Gluten-free snacks cheese stick based on mocaf (modified cassava) flour: properties and consumer acceptance

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Gluten-free snacks cheese stick based on mocaf (modified cassava) flour: properties and consumer acceptance

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Abstract. Mocaf (modified cassava) flour is the substitution of wheat flour that gluten free and suitable for snacks. Effects of different ratio mocaf flour to cheese stick snacks was investigated for chemical, physic (hardness, color) and sensory properties. The mocaf and wheat flour were mixed in the ratio of 0/100; 25/75; 50/50; 75/25 and 100/0. Based on the results, chemical properties i.e. moisture, ash, protein, fat and carbohydrate between cheese stick based on 100% mocaf and 100% wheat flour were significantly different (p < 0.05). Moisture content of cheese stick snacks based on 100% wheat flour and 75/25 (mocaf/wheat) was not significantly different. Fat and carbohydrate in flour blend snacks ratio of 25/75 and 50/50 were not significantly different with 100% wheat flour. Ash content in cheese stick snacks significantly varied among the difference flour ratio. The increasing level of mocaf flour substitution has a tendency of decreasing the protein content while the highest fat content in cheese stick snacks was shown by 100% mocaf flour (36.37%). In mocaf flour substitution, significant variation of color lightness level ranged from 62.84 to 68.44. The hardness of cheese stick snacks based on 100% wheat flour and 100% mocaf flour were 5.82 and 4.62 N respectively and non-significantly different. Chemical, hardness and color properties in mocaf flour are caused by microorganism activities in fermentation process. The highest sensory value in overall acceptability of cheese stick was mocaf flour level of 25% and 100% while texture and flavor showed non-significant variation among the different ratio of flour blend snacks. In the present work reported that gluten-free snacks of cheese stick based on 100% mocaf flour resulted in good quality products and acceptable for consumers in market.

1. Introduction
In this digital and technology era, food producers can promote their products easily and popular quickly. Hence products innovation and modification i.e. cooking process, flavor, packaging, storage qualities, additional nutrition and media promotion should be upgrade continually to increase sale value of the product [1; 2]. Nowadays snacks become favorite food for consumers due to simple, ready to eat and have a long period of shelf life. Global Industry Analysts, Inc. predicts that global trend market of snack exceed US$630 billion in 2020 mainly for foods with healthy benefits i.e. functional snack, protein fortification,
organic snack and natural snack because of consumers awareness about healthy diets and changing eating habits [3]; [4]. Generally, the raw material of snack is wheat flour that have a elasticity characteristic because of gluten protein content on its constituent component [5]. However some people who have allergy to gluten, wheat flour should be avoided [6]. One of the substitution of wheat flour is mocaf (modified cassava) flour.

Many studies were conducted about mocaf flour production methods and resulted a different characteristics of mocaf flour [7]; [8]. The production method of mocaf flour that fermented by both L. plantarum and L. acidophilus resulted an increase in crude protein content whereas there was a decrease in content of crude fat and ash [9]. The mocaf flour from Research Unit for Natural Product Technology, Indonesian Institute of Sciences is used as raw material for making various food products like cookies, noodle, meatball and traditional snacks at home industry. The mocaf flour contains moisture content (4-5%), ash (0.08-0.1%), crude fat (0.25–0.3%), protein (0.5-0.7%), carbohydrate (90-95%), energy (383 kkal/100g), crude fiber (0.1-0.2%), pH (6- 6.5), HCN (9.5-10 ppm) [8,10].

Cheese stick was originated from onion stick that reformulated with cheese flavor and mostly wheat flour is used as raw material [11]. The aim of this research were to formulate gluten-free snack cheese stick from mocaf flour and to evaluate chemical properties, hardness, color, sensory properties to untrained panelists and consumers acceptance to visitors in Yogyakarta Education Park.

2. Materials and methods

2.1. Materials

Mocaf flour size of 80 mesh was produced from Research Unit for Natural Product Technology, Indonesian Institute of Sciences, Yogyakarta. These flour made from cassava chips that fermented with “Starmof” starter [8]. Wheat flour and cheddar cheese were bought from the local market in Yogyakarta, Indonesia.

2.2. Preparation of product

The mocaf and wheat flour were mixed in the ratio of 0/100, 25/75, 50/50, 75/25 and 100/0. 50% from mocaf weight was mixed with hot water at 70 °C to the gel formed. Gel was then mixed with 18.75% cheddar cheese, 41.25% seasoning and 2.5% chopped of celery then stirring well. Dough was grinded in Oxone 355-AT machine with the thickness of 3 mm and length about 8 cm. After fried at 175 °C for 15 min and drained, the snacks were stored in sealed plastic 0.8 mm at room temperature for further investigation [10].

2.3. Microstructure of mocaf flour

Microstructure of mocaf flour was conducted using Scanning Electron Microscope (SEM) Hitachi SU3500. The mocaf flour were fixed on aluminium stubs using double sided adhesive tape and were coated with a thin layer of gold. An Acceleration potential of 3.00 kV was used during micrography.

2.4. Moisture content

Two grams of the samples (W) was dried in oven at 105 °C for 3 h. The dry samples then cooled in the desiccator and finally weighed till constant (W1) [12]

\[
\text{water content} = \frac{W}{W_1} \times 100\% \quad (1)
\]

2.5. Ash content

Two grams samples (W) was placed in porcelain cup (W2) then putted in muffle furnance at 550 °C. The dry samples cooled in desiccator and weighed till constant (W1) [12]

\[
\text{ash content} = \frac{W_1 - W_2}{W} \times 100\% \quad (2)
\]
2.6. Protein content
0.51 g of the samples was mixed with 2.5 g SeO\textsubscript{2} powder, 100 g K\textsubscript{2}SO\textsubscript{4}, 20 g CuSO\textsubscript{4}.5H\textsubscript{2}O and 25 mL concentrated H\textsubscript{2}SO\textsubscript{4} in Kejdahl flask and heated in hot plate for 2 h. The blend was diluted with water to 100 mL, 5 mL of the solution, 5 mL NaOH 30\% and 2 mL PP indicator was distilled for 10 min. Use 10 mL of boric acid 2\% as a container. Titration with HCL 0.01 N and determine the blank fix [12]

2.7. Crude Fat content
Crude fat was determined by acid hydrolysis method. Sample of 2 g (W) was putted in closed paper tube then dried in oven at 80 °C for 1 h (W\textsubscript{1}). The dry sample was moved in Soxhlet instrument and extraction process using n-hexane solvent for 6 h. The samples was distilled from n-hexane and dried in oven at 105 °C. Finally cooled and weighed till constant (W\textsubscript{2}) [12]

\[
crude fat = \frac{W - W_2}{W_2}
\]  
(3)

2.8. Carbohydrate

\[
\% ~ Carbohydrate: 100\% -(\% ~ Ash + \% ~ Moisture + \% ~ Protein + \% ~ Crude fat) (by differences)
\]  
(4)

2.9. Hardness
The hardness of cheese stick was measured using Universal Testing Machine Zwick SA/0.5. A test speed before reach the sample was 50 mm/min with pre-load of 0.02 N. While the test speed when reach a sample was 10 mm/min.

2.10. Color
The color of cheese stick was determined by Chromameter Konica Minolta CR-400 using CIE method. The CIE color scale was estimated as:
L* = lightness 0 – 100 is white color
\(a^*\) = red color 0 – 60 and green color 0 – (-60)
\(b^*\) = yellow color 0 – 60 and blue color 0 – (-60)
The total color difference (\(\Delta E\)) [13]:
\[
\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}
\]  
(5)

Where :
\(\Delta L\) = (L sample – L standard)
\(\Delta a\) = (a sample – a standard)
\(\Delta b\) = (b sample – b standard)
L* a* b* standard used parameter of cheese stick snacks color based on 100% wheat flour.

2.11. Sensory evaluation
Sensory evaluation of cheese stick was conducted by 30 untrained panelists. The method using 7 point hedonic scale for color, texture, flavor and overall acceptability with 1 (dislike extremely), 2 (dislike), 3 - 4 (neither like nor dislike), 5 (like) and 6 - 7 (like extremely) [14]. The sensory evaluation was performed in sensory laboratory where it was blocked with a cabinet for each panelist. Fresh water was prepared for neutralizing the attributes of the samples. One out of five samples based on sensory evaluation was selected to evaluate consumer acceptance. The consumer acceptance evaluation was conducted by 100 visitors in
Yogyakarta Education Park. A form which contain about age, mocaf knowing, education level, jobs, consumer consideration factors, flavor, texture, color and overall acceptability of cheese stick were filled by visitor.

2.12. Statistical analysis
The data were analyzed using CoStat 6.4 (CoHort software, Monterey, CA, USA) and analysis of variance (ANOVA) with Duncan’s means test (significance level of p < 0.05). All the data are presented as the mean with standard deviation. Three replications of analysis from different cheese stick snacks were used in all of the quality measurements.

3. Results and discussion

3.1. Microstructure of mocaf flour
The micrograph of mocaf flour is presented in Figure 1. The amorphous of mocaf granules indicates that fermentation process in mocaf flour production. Fermentation in food processing is related to organoleptic quality of the food [4,15]. Microorganism work for one’s living by doing chemical reaction process that called by metabolic activities. The metabolic activities release the energy by degrading complex molecule to simple molecule.

In the beginning process, microorganism release an enzyme to destroy cassava surface area and it happens degrading starch [16]. The next process microorganism released an enzyme to break starch linkages into glucose. Through anaerobic path, it converts glucose into lactic acid to get energy for microorganism cell [14,17]. The organics acids produced by microorganism contribute to the refreshing flavor, aroma and texture [4].

3.2. Chemical properties of cheese stick snacks
Table. 1 is the chemical properties of cheese stick snacks. The moisture content between cheese stick snacks based on mocaf and wheat flour were significantly different (p < 0.05). This result indicated that the structural differences in the amylopectin and amylose of starch in different flour [13]. Moisture content of cheese stick snacks based on flour blends 25/75 increased significantly (p < 0.05). Generally cassava and wheat have more amylopectin than amylose. Amylose is linear or slightly branched component of starch that has a strong bond. While amylopectin is highly branched component in starch and the size of amylopectin is larger than amylose. Amylopectin has a shorter chains and a lot of α-(1,6)-branches that easy to bind with water. In flour blends (mocaf/wheat flour) ratio of 75/25 the moisture content decreased significantly and changed on 100% mocaf flour (p < 0.05) due to difference number of amylopectin and amylose between mocaf and wheat flour [18].

Ash content in cheese stick snacks based on difference flour ratio showed that significantly different (p < 0.05). Ash content indicates anorganic component or mineral content in the food product [19]. Cheese stick based on 100% wheat flour rich in mineral content than 100% mocaf flour. This might be probably due to cassava fermentation process in mocaf flour production. Minerals source in cassava used by microorganism for growth cell and electron acceptor in bioenergy reaction [20].

The higher protein content in cheese stick snack was shown by 100% wheat flour. Protein in the wheat flour has a complex structure, called by the gluten complex. Gluten proteins in wheat flour give dough its viscoelastic property necessary in baking process [6,21,22]. The result implies that the increasing level of mocaf flour substitution has a tendency of decreasing the protein content (p < 0.05).

Fat content changed not significantly in cheese stick snacks based on 100% wheat flour, flour blends (mocaf/wheat flour) 25/75 and 50/50. The increase of fat content by increasing the mocaf flour ratio 75/25 (p < 0.05) and the highest fat content in cheese stick snack was shown by 100% mocaf flour (36.37%). Carbohydrate of cheese stick snacks was decreased significantly (p < 0.05) in flour blends (mocaf/wheat flour) ratio of 50/50, 75/25 and 100/0 respectively. The decrease in carbohydrate and increase in fat content with mocaf flour substitution may be due to carbon and nitrogen source in carbohydrate during cassava fermentation process used by microorganism for its growth and to be converted into fatty acid [23].
3.3. Hardness and color of cheese stick snacks

The color of the food product appears from variety and raw material composition then some processing i.e. mixing and frying. In market place consumers usually have a tendency to choose product with natural color and non-synthesis color ingredient of the food product. In the present work, the color of cheese stick snacks referred to cheese stick based on 100% wheat flour (Lightness= 63.09). In mocaf flour substitution, the lightness level ranged from 62.84 to 68.44. The lightness of cheese stick snacks based on 100% wheat flour and mocaf flour 75% were not significantly different. The total color difference of cheese stick snacks significantly decreased (p < 0.05) with mocaf flour substitution ratio of 25/75 and 50/50 and increased on 100/0. Non-significant variation in mocaf-wheat flour blend snacks of 50/50;75/25 and 50/50; 100/0. During the frying process has occurred water and cooking oil mass transfer due to difference of concentration between water and cooking oil in surface and inside area of dough. The reaction between sugars and amino acids caused the primary color in cheese stick products [13].

The hardness of cheese stick snacks based on 100% wheat flour (control) and 100% mocaf flour were 5.82 and 4.62 N respectively and non-significantly different (p < 0.05). The effects of mocaf flour substitution ratio to the hardness of cheese stick snacks were changed significantly on 50/50 and 75/25 towards 100% wheat flour. This can be explained by the water binding capacities of starch in mocaf flour [24]. Moreover the fermentation cassava in mocaf flour production was also affected to the stabilizing of amorphous regions in starch granule and leads to the product texture. However wheat flour has a higher gluten complex that influence the hardness of cheese stick snack.

Figure 1. Micrographs of mocaf flour

Table 1. Chemical properties of cheese stick snacks

| Mocaf/wheat flour ratio | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate (%) |
|-------------------------|--------------|---------|-------------|---------|------------------|
| 0/100                   | 4.30±0.06c   | 3.72±0.04a | 9.99±0.63a  | 25.19±0.53c | 56.79±0.60a     |
| 25/75                   | 5.42±0.13a   | 2.88±0.03b | 8.08±0.39b  | 26.78±1.77c | 56.85±1.48a     |
| 50/50                   | 5.39±0.28a   | 3.34±0.01c | 6.93±0.17c  | 26.72±0.38c | 57.61±0.65a     |
| 75/25                   | 4.28±0.13c   | 3.11±0.13d | 4.99±0.12d  | 32.94±0.31b | 54.67±0.36b     |
| 100/0                   | 4.74±0.04b   | 3.49±0.06b | 4.07±0.12e  | 36.37±0.09a | 51.33±0.08c     |

Values are expressed as mean ± standard deviation. Means in the same column with different letters were significantly different at p < 0.05
Table 2. Color and hardness of cheese stick snacks

| Mocaf/wheat flour ratio | L*      | a*      | b*      | ΔE      | Hardness (N) |
|------------------------|---------|---------|---------|---------|-------------|
| 0/100                  | 63.09±0.42d | 8.73±0.13a | 27.95±0.20a | -       | 5.82±0.78a  |
| 25/75                  | 68.44±0.45a | 6.60±0.29c | 25.07±0.37cd | 6.44±0.64a | 5.49±0.90b  |
| 50/50                  | 65.33±0.33b | 7.50±0.13b | 25.83±0.15b | 3.34±0.19bc | 4.26±0.30bc |
| 75/25                  | 62.84±0.17d | 7.45±0.15bc | 25.46±0.19bc | 2.82±0.24bc | 3.95±0.79bc |
| 100/0                  | 63.95±0.45c | 7.26±0.06bc | 24.79±0.30d | 3.61±0.29b  | 4.62±0.14abc|

Values are expressed as mean ± standard deviation. Means in the same column with different letters were significantly different at p < 0.05

3.4. Sensory evaluation and consumer acceptance

The result to sensory evaluation of color, texture and flavor of cheese stick snacks are shown in Table 3. Sensory evaluation was conducted by 30 untrained panelists to cheese stick based on different flour. Texture and flavor showed non-significant variation among the different ratio of mocaf-wheat flour blend snacks. The ratio of mocaf flour level showed increasing trend of color value of cheese stick snacks. Significant difference was observed in overall acceptability of cheese stick snacks based on flour blends 25/75 and 0/100, 75/25 with the highest sensory value in mocaf flour level of 25% and 100%. According to sensory value, cheese stick snacks based on 100% mocaf flour were selected to observe consumer acceptance in market.

The 100 visitor in Yogyakarta Education Park consists of female 70% and male 30% with age variation were 1-25 years = 33%; 26 - 50 years = 62%, and 51 – 75 years = 5%. The education level was junior high school to Phd and other. While jobs i.e. students, college, entrepreneur, housewife, teachers, soldiers, dealer, private employees, lectures, civil servants and farmers. Visitor knowing about mocaf flour products about 43% and 57% did not know. The result implies that food products based on mocaf flour do not popular yet in Indonesian community. In United Kingdom, for example, people became more aware of celiac diseases so they will demand healthier eating alternatives that gluten free food. Gluten Free Foods Ltd. was established in 1970 to meet the needs of this demand and introduced gluten free bakery with products such as biscuits, cookies, pasta and wafer bars [25]. The trend market of healthy snacks is predicted rapid growth and there is potential market for processing snacks based on mocaf flour. Figure 2 indicated that the flavor (43%) and packaging (22%) were the primary factors for consumer to purchase a food product. Figure 3 showed that a good response from consumer sensory perception of cheese stick snacks based on 100% mocaf flour.

Consumers sensory perception i.e. flavor (taste and aroma), color and texture of food attributes plays a vital role in food preference whereas design, graphics, color and material of food packaging influence to consumer purchase decision [26,27]. The principal roles of food packaging are to protect food products from outside influenced, damage and to provide consumer with ingredient and nutritional information [28]. Products quality and unique packaging of cheese stick snacks based on mocaf flour should be a concern for commercialization scale. The introduction of snacks based on mocaf flour would contribute the diversity of functional food products if the product fortified with micronutrient for enhance of physiological function.
Table 3. Sensory evaluation of cheese stick snacks

| Mocaf/wheat flour ratio | Color       | Texture     | Flavor      | Overall acceptability |
|-------------------------|-------------|-------------|-------------|-----------------------|
| 0/100                   | 4.17±1.21b  | 4.43±1.28a  | 4.73±1.26a  | 4.40±1.22b            |
| 25/75                   | 5.20±0.76a  | 5.00±1.02a  | 4.70±1.09a  | 5.05±0.86a            |
| 50/50                   | 4.80±0.96a  | 4.93±1.01a  | 4.73±0.98a  | 4.79±1.07ab           |
| 75/25                   | 4.23±1.28b  | 4.43±1.25a  | 4.40±1.07a  | 4.39±1.15b            |
| 100/0                   | 4.87±0.90a  | 4.87±0.82a  | 4.80±1.00a  | 4.84±1.07ab           |

Values are expressed as mean ± standard deviation. Means in the same column with different letters were significantly different at p < 0.05

Figure 2. Consumers preference factors to a food product
Figure 3. Consumer acceptance to gluten-free snacks “cheese stick” based on 100% mocaf flour

4. Conclusion
In this study, mocaf flour is the substitution of wheat flour to produce gluten free snack cheese stick. Chemical properties of cheese stick showed the significant variation due to the fermentation process in mocaf flour whilst gluten complex in wheat flour. The color and hardness of cheese stick based on mocaf and wheat flour have the same qualities. In the sensory evaluation, texture and flavor showed non-significant variation among the different ratio of mocaf-wheat flour blend snacks. The highest sensory value of cheese stick snacks was mocaf flour level of 25% and 100% in overall acceptability. The consumer acceptance evaluation indicated that the flavor and packaging were the primary factors for consumer to purchase a food product. Cheese stick snacks based on 100% mocaf flour showed a good response from consumer sensory perception.

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