Physical Characteristics of *Coleus tuberosus* Flour and Noodle in Various Arenga Starch Substitution

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**Abstract.** *Coleus tuberosus* is one of local commodities in Indonesia which contains high carbohydrate. However, its utilization does not maximally. Therefore, *C. tuberosus* made into flour by grater method, and then used for noodle making with arenga strach as substituting material. The aim of this study was to determine the effect of *C. tuberosus* flour substitution in noodle preparation from arenga starch on its textural and sensory properties. In this study, noodle was made in some variations which were 100% arenga starch; 75% arenga starch:25% *C. tuberosus* flour; 50% arenga starch:50% *C. tuberosus* flour and 100% *C. tuberosus* flour. Characterization of noodle were investigated including water content, strength, tensile strength, strain at break and stickiness. Sensory evaluation was conducted to analyse consumers acceptance. Noodle was compared with two commercial products. The result showed that arenga starch substitution in *C. tuberosus* noodle affect textural properties of noodle. The higher concentration of *C. tuberosus* flour caused tensile strength and strain at break getting low. The water content and stickiness were increased as the *C. tuberosus* flour substitution ratio increase. None of the noodle resulted from *C. tuberosus* flour and arenga starch mixture was exactly as same as maize and rice commercial noodles. However 25% of *C. tuberosus* noodle has better characteristics than other *C. tuberosus* noodles.

1. Introduction

Diversification of staple food consumption is not intended to replace rice in total but changing people’s food consumption patterns so that people will consume a wider variety of food and get better nutrition. Various tubers have a prospect for development as a rice substitute and processed into prestigious food.

*Colesus tuberosus* is one of carbohydrate sources which potential as wheat or rice substitute. In taxonomy, this tuber is classified in family Lamiaceae. High content of flavonoid and phenolic in this tuber, makes it potential as a food with functional properties. Nugrahani et al [10] mentioned that *C. tuberosus* had component which potential as antioxidant and anticancer. High potential of carbohydrate content and functional properties in *C. tuberosus* was not used yet as a processed food.

High carbohydrate content in *C. tuberosus* was not used as a processed food. High content of flavonoids and phenolic in this tuber, makes it potential as a food with functional properties. While the raw material for noodle production were still imported. Utilization *Colesus tuberosus* as a noodles was expected could increase economic and benefit value of this tuber.

Noodle is one of very popular food in Indonesia, because its taste and practical in preparation. According to BPS [2], noodle consumption in Indonesia reached 80 grams/capita/week both in rural and urban areas. Indonesia is the 2nd largest noodle consuming country in the world after China. While raw
material for noodle production were still imported. Utilization *C. tuberosus* as a noodles was expected could increase economic and benefit value of this tuber. The aim of this study were to determine characteristic of *C. tuberosus* flour and to determine effect of arenga starch substitution on textural characteristic of *C. tuberosus* noodle.

2. Experimental

2.1. Material

*C. tuberosus* tubers obtained from Mertelu Village, Gedangsari, Gunungkidul, Yogyakarta. *C. tuberosus* was made into flour by peeling the skin, slicing the tuber, drying and then milling. Arenga starch was bought from home industry at Klaten, Central Java.

2.2. Swelling Power and Solubility of *C. tuberosus* flour

Swelling power and solubility of *C. tuberosus* flour were conducted according to Adebowale, *et al* [1]. *C. tuberosus* flour (1 gram) was added into 50 ml of distilled water and stirred until homogeneous. Then the slurry was inserted into a centrifuge tube, and heated to temperature of 60, 70, 80 or 90°C for 30 minutes in the water bath. The samples were cooled to room temperature and centrifuged at ± 3000 rpm for 15 minutes. Supernatant was dried until obtain constant weight (W2). The pellet was moved into a bottle and was weighed (N1), then the pellet was dried to obtain a constant weight (N2).

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\text{Solubility} \ (\%) = \frac{W2 \ (g)}{W1 \ (g)} \times 100\% \quad (1)
\]

\[
\text{Swelling power} \ (g/g) = \frac{N1 \ (g)}{N2 \ (g)} \quad (2)
\]

2.3. Noodle making

Noodle-making was done by modifying the noodle-making method on a large scale according Haryadi [5]. Five variations flour mixture i.e. 100% arenga starch; 25% *C. tuberosus* flour:75% arenga starch; 50% *C. tuberosus* flour:50% arenga starch; 75% *C. tuberosus* flour:25% arenga starch; and 100% *C. tuberosus* flour made into dough by adding water to flour with ratio mixture flour and water was 1:0.5. Dough was molded into pellets using Food Extruder PD-45N, La. Pramigianaa 15 mm diameter mold. Pellets steamed for 4 minutes to gelatinize starch. Gelatinization occurs only on the surface of pellet so that it can serve as an adhesive when it was made as noodle. Pellets then molded into noodle with diameter 0.7 mm and obtained raw noodle strands. Raw noodle steamed in a steamer for ±20 minutes. Noodle then dried in the cabinet dryer at 60°C for 6 hours until water level was ± 10%.

2.4. Tensile strength and strain at break of noodle

Tensile strength and strain at break was done according to Chen *et al* [4]. Noodle samples that have been cooked in the optimum cooking time is clamped in the universal testing machine tools, then pulled with 5 kg force speed 1.00 mm/sec to drop. Maximum force at the time of breaking noodle expressed as tensile strength, while the strain at break compared beginning noodle expressed as strain at break percent.

2.5. Stickiness of noodle

Noodle stickiness determined according to Chen *et al*. [4] by taping two strands of noodle that has been cooked and removed from water, then pulled to separate them each other using universal testing machine. Measurements were made with speed 1.00 mm/sec and 5 kg load.

2.6. F break of dry noodle

The strength of dry noodle (F break) was conducted according to Suryani [13]. Dry noodle was cut into 1 cm length, then placed and clamped on measurement table Lloyd Instrument in perpendicular position to the discounter. The sample was then pressed with a cylindrical probe (diameter 3.5 cm) with a speed of 1 mm/second using 10kg heavy load until the sample broke. Maximum force when dry noodle fracture was calculated as strong fracture of dry noodle.
3. Results and Discussion
3.1. Swelling power and Solubility
The results of swelling power and solubility analysis of *C. tuberosus* flour can be seen in table 1. From these results it can be seen that the swelling power and solubility increase as the temperature increase. The starch granules will continue expand at temperature above the gelatination temperature of flour [12]. The solubility of starch are also influenced by the presence of amylose-lipid complexes. Amylose-lipid complexes are insoluble in water and require a higher temperature to dissociate the compound [12]. Swollen starch granules will become increasingly vulnerable to shear forces resulting in disintegration and will release the material dissolved when the starch granules were destroyed [12].

| Temperature (°C) | Swelling power (g/g) | Solubility (%) |
|------------------|---------------------|---------------|
| 60               | 4.83\(^c\)           | 6.67\(^a\)    |
| 70               | 5.35\(^c\)           | 7.57\(^ab\)   |
| 80               | 8.60\(^b\)           | 8.54\(^b\)    |
| 90               | 13.62\(^c\)          | 10.44\(^c\)   |

The values with different superscripts within a column are significantly different (p < 0.05) by Duncan’s multiple range test.

Swelling power and solubility is influenced by the amylose content in starch. The higher amylose content, the lower the swelling power. This is caused by molecules of linear amylose thus reinforcing its internal network [7]. Swelling power of starch is highly dependent on the strength of inter and intra-molecular starch granules. According to Leach [7], that binding is influenced by various factors including: comparison of amylose and amylopectin, amylose and amylopectin molecular weight, molecular weight distribution, degree of branching, and the length of the outer branches of amylopectin molecules that may play a role in bindings. When the granules swell, the amylose molecules will separate from the network and leach into the liquid [7]. Swelling power and solubility is proportional until the equilibrium is reached. Equilibrium is reached when the concentration of soluble starch and expanded starch granules had a same amount [7].

From statistical analysis of data with p <0.05%, solubility *C. tuberosus* flour at 60°C and 70°C were not significantly different. At a temperature 60-70°C starch granules still not absorb water quickly. When starch is heated at temperature 80-90°C, the starch getting closer to gelatinization temperature so the solubility increase rapidly and demonstrated significantly different results. Similar results were shown for the swelling power, at 60°C and 70°C did not differ significantly and at temperature 80°C and 90°C has significantly different swelling power.

3.2. Textural characteristics of noodle
Tensile strength is one of the physical properties of noodle which shows maximum force required to break the noodle. Strain at break shows the change in length of noodle acquiring the maximum tensile force to break up compared to the initial length. The higher tensile strength and strain at break will have better noodle quality, and it is expected by the consumer.

Noodle strength is influenced by the amylose content of flour used [3]. Granular structure and noodle will be more compact because of the increased bonding between amylose molecules that form crystalline clusters [9]. Tensile strength is directly proportional to strain at break, it could be due to more compact nozzle, then noodle will be more easy to pull and more difficult to break at withdrawal. Statistical analysis was done with p <0.05% showed that tensile strength were significantly different for all samples noodle. Arenga starch and *C. tuberosus* mixing will give real effect to noodle tensile strength. Samples 100% *C. tuberosus* flour has a tensile strength that is not significantly different from the commercial product B, and samples with *C. tuberosus* 25% are not significantly different from the commercial product A. Noodle made with *C. tuberosus* ratio of 0% in the flour mixture has strain at
break which is not significantly different from the commercial product A and product B, tensile strength value of *C. tuberosus* noodle was lower than that of from rice noodle [14]. Higher concentration of *C. tuberosus* flour in flour mixture, will make lower amylose content of flour mixture. The bond between amylose molecules causing declining compactness of noodle granular. The force required to break the noodle will be smaller due to increased concentration of *C. tuberosus* flour. Compare to noodle from rice noodle [15], strain at break of *C. tuberosus* flour was much higher than rice noodle.

F break of noodle illustrates the strength of mechanical treatment (shock) during distribution/storage which caused the destruction of dried noodle/before cooking. The greater force needed to break the noodle, the more powerful of resulting noodle. Noodle is expected to have a strong value for fracture (N) which is great because it is not easily broken. Table 2 displays test results noodle textural properties.

**Table 2. Textural characteristics of noodle**

| Noodle                  | Tensile strength (N) | Strain at break (%) | F break (N) | Stickiness (N) |
|-------------------------|----------------------|---------------------|-------------|---------------|
| (C.tuberosus flour : arenga starch) | 0% : 100%            | 0.19<sup>c</sup>   | 54.39<sup>c</sup> | 3.67<sup>d</sup> | 0.01<sup>ab</sup> |
|                         | 25% : 75%            | 0.12<sup>d</sup>   | 46.36<sup>bc</sup> | 3.19<sup>f</sup> | 0.01<sup>b</sup> |
|                         | 50% : 50%            | 0.10<sup>e</sup>   | 35.43<sup>abc</sup> | 2.50<sup>e</sup> | 0.02<sup>c</sup> |
|                         | 75% : 25%            | 0.08<sup>b</sup>   | 20.07<sup>ab</sup> | 2.16<sup>d</sup> | 0.04<sup>d</sup> |
|                         | 100% : 0%            | 0.06<sup>c</sup>   | 15.38<sup>bc</sup> | 1.79<sup>e</sup> | 0.05<sup>c</sup> |
| Maize commercial        | 0.03<sup>d</sup>     | 20.50<sup>f</sup>  | 1.08<sup>b</sup>  | 0.01<sup>a</sup> |
| Rice commercial         | 0.05<sup>a</sup>     | 59.52<sup>c</sup>  | 0.79<sup>c</sup>  | 0.01<sup>b</sup> |

The values with different superscripts within a column are significantly different (p < 0.05) by Duncan’s multiple range test.

Strength of dry noodle influenced by bonds between molecules in the starch granules. Suryani [13] states that the higher the number of levels of high amylose starch in the flour mixture, the more crosslinking on the starch granules so that the bonds between the starch molecules stronger so it is not easily broken. High amylose content which causes retrogradation perfect so that the structure of the resulting instant starch noodle tougher, stronger, and compact [11]. Noodle made from materials that yield high amylose, has a tensile strength, and strong texture / compact [8]. Good quality of noodle should have high value of tensile strength, strain at break and F break. In the other hand, stickiness value of noodle should be lower.

Excessive starch leaching (high cooking loss) will make the noodle surface becomes sticky. Noodle sticky surface will be positively correlated to its solubility. When noodle has high adhesiveness, it will make noodle strands become stuck together and difficult to be separated and it is inevitable happened because it is not preferred by consumers. Noodle made from starches with low amylose content such as sweet potato starch, potato starch and cassava starch very easy to stick and be difficult to separate between noodle strands with one another during the drying process [4].

From table 2, it can be seen that stickiness of noodle increased along with the increase of *C. tuberosus* flour. From statistical analysis with p <0.05%, noodle with 100% arenga starch has a stickiness that is not significantly different from commercial products A and B, while made with C. *tuberosus* concentration of 25% was not significantly different from the product B. For other commercial samples have values significantly different adhesiveness. Black potato starch mixed with starch sugar will affect the stickiness of noodle. Black potato starch has sticky properties for mengdanung banyk amyllopectin. Starch sugar which has a high amylose content will make noodle produced has a low adhesiveness. Amylose can increase the bond strength between molecules capable of forming crystalline clusters so as to prevent the occurrence of amylose leaching and decrease the stickiness [6].

4. Conclusion

The higher concentration of *Coleus tuberosus* flour caused F break, tensile strength and strain at break getting low. The water content and stickiness were increased as the *Coleus tuberosus* flour substitution
ratio increase. Noodle from 25% *C.tuberosus* flour and 75% arenga starch has better characteristic than other *C.tuberosus* noodles.

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