Quality assessment of dry noodles made from blend of mocaf flour, rice flour and corn flour

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Abstract. Mocaf flour, rice flour, and corn flour in different concentrations were used to produce dry noodles. The aims of this study were to investigate physicochemical properties of the flours and the quality characteristics of dry noodles made from these flours. Dry noodles were prepared by gelatinization of blending flours followed by feeding the dough to extruder and drying overnight in room temperature. Flours were analyzed for chemical and pasting properties and noodle samples were evaluated for chemical, cooking, and texture properties. The results showed there were significant differences in protein content and elongation between noodles made from blending mocaf and rice flour with that of blending mocaf, rice, and corn flour. The moisture, ash, and protein content of noodle samples ranged from 10.98 to 14.18%, 1.23 to 1.39%, and 4.09 to 5.58%, respectively. Values of noodle cooking quality were ranging from 12.0 – 13.8 minutes, 10.6 to 14.3%, and 204 to 248%, respectively for cooking time, cooking loss, and cooking weight. The elongation, hardness, and adhesiveness of noodles ranged from 276 to 374%, 3,523 to 10,478 gf, and -81.99 to -52.49 g.sec.

1. Introduction

The primary source of carbohydrate in Indonesia now leads in rice and flour-based foods including noodle. It needs to be aware because most of the types of noodle are made of wheat flour. Indonesia is not wheat-producing country, so that the direction of these changes can lead to dependence on imported food that endangers national food. Dependence of food against another country can affect the susceptibility to foreign intervention in economic and political [1]. In order to reduce imports of wheat flour, a lot of efforts have been made to find a replacement. Besides that, there are recently growing consumer demands for gluten-free products in the food industry including noodles [2]. One source of carbohydrates that can replace wheat flour is cassava starch, rice flour, corn starch, and buck wheat flour [3].

Rice, cassava and corn are three types of crops with the highest production number in Indonesia. In 2015, rice, cassava, and corn production was 75,397,841 tons, 21,801,415 tons, and 19,612,435 tons respectively [4]. Many Indonesian cuisines use rice flour as an ingredient. The physical and chemical attributes of food during processing are affected the physicochemical properties of rice. Mocaf is a product derived from cassava that uses the principle of modifying cassava cells in fermentation. Advantage mocaf has aroma and flavor better than regular cassava flour, white has more color than usual cassava flour [1]. Corn as raw material of noodles has advantages such as having a natural yellow color produced by β-carotene, lutein, and zeaxanthin [5].

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The heating processing for pre-gelatinization is critical step for maintaining noodle strands because gluten-free flour is not able to form a cohesive dough structure [2]. Generally, there are two different ways to produce gluten-free noodles [6]. The first gluten-free flour is mixed with water, then the dough is extruded through a die and the extruded strands are dropped into hot water. The other way is that gluten-free flour batter is prepared, coated onto a rotating heated drum, transferred into a steaming tunnel, and then dried before cutting.

Exploration of non-wheat carbohydrate source for the manufacture of noodles has been done, ranging from the partial substitution up to full substitution without using wheat flour. Yadaf, et al. [7] have substituted wheat flour by 25 percent of sweet potato, colocasia and water chestnut flours to manufacture noodles. Wandee, et al. [8] reported the substitution of rice flour with canna cross-linked starch has improved the tensile strength and elongation of noodles. Meanwhile, a composite of corn flour and cassava flour has been done by Pato et al. [5] and showed that on ratio of 55% cassava flour and 45% corn flour resulted in instant noodle which met the Indonesian quality standard of Instant Noodle (SNI 01-3551-2000) except for protein content of less than 4%. The addition of selected tropical starches such as mung bean starch, canna starch and sweet potato starch to rice flour had significantly modified cooking quality and texture properties of noodles [9]. The physicochemical properties of starch have an essential role in both starch noodle processing and the final starch noodle quality [10].

However, very little information is available on the blending of mocaf, rice, and corn flours for noodle production. Our study was meant to investigate the chemical and pasting properties of mocaf, rice, and corn flours. The applicability their blends in relation to their dry noodle preparation was also examined by chemical, textural, and cooking analysis.

2. Materials and Methods

2.1. Raw materials
Commercial mocaf flour was purchased from small medium enterprise “Harapan Jaya” Subang Regency, Indonesia. The corn flour and rice flour was produced in Food Laboratory, Development Center for Appropriate Technology. Rice and corn seed were collected from local market in Subang, Indonesia. The corn seed was crushed using the chopper machine, and then the corn husk was separated by floating process. The rice corn (grits) soaked in water for 4 hours, dried until moisture content less than 10% (wb), then refined using a disc mill. Rice was soaked in water for 2 hours and drained well. Fine milled to make flour using disc mill machine, and dried flour rice till moisture content less than 10% (wb). All of flour was sifted using a sieve size of 40 meshes.

2.2. Dried noodle preparation
Noodles were produced by mixing 1 kg of blending flour appropiated with treatment and additional ingredients salt (1%) and water (40%) based on flour. Mix all of materials lasted 15 minutes using commercial laboratory mixer and steamed for 30 minutes. The resulting dough was fed in the small scale single-screw extruder (constructed by Development Center for Appropriate Technology) at temperature setting of 60 °C and speed 50 rpm. Noodles strand was dried overnight in room temperature. The treatment of blending flour as follows:
MR1 = 50% the mocaf flour and 50% rice flour
MR2 = 60% the mocaf flour and 40% rice flour
MR3 = 70% the mocaf flour and 30% rice flour
MRC1 = 40% the mocaf flour, 30% rice flour, and 30% corn flour
MRC2 = 50% the mocaf flour, 30% rice flour, and 20% corn flour
MRC3 = 60% the mocaf flour, 30% rice flour, and 10% corn flour

2.3. Analyses of noodles
Noodle samples were analyzed for chemical, cooking, and texture properties.
2.3.1. Chemical analysis. The procedures for analysis of moisture and ash content are as outlined by the Indonesian National Standard (SNI 01-2891-1992) about analytical methods for food and beverages. Protein content was measured according to the Dumas combustion method by using DuMaster Buchi D-480, Switzerland.

2.3.2. Pasting Analysis. The pasting properties of flours were evaluated using a Rapid Visco Analyzer (RVA-TecMaster, Macquarie Park, Australia). Mocaf, rice, and corn flours were analyzed following the procedure of RVA™ General Pasting Method STD2. Flour samples, weighing 3.5 g (14% moisture content), were mixed with 25 g of distilled water in disposable aluminum RVA canisters. The sample was spunned (160 rpm) at 50°C for 1 min, heated to reach 95°C in 7.5 min, and then held at 95°C for 5 min. Afterwards, it was cooled back to 50°C in 7.5 min, and then held at 50°C for 2 min.

2.3.3. Cooking quality analysis. Cooking time, cooking weight, and cooking loss of dry noodles was measured according to the method reported by Wandee et al. [8]. Dried noodles (about 5 g) were cut into lengths of 4-5 cm and cooked in 200 ml boiling distilled water in a covered beaker. The optimum cooking time was evaluated by observing the time of disapperance of white core of the noodle strands every 30 second, by pressing the cooked noodle between two transparent glass slides. Dry noodles (about 1 g) were cut into small pieces lengths of 3–5 cm, and boiled in 30 ml water boiling water until completely cooked according result of cookint time test. The cooked noodles were then placed on a nylon screen, rinsed with distilled water, drained for 1 min. The wet noodle immediately was weighed as cooking weight. The cooking water and rinse water in a pre-weighed glass was evaporated and dried in a hot-air oven at 105 °C to a constant weight. Cooking weight of noodles was expressed as the percentage of g cooked noodle/g dried noodle, while cooking loss was expressed as the percentage of dry matter loss during cooking to dry sample weight. Cooking weight and cooking loss were calculated by equation (1) and (2).

\[
\text{Cooking weight (\%)} = \frac{W_1 - W_2 \times (1 - M)}{W_2 \times (1 - M)} \times 100\% \quad (1)
\]

\[
\text{Cooking loss (\%)} = \frac{W_3}{W_2 \times (1 - M)} \times 100\% \quad (2)
\]

Where, \(W_1\) is the weight of noodles after cooking (g); \(W_2\) is the weight of noodles before cooking (g); \(W_3\) is the weight of dry matter (g) and \(M\) is the moisture content of noodles before cooking (%).

2.3.4. Textural Profile Analysis. Textural profile of noodles was expressed as elongation, hardness and adhesiveness and measured using a texture analyzer (TAXT-Plus, Stable Micro Systems, Surrey, UK). Strip of noodles was cooked appropriate to time cooking test, drained for about 2 minutes at room temperature. Analysis of noodle texture followed Stable Micro System guidelines and [11] with some modification. Elongation of cooked noodles was measured by using spaghetti tensile grips (A/SPR) rig at pre-test speed of 1 mm/s, test speed of 3 mm/s, post-test speed of 10 mm/s, and initial distance between clamps of 2 cm. Hardness and adhesiveness of cooked noodles was examined by placing a set of noodle strands on the flat metal plate under the probe. Test was done by using a cylinder P/36R probe at mode; trigger type, auto 0.5 g; pre-test speed 2 mm/s, test speed 2 mm/s; post-test speed 10 mm/s, and strain of 60%. Five replicates of cooked noodles at each level of treatment were determined.

2.3.5. Statistical analysis. Variance analysis of data of each treatments was carried out on a statistical package SPSS. The significant difference among mean values was analyses using one-way analysis of variance (ANOVA) followed by Duncan’s test at a significance level of (P < 0.05).
3. Result and Discussion

Mocaf, rice, and corn flour contain no gluten, the quality of noodles made from blending these flours depend solely on the physicochemical properties of their starch. Table 1 presented the chemical and pasting properties of these flours.

Table 1. Chemical and pasting properties of mocaf, rice, and corn flour

| Parameter                  | Mocaf flour | Rice flour | Corn flour |
|----------------------------|-------------|------------|------------|
| Moisture content, %        | 10.62       | 5.05       | 6.05       |
| Ash content, %             | 1.29        | 0.27       | 0.48       |
| Protein content, %         | 1.77        | 10.07      | 7.07       |
| Amylose content, %         | 27.83       | 26.61      | 27.98      |
| Amylopectin content, %     | 36.04       | 40.33      | 32.92      |
| Peak Viscosity, cP         | 4,755       | 4,510      | 1,999      |
| Hot Paste Viscosity, cP    | 2,775       | 1,835      | 1,770      |
| Breakdown Viscosity, cP    | 1,976       | 2,675      | 229        |
| Final Viscosity, cP        | 3,346       | 3,193      | 4,034      |
| Pasting Temperature, °C    | 69.5        | 79.7       | 79.7       |

The flours used in this study were enough dry with moisture content below 11%. Ash content of mocaf flour was higher than rice and corn flour, but the lowest in protein content. Amylose content is an important factor that will affect noodle quality. Corn flour had the higher amyllose content than rice and mocaf flour. Table 1 showed that peak viscosity (PV) and hot paste viscosity (HPV) of mocaf flour was highest, following by rice flour and corn flour. The high PV indicates the ability of starch to swell freely before their physical breakdown [12]. HPV gives an indication of the ability of starch to withstand heating and shear stress. The measure of the susceptibility of cooked starch granules for disintegration can be assessed from breakdown viscosity value. Final viscosity (FV) shows the ability of the material to form a viscous paste or gel after cooking and cooling. The tendency of starch retrogradation can be predicted by using setback viscosity value. Corn flour had the highest final viscosity and setback viscosity value, indicating that the starch was easier to retrograde. Mocaf flour had a lower pasting temperature than corn flour and rice flour. Amylose contents, lipids contents and by branch chain-length distribution of amylopectin may attribute to pasting properties of starch [13].

The moisture content, ash content, and protein content of dry noodles made from mocaf, rice, and corn flour are presented in Table 2.

Table 2. Chemical analysis of dry noodles made from mocaf, rice, and corn flour

| Treatments | Moisture, % | Ash, % | Protein, % |
|------------|-------------|--------|------------|
| MR1        | 14.18 \textsuperscript{a} | 1.23 \textsuperscript{a} | 5.55 \textsuperscript{a} |
| MR2        | 10.98 \textsuperscript{b} | 1.24 \textsuperscript{a} | 4.89 \textsuperscript{b} |
| MR3        | 13.65 \textsuperscript{c} | 1.39 \textsuperscript{b} | 4.09 \textsuperscript{c} |
| MRC1       | 13.13 \textsuperscript{c} | 1.29 \textsuperscript{ac} | 5.58 \textsuperscript{a} |
| MRC2       | 13.33 \textsuperscript{ac} | 1.25 \textsuperscript{a} | 5.09 \textsuperscript{d} |
| MRC3       | 13.74 \textsuperscript{ac} | 1.33 \textsuperscript{e} | 4.52 \textsuperscript{e} |
The increasing moisture content of products will result in a reducing their shelf life, hence proper drying of the noodles will be required [14]. The moisture content of noodle samples ranged from 10.98% to 14.18%, and were not significantly different (p>0.05), except the sample MR2 with 60% of mocaf flour and 40% rice flour was significantly different (P<0.05) from other samples. The final moisture content of dried noodles is usually less than 14% [6].

The ash content of dry noodles ranged from 1.23 to 1.39%. There were no significant difference (p>0.05) between all samples except for samples MR3 (contained 70% mocaf flour and 30% rice flour) and MRC3 (contained 60% mocaf flour, 30% rice flour, and 10% corn flour). Compositional differences of the flour blends resulted in the differences of noodle ash content. The ash content of noodles increased with addition of mocaf flour. In this study, the ash content of mocaf flour, corn flour, and rice flour were 1.29%, 0.48%, and 0.27% respectively.

The results showed the protein content of noodles ranged from 4.09% to 5.58% with samples MR1 and MRC3 having the highest and lowest values respectively. Samples MR1 and MRC1 were not significantly different (p>0.05), but differed significantly (p<0.05) from other samples. The addition of mocaf flour decreased the protein content of noodles. The low protein content of noodles was as a result of the low protein content of mocaf flour for 1.77%, whereas corn flour and rice flour had protein content of 7.07% and 10.07% respectively. Pato et.al [5] showed that protein content of instant noodles decreased when addition of tapioca flour increased and corn flour decreased.

The cooking test can be influenced by the nature and quality of raw materials, the shape of the final product, the processing system, drying and the cooking system itself [15]. Figure 1 – 3 presented cooking tests which included cooking time, cooking loss, and cooking weight of dry noodles made from mocaf, rice, and corn flour.

**Figure 1.** Cooking time of dry noodles made from mocaf, rice, and corn flour

The cooking time of the different samples ranged from 12.0 – 13.8 minutes, with samples MR3 (70% mocaf flour, 30% rice flour) and MRC1 (40% mocaf flour, 30% rice flour, and 30% corn flour) having the lowest and highest values, respectively. The results showed that there were significant differences (p<0.05) in the cooking time between sample MR3 and MRC1, but not were significant differences from the other samples. The difference in cooking time of noodles obtained in this work may indeed be due to difference in their gelatinization properties. The low pasting temperature can decrease cooking time of noodles [16]. Table 1 showed that mocaf flour had the lowest pasting temperature, followed by rice flour and corn flour. Therefore the pasting temperature of flour mixtures
was increased, as the ratio of mocaf flour in the blending flour decreased. Furthermore amylose-lipids complex in corn flour might have delayed the swelling of individual granules within the noodle causing delay in cooking [16]. Omeire et al. [17] studied noodle made with 80% of wheat flour, 10% of cassava flour, 10% of defatted flour, and reported the cooking time of the noodle samples ranging from 10 to 16 minutes. Cooking time of noodles prepared from blending of rice flour with canna starch, mung bean starch, and sweet potato starch ranging from 7.2 to 9.2 minute [9].

![Cooking loss of dry noodles made from mocaf, rice, and corn flour](image)

**Figure 2.** Cooking loss of dry noodles made from mocaf, rice, and corn flour

Cooking loss show the amount of solids (dry matter) which dissolve in water during cooking. The result in the cooking loss ranged from 10.6 to 14.3%. There were significant differences between sample MR2 with MRC1 and MRC3, but not were not significant differences from the other samples. Amylose content correlated negatively with cooking loss [12] and the higher peak viscosity, cooking loss of noodles tended to be higher [18]. Purwandari et al. [19] reported cooking loss of gluten-free noodle ranging from 11.20% to 27.38%. These noodles made from konjac flour, breadfruit and pumpkin flour with texturing agent fermented cassava flour or tapioca flour.

![Cooking weight of dry noodles made from mocaf, rice, and corn flour](image)

**Figure 3.** Cooking weight of dry noodles made from mocaf, rice, and corn flour

Cooking weight showed the weight gain of the noodles during the cooking and it is an indication of the amount of water was absorbed by noodles during cooking. Excess water absorption usually results soft and sticky noodles, but insufficient water absorption produces noodles with a coarse and hard texture [20]. The cooking weight of the noodle samples were ranging from 204% to 248%, and not
significantly different (p>0.05) among all samples. The high cooking weight would be related to the high starch and protein content of the noodle samples [14]. Starch content of rice, mocaf, and corn flour were 66.94%, 63.87%, and 60.90%, respectively. Qazi et al. [9] reported noodles made from pure rice flour, mung bean starch, canna starch, and sweet potato starch or blends of rice flour with one of this starch were ranged from 168.5 % to 188.9 %. Similarly with the results from [21, 9] that the variation in cooking weight of these samples might also be due to the differences in the swelling power and pasting properties of flour and starch used to made the noodles.

The texture properties (elongation, hardness, and adhesiveness) of dry noodles made from mocaf, rice, and corn flour are shown in Table 3.

| Treatments | Elongation (%) | Hardness (gf) | Adhesiveness (g.sec) |
|------------|---------------|--------------|----------------------|
| MR1        | 275.72<sup>a</sup> | 3,523<sup>a</sup> | -54.73<sup>ab</sup> |
| MR2        | 292.07<sup>a</sup> | 5,125<sup>ab</sup> | -52.49<sup>a</sup> |
| MR3        | 302.17<sup>ab</sup> | 5,953<sup>ab</sup> | -57.03<sup>ab</sup> |
| MRC1       | 374.20<sup>c</sup> | 10,478<sup>c</sup> | -55.85<sup>ab</sup> |
| MRC2       | 362.45<sup>c</sup> | 7,507<sup>b</sup> | -77.09<sup>ab</sup> |
| MRC3       | 335.79<sup>bc</sup> | 5,183<sup>ab</sup> | -81.99<sup>b</sup> |

Same capital letters indicate no significant differences among treatments (p > 0.05).

Elongation shows the distance to break the noodle strands. Elongation is the measure for extensibility and correlates well with tensile strength. The elongation of noodles ranged from 275% to 374%. There were significantly different (p<0.05) between noodle samples made from blending mocaf and rice flour (MR1, MR2, MR3) with noodle samples made from blending mocaf, rice, and corn flour (MRC1, MRC2, MRC3). The highest elongation found in sample MRC1 (noodle made from mocaf, rice, and corn flour of 40%, 30%, 30%, respectively). Noodles prepared from blending of mocaf flour 50% and rice flour 50% (MR1) required shortest time to break, which indicated the lowest extensibility. Increased elongation was found in noodles made from high amylose flours. The same results reported by [12] that the increase of amylose content of rice flour resulted noodles which more difficult to stretch and break. There was positive correlation between amylose content of rice flour with tensile strength and extensibility of noodles. Relative extension (elongation) of noodles prepared from blending of rice flour with canna starch, mung bean starch, and sweet potato starch ranging from 101% to 239% [9].

The hardness of noodles ranged from 3,523 gf to 10,478 gf with samples MRC1 (40% of mocaf flour, 30% rice flour, and 30% corn flour) and MR1 (50% of mocaf flour and 50% rice flour) having the highest and lowest values, respectively. High hardness of noodles may be attributed to the highest amylose content. Amylose of starch will bind to each other with a bonding matrix, will increase the hardness of noodles. Low gel hardness of starch may be attributed to lower amylose content of starch which caused less retrogradation of the starch during gel formation and consequently weaker gel structure [21].

Adhesiveness is a measure of the stickiness of the noodle. The high amylose in the mixed flour decreased the adhesiveness of noodles. The lower amylose content formed the weak gel structure, resulting in greater soluble solids and so higher adhesiveness. In addition, Retrogradation amylopectin required longer times than amylose and amylopectin crystals are less stable than amylose crystals [22]. The higher amylopectin content caused the noodle dough too sticky due to amylopectin was difficult to retrograde to maintain the noodle structure. Gluten-free noodle made from konjac flour, breadfruit
and pumpkin flour had hardness ranging 2,237 to 4,954 gf and adhesiveness ranging -158 to -1,097 g [19].

Assessing the best treatment used effective index method [23]. Parameters fixed in this calculation were chemical quality, cooking quality and texture quality. The result showed that combination 40% mocaf flour, 30% rice flour, and 30% corn flour (sample MRC1) had the first grade.

The advantages for consumers and also noodles industry if they consume or use three ingredients of mocaf, rice and corn flour are the availability of abundant raw materials at affordable prices, no addition of synthetic dyes due to the natural yellow color of corn flour, and noodles contain high dietary fiber. Noodles made from mung bean starch are preferred for its desired appearance and excellent texture because high amylose content. Canna noodles also have much better to extrusion noodles made from sweet potato. Pure sweet potato starch is generally considered inferior for the noodles production compared with other starches such as mung bean, canna, and corn starch but sweet potato starch plays a role in substitution for expensive those starches [3]. But the availability of mung bean and canna in Indonesia is not as abundant as cassava, rice or corn.

4. Conclusion

Physicochemical properties of flours, especially the amylose and protein content, associated with the quality of noodle produced. Noodles produced from blending mocaf, rice, and corn flour had protein content, cooking loss, elongation, and hardness higher than that of blending mocaf and rice flour. Protein content of noodle increased as decrease in percentage of mocaf flour in the noodle. Noodle made from 40% mocaf flour, 30% rice flour, and 30% corn flour had the best quality mainly in term protein content and texture properties, even though the cooking quality was less. This noodle had protein content, ash content, elongation, hardness, adhesiveness, cooking time, cooking loss, and cooking weight of 5.58%, 1.29%, 374.20%, 10,478 gf, -55.85 g.sec, 13.75 minutes, 14.28%, and 226.91%, respectively.

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