abstract. Macaroni is one type of food products that are widely used as appetizer or main dishes ingredient. Macaroni is generally made from wheat flour. However, macaroni in this study was made from cassava to produce a healthier gluten free product. The aim of this research was to investigate the effect of Glycerol Mono Stearate and guar gum on the characteristics of cassava macaroni. The research was arranged with Completely Randomized Designs with the concentration of GMS (0.1%, 0.25%) and guar gum (0.25%, 0.5%) against control. Parameters observed were water absorption, cooking loss, texture and proximate analysis. The results showed that the use of GMS and guar gum had significant effect on water absorption, cooking loss and texture of macaroni. Macaroni with best physical characteristics was obtained from GMS 0.1% and 0.25% guar gum which had water absorption 128.495%, cooking loss 5.060%, hardness 27.530 N, adhesiveness 0.920 mL. The macaroni had moisture content of 7.892%, fat 0.047%, protein 0.777%, carbohydrate 88.890%, ash 2.383% and energy 359.690 Kcal, which was not significantly different from the control.

1. Introduction
Macaroni is a food product that has good acceptance by consumers because it is easy to serve, has good sensory attributes and a long shelf life [1-3]. It has variety forms and can be processed into many foods both main dishes and snacks. Macaroni which has the ideal physical and sensory properties is to have high tensile strength in dry form, high hardness when raw, low cooking loss and low adhesiveness after cooking. Good quality macaroni is usually obtained from product which uses high protein flour. Wheat flour is high in protein, contains high gluten which forms a strong matrix structure [2-3].

The gluten content in wheat flour, for consumers who have allergies to gluten, such as celiac disease patients, or autism are things that are avoided. Celiac disease is an immune-mediated disease that causes inflammation of the upper small intestine when consuming gluten. The treatment for celiac disease is not consuming foods that contain gluten [4]. Whereas in autistic children, opioid peptides derived from foods that contain gluten, pass through the permeable intestinal membrane and enter the central nerve which provides a neurotransmitter effect resulting
in physiological symptoms of autism. Therefore autistic children avoid consuming foods that contain gluten [5].

Development of macaroni from non-wheat carbohydrates can be made to produce gluten free product. Cassava is a potential local carbohydrate source to be utilized. Cassava is a food crop that have high productivity. The main nutrition of cassava is 83.94% carbohydrates, especially starch. The amyllopectin fraction on cassava starch is higher than the amylose fraction [6-8]. Furthermore, the ideal type of starch used to make gluten-free pasta products has a higher amyllopectin composition than the amylose [9]. The problem in production gluten free macaroni is viscoelasticity of non gluten flour. Non gluten flour has fairly low viscoelasticity that will be produce macaroni with low textural characteristics.

Some previous research on gluten free macaroni production was the use of hydrocolloid in high-yield rice-based macaroni paste [9], gluten-free precooked pasta made from buckwheat flour[10], gluten-free macaroni based on purple sweet potato flavored sweet potato[11], brown rice-based macaroni paste[3]. The use of a texturing agents such as emulsifier (GMS) and hydrocolloid (guar gum, xanthan gum, CMC) can improve the textural properties of macaroni[2][12]. This study aimed to determine the effect of adding GMS and guar gum on the quality of cassava-based gluten free macaroni.

2. Methods
The research was carried out in processing, chemical, physical and nanotechnology laboratories of Indonesian Center for Agricultural Postharvest Research and Development from April 2017 to April 2018.

2.1. Materials
Material used for making macaroni is mocaf flour (PRODES brand) obtained from koperasi of Indonesian Center for Agricultural Postharvest Research and Development, tapioca (Pak Tani’s brand), salt (Refina’s brand) obtained from Koperasi PUSPITA, Bogor. Glycerol Mono Stearate (GMS) and commercial guar gum are obtained from suppliers from Jakarta, Yellow food colorant and water. Chemicals for analysis were obtained from the Setia Guna, Bogor. The equipments used were steamer pans, stoves, filter cloth, re-noodle, digital scales, ovens, desiccators, pans, stopwatches, texture analyzers,

2.2. Macaroni Production
The process of macaroni production was as follows: mocaf flour90% w/w mixed with 10%-w/w tapioca and 2% w/w salt then mixed evenly. Guar gum and GMS were added according to treatment and mixed evenly. Then add water as much as 25% v/w, mixed until evenly distributed and then steamed for 30 minutes. The dough is then processed by re-noodle and cut to obtain fresh macaroni. Fresh macaroni was then dried at 50 °C for 3 hours until dry macaroni was obtained.

The study was designed using a Completely Randomized Design (CRD), with four treatments, i.e: a.GMS 0.1%; guar gum 0.25%), b. GMS 0.1%; guar gum 0.5%, c. GMS 0.25%; guar gum 0.25%, d. GMS 0.25%; 0.5% compared to controls (without addition GMS and guar gum).

Parameters observed were texture, cooking loss, water absorption, moisture content, ash content, fat content, protein content, carbohydrate and energy. The data were analyzed by ANOVA and post hoc Duncan’s test using SPSS for window (ver.20) software. The best product selection with the De Garmo effectiveness index method. The best product was then analyzed morphologically using SEM and RVA, compared to control.
2.3. **Analyses Methods**

2.3.1. **Cooking quality**
Cooking quality is determined based on water absorption and cooking loss values [13]. Macaroni samples as much as 20 g cooked with 300 ml of water are based when the macaroni is perfectly hydrated (cooked), then drained for 5 minutes, then they are weighed. The residue of boiled water is dried in an oven at 105 °C, to a constant weight to measure cooking loss. The amount of water absorbed (water absorption) and cooking loss is calculated based on the following formula:

\[
\text{Water absorption} = \frac{\text{weight of cooked pasta (g) - weight of raw pasta (g)}}{\text{weight of raw pasta (g)}} \times 100\%
\]

\[
\text{Cooking loss} = \frac{\text{dry weight of boiled water residue (g)}}{\text{weight of raw pasta (g)}} \times 100\%
\]

2.3.2. **Texture measurement**
Macaroni texture was analyzed using the Texture Pro CT V1.2 Build 9 (Brokfield Engineering Labs Inc., USA) with TA4 / 1000 probes (cylindrical and 38.1 mm in size) and TA-BT-KIT fixture for cooked macaroni. The tool was set with the parameters of pre-test speed of 2 mm / s, the test speed of 0.5 mm / s, trigger load of 4.5 g and the percentage of deformation of 75%. Each sample was tested with five replications. Texture parameters measured are hardness and adhesiveness [9].

2.3.3. **Moisture content**
Moisture content was analyzed using the gravimetric method. Samples of 1-2 grams were dried in an oven at 105 °C until constant weight [14].

2.3.4. **Ash content**
Ash content was analyzed using the gravimetric method. The crucibles and lid are dried at 105 °C, cooled in a desiccator then weighed. 2-3 g of the sample is weighed into a crucible. Place crucibles into muffle furnace then ignited in a 550 °C until the process of incineration is perfect. The cup containing the sample is cooled and weighed until a constant weight is obtained. Ash content calculation formula:

\[
\text{Ash content (\% b / b)} = \frac{\text{sample weight before incineration (g) - empty cup weight (g)}}{\text{(sample weight + cup after diabetetic (g))}} \times 100\%
\]

2.3.5. **Protein content**
Protein content was analyzed by kjeldahl method. Two grams of sample is put in a measuring cup, added with sulfuric acid then decanted for 2-4 hours. Then, they are distilled.

2.3.6. **Fat content**
Fat content was analyzed by the Soxhlet method. 1-2 g of sample is put into soxhlet flask, added with hexane, then they are extracted. The extract then dried at 105 °C, until the hexane dries, allowed to stand for 30 minutes then weighed.

2.3.7. **Carbohydrate content**
Carbohydrate levels are determined by the by difference method which is 100% reduced by water, fat, protein and ash content.
2.3.8. Energy
Energy values are calculated based on fat, protein, and carbohydrates composition.

2.3.9. Characteristics of microstructure
Morphological property of evaluated starches was evaluated by using a digital scanning electron microscope, (Model EVOLS10, ZEISS, Oberkochen, Germany). The starch granules previously dehydrated in ethanol were sprayed on a metal plate covered with a double-sided adhesive tape and taken to a metalizer (Model SCD 050, Balzers, Liechtenstein) for application of a 20 nm silver layer. The sample was then observed with the digital scanning microscope.

3. Result and Discussion

3.1. Cooking quality
Cooking quality is an important parameter that determines the quality of macaroni. Cooking quality observed in macaroni were water absorption and cooking loss (loss of solids due to cooking). Water absorption indicates the percentage of water that can be absorbed by macaroni compared to the weight of raw macaroni [9]. Good macaroni can absorb water, at least twice its weight [15]. The water absorption capacity of cassava macaroni ranged between 111.345% - 141.220% (Table 1). The highest water absorption in the use of 0.1% GMS combined with 0.5% guar gum. The results of ANOVA showed that the use of GMS and guar gum had a significantly different effect on the water absorption capacity of cassava macaroni. Water absorption of cassava macaroni increased with the increasing of the use of guar gum (Table 1).

| Treatments               | Water absorption (%) | Cooking loss (%) |
|--------------------------|----------------------|------------------|
| GMS 0.1%; Guar gum 0.25% | 128.495<sup>bc</sup> | 5.060<sup>ab</sup> |
| GMS 0.1%; Guar gum 0.5%  | 141.220<sup>c</sup>  | 3.490<sup>a</sup> |
| GMS 0.25%; Guar gum 0.25%| 115.765<sup>ab</sup> | 4.501<sup>ab</sup> |
| GMS 0.25%; Guar gum 0.5% | 119.455<sup>ab</sup> | 5.846<sup>ab</sup> |
| GMS 0%; Guar gum 0%      | 111.345<sup>a</sup>  | 7.553<sup>ab</sup> |

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

Guar gum is a hydrocolloid that has many hydroxyl groups that are able to bind water. Increasing the concentration of guar gum will increase the water absorption capacity of cassava macaroni. Guar gum is formed from high molecular weight polysaccharides (50,000-8,000,000) consisting of galactomannan and have ability to bind water that can increase the rehydration rate of pasta [2][16]. The addition of GMS to the process of making pasta will reduce the water absorption of the produced pasta [17]. GMS which is an emulsifier composed of glycerol and fatty acids, has a non-polar group that does not like water.

In terms of cooking loss parameter, the ranged was between 3.4901-7.5532%. The lowest cooking loss in the use of 0.1% GMS combined with 0.5% guar gum. The use of GMS and guar gum reduces cooking loss of cassava macaroni (Table 1). The results of ANOVA showed that the use of GMS and guar gum had a significantly different effect on cooking loss of cassava macaroni.

GMS will form complex bonds with starch to form a compact structure that would be reduce the starch loss during rehydration. While the use of hydrocolloid, will increase the ability to bind water, its cause the water penetrates into the paste structure so can reduce the lost of paste residue during cooking [9][18]. The previous study on gluten free pasta from brown rice showed that the use of GMS can reduce cooking loss of gluten free pasta made from brown rice. The addition of GMS to the paste will reduce the cooking loss from the paste produced and improve the final
quality of the pasta product [17,19]. Gum or hydrocolloid is widely used in starch-based products to improve stability, facilitate processes and modify texture. Hydrocolloid improves the texture of the product [20-21].

3.2. Textural quality

Texture is an important parameter of the quality of cooked macaroni. Characteristics of hardness and high elasticity or called “al dente” are important parameters that show the quality of macaroni [1]. Texture parameters observed were hardness, adhesiveness and springiness. Cassava macaroni hardness ranged from 26.060 to 32.820 N. The lowest hardness value in the treatment of GMS 0.25% combined with guar gum 0.25%. The hardness value of cassava macaroni with the addition of GMS and guar gum is lower than the control. The results of ANOVA showed that the use of GMS and guar gum did not give a significant different effect on cassava macaroni hardness (Table 2).

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

| Treatment | Hardness (N) | Adhesiveness (mJ) |
|-----------|-------------|------------------|
| GMS 0,1%; Guar gum 0,25% | 27.530<sup>a</sup> | 0.920<sup>ab</sup> |
| GMS 0,1%; Guar gum 0,5% | 27.680<sup>a</sup> | 1.663<sup>c</sup> |
| GMS 0,25%; Guar gum 0,25% | 26.060<sup>a</sup> | 1.227<sup>bc</sup> |
| GMS 0,25%; Guar gum 0,5% | 29.300<sup>a</sup> | 0.633<sup>a</sup> |
| GMS 0 %; Guar gum 0 % | 32.820<sup>a</sup> | 1.747<sup>c</sup> |

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

Guar gum is a hydrocolloid which has high water-binding ability. Macaroni with the addition of guar gum has the ability to absorb high water so that it has a softer texture when cooked. This is in accordance with the water absorption data which shows an increase in water absorption by increasing the level of guar gum used.

Whereas for adhesiveness parameters, adhesiveness of cassava macaroni ranged between 0.633-1.633 mJ (Table 2). The highest adhesiveness value in the 0.1% GMS treatment combined with guar gum 0.5%, while the lowest value in the GMS 0.25% treatment combined with 0.5% guar gum. Adhesiveness is the power that needed to pull food from its surface. The adhesiveness value is related to stickiness, where the higher the value of adhesiveness, the more sticky the macaroni. In pasta made from precooked buckwheat, the low adhesiveness value shows low stickiness [10][22].

From ANOVA it can be considered that the use of guar gum and GMS has a significant effect on adhesiveness. Adhesiveness of cassava macaroni decreased with the addition of GMS. The use of GMS can reduce the stickiness of the paste produced. GMS will form a matrix complex with amyllose so that amyllose is retained in starch granules so that the solubility will decrease when its gelatinized and reduce the stickiness of the paste [17]. The use of GMS and guar gum will form a more compact macaroni structure, so that when cooked, less starch leached out which results in a more non-sticky texture. Good quality pasta shows a low stickiness value.

3.3. Determination of Best Treatments From Cooking and Textural Quality

Cooking quality data (water absorption and cooking loss) as well as texture (hardness and adhesiveness) were then analysed by the effective index method to determine the best treatment. For water absorption parameters, the best value is the treatment with the highest value whereas for the parameters of cooking loss, hardness and adhesiveness, the best value is the lowest value treatment. Furthermore, by using the effectiveness index formula, the effective value of each treatment is calculated. From the calculation results obtained information that the highest value of effectiveness was obtained from the treatment of using 0.1% GMS combined with 0.25% guar gum.
3.4. Chemical characteristics
Chemical characteristics measured are proximate contents (moisture content, protein content, fat, carbohydrate, ash content and energy). Proximate analysis results of cassava macaroni can be seen in the Table 3.

3.4.1. Moisture content
Moisture is an important parameter of cassava macaroni. The moisture content of cassava macaroni ranged from 6.977-7.892%. The lowest water content in the GMS 0.25% treatment. Cassava macaroni water content decreased with increasing GMS concentration. The results of variance analysis showed GMS and guar gum had a significantly different effect on the moisture content of cassava macaroni, GMS (Glycerol Mono Stearate) is an emulsifier composed of glycerol which is hydrophilic and fatty acids, especially stearic acid, which is hydrophobic [23]. The presence of hydrophobic groups can reduce the water content of the material.

Table 3. Means of proximate content of cassava macaroni

| Treatment | Moisture content (%) | Ash Content (%) | Fat Content (%) | Protein Content (%) | Carbohydrate content (%) | Energy (Kcal) |
|-----------|----------------------|-----------------|-----------------|---------------------|--------------------------|--------------|
| GMS 0.1 %; | 7.892^b              | 2.383^a         | 0.04            | 0.777               | 88.890                   | 359.690^a    |
| Guar gum 0.25% |               |                 |                 |                     |                          |              |
| GMS 0.1%; | 7.977^ab             | 2.295^a         | 0.06            | 0.705               | 89.470                   | 362.992^a    |
| Guar gum 0.5% |                |                 |                 |                     |                          |              |
| GMS 0.25%; | 6.977^a             | 1.850^a         | 0.24            | 0.740               | 90.255                   | 365.585^b    |
| Guar gum 0.25% |               |                 |                 |                     |                          |              |
| GMS 0.5%; | 6.977^a             | 2.383^a         | 0.17            | 1.008               | 89.480                   | 363.318^a    |
| Guar gum 0 % |                |                 |                 |                     |                          |              |

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

3.4.2. Ash content
Cassava macaroni ash content ranged from 1.850-2.383%. Based on the results of analysis of variance, use and GMS did not have a significant effect on cassava macaroni ash content.

3.4.3. Fat content
The fat content of cassava macaroni ranged from 0.047 to 0.173% (Table 3). Treatment GMS 0.1% combined with guar gum 0.25% has the lowest fat content, whereas treatment GMS 0.25% combined with guar gum 0.5% has the higher fat content. The results of ANOVA showed that the use of GMS and guar gum was not a significantly different effect on the fat content of cassava macaroni.

3.4.4. Protein content
The protein levels ranged between 0.680-1.008% (Table 3). The highest protein level of cassava macaroni was the combination between GMS 0.25% combined and 0.5% guar gum. Protein levels in all treatments were higher than control. The results of variance analysis showed that the interaction between GMS and guar gum had a significantly different effect on the protein content of cassava macaroni.

Guar gum is formed from high molecular weight polysaccharides (50,000-8,000,000) consisting of galactomannan consisting of linear (1,4) β-D-mannopyranosyl chains with 1.6 α-D-galactopyranosyl residues on the side/branch. Comparison of mannose: glucose around 2: 1. Commercial Guar gum contains 4-12% water, 2-5 acid dissolved ash, 0.4-1.2% ash and 2-6%
protein[16]. The presence of protein in guar gum can increase the protein content of cassava macaroni.

3.4.5. Carbohydrate content
Carbohydrate level of cassava macaroni ranged from 88.890 to 90.255% (Table 3). The lowest carbohydrate content was in the use of 0.1% GMS and 0.25% guar gum, while the highest carbohydrate level in GMS 0.25% treatment and guar gum 0.25%. The treatments had significantly effect on carbohydrate content of cassava macaroni. Guar gum that consisting of polysaccharides would increase carbohydrate content of cassava [13].

3.4.6. Energy
The energy of cassava macaroni energy ranged from 359.690 to 365.585 Kcal. The lowest energy owned by 0.1% GMS treatment combined with 0.25% guar gum, while the highest energy use of GMS 0.25% and guar gum 0.25%. The results of analysis of variance showed the treatments had a significantly different effect on the energy content of gluten free macaroni. The use of GMS will increase fat content which can increase the energy of cassava macaroni. In the other side, the use of guar gum which contains a lot of galactomannan which acts as a food fiber, will reduce the energy from the paste produced [16][23].

3.5. Microstructure of the best treatment compared with control
Microstructure analysis was conducted using Scanning Electron Microscope (SEM). The best treatment and control was cut in cross section then analyzed to find out the microstructure profile as shown in Figure 1.

![Figure 1. Raw macaroni microstructure using SEM: a. control, b. GMS 0.1%;guar gum 0.25%](image)

Based on the microstructure profile of this macaroni, for the control samples (image a) there are quite a lot of holes and less compact structure. It was compared to the best treatment (GMS 0.1%; guar gum 0.25%), that has less holes and more compact structure. In the cross section, it can be seen that for both samples, starch granules have also undergone a perfect gelatinization process, with visible interlocking between granules of starch granules.
4. Conclusions
The use of GMS and guar gum had significantly effect on water absorption, cooking loss and adhesiveness of cassava macaroni. The use of GMS and guar gum had also significantly effect on protein, carbohydrate and energy of cassava macaroni. The best physical quality of cassava macaroni resulted from the using of GMS 0.1% and guar gum 0.25%. These products were not significantly different with the control in terms of proximate analysis. The microstructure of the product was more compact than the control.

5. References

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