Nutritional content and organoleptic properties of bread made from modified cornflour

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Abstract. Corn flour can be used as a raw material for making bread as a substitute for wheat flour. Although it does not have sufficient gluten to develop bread, it has added value to bread by using modified cornflour. This study aims to determine the best formulation for processing modified cornflour into bread based on SNI and organoleptic. This research was conducted with a completely randomized design (CRD) with 3 replications. The treatment in this study was the substitution of wheat flour using modified cornflour with a concentration of 0% (control), 20%, 40%, and 60%. The results showed that the highest water and carbohydrate content was obtained from substitution with 20% modified cornflour, highest ash and fat content from 40% modified cornflour substitution, and the highest protein content was found in the control treatment or without modified cornflour substitution. Organoleptic testing showed no significant differences (p>0.05) in color and aroma of all treatments, while for texture, taste, and overall appearance, the highest score was obtained from control and substitution with 20% modified cornflour, where the score obtained for 20% substitution of modified cornflour was 3.63, 3.67, and 3.93 (like) respectively.

1. Introduction
Bread is a typical food that we can find every day and everywhere, even for some group of people, it becomes their breakfast and snack menu because it is more practical, cheaper, and prepared faster. The bread itself is a processed food made from wheat flour and fermented with yeast and then baked at a particular time and temperature to produce a distinctive texture, aroma, and flavor. Wheat contains a typical protein called gluten and plays an essential role in bread texture forming [1]. Studies show that gluten in wheat has an adverse health effect due to its correlation with some digestion problems. Lerner et al. [2] reported that multiple detrimental aspects of gluten affect human health, including gluten-dependent digestive and different digestive manifestations mediated by potentially immunological or toxic reactions that induce gastrointestinal inadequacy. Data about wheat α-amylase inhibitors activity in wheat gluten suggest that eating raw wheat gluten, flour, or dough could pose a health risk [3].

This fact encourages a lot of research to reduce the adverse effects of gluten on food processed products. Some researchers reported studies about food crops that are potential for a substitute for wheat flour, such as rye [4], sorghum [5], potato starch [6], oat [7], corn [8] and others. Corn is a food crop commonly found in Indonesia, and some people use it as a staple food. Corn is known to have
several advantages due to its complex nutritional content and functional properties [9], so it is now widely used as a substitute for rice by people with specific diets.

Corn that is over mature and dry can no longer be processed directly but can be made into flour. Yellow corn flour has advantages over commercial flour due to its lower total carbohydrate content (83.83%) than commercial flour (87.13%). Besides, the fiber content of corn flour is also higher (1.02%), and the reducing sugar content is lower (0.61%) than the commercial flour (3.75%) [10]. Corn flour is different from corn starch commonly found in the market. It is obtained by grinding old corn kernels to a smooth texture like flour in general. Corn flour has a lower total protein content compared to commercial wheat flour. Hence, Processing corn into flour needs several special steps that affect the cornflour quality so that the cornflour obtained is called modified cornflour (MCF) [11]. Some of the processes that can be done to produce MCF are fermentation [12], soaking in warm water [13], milling involving enzyme [14], and pre gelatinization [15].

Some examples of products made using corn flour as essential ingredients include noodles [16], cake [17], biscuits [18], and cookies [19]. However, using cornflour as a raw material in specific food preparations has several obstacles, especially for products that use wheat flour as the main ingredient. These obstacles are due to its functional properties in forming a dough that has not matched wheat flour due to lack of gluten, so it is necessary to obtain products with the desired texture and taste. One of the attempts that can be made is by substituting wheat flour with cornflour at a specific concentration. The adverse effects of gluten are expected to be reduced by this, yet the same characteristic can still be obtained.

This present work aimed to find the best substitute formulations for wheat flour using modified cornflour targeting a good sensory acceptance and good nutritional value based on Indonesian National Standard (SNI) for bread.

2. Material and methods

2.1. Materials

Dried corn grains (NASA 29 variety) were purchased from farmers in Takalar Regency, South Sulawesi. Yeast, wheat flour, dry yeast, salt, powdered milk, eggs, sugar, butter, cake emulsifier, and salt was obtained from the local market in Makassar, South Sulawesi.

2.2. Preparation of modified corn flour

Modified corn flour was obtained by the following method. Corn kernels were dried under the sun until they reached 10.41% of moisture content. 2 kg of shelled corn soaked in tape yeast obtained from the market as much as 20 grams in 3 liters of water for 48 hours. The corn was then drained and dried under the sun for 2 days, and during the drying process, the corn was turned upside down to dry evenly. The dried corn grain was milled using a seed miller and sieved using 80 mesh sieve until fine corn flour is produced. This flour was packaged in a cellophane bag until used.

2.3. Preparation of bread

Corn flour was mixed with wheat flour with varying proportions (0:100; 20:80; 40:60; 60:40). The corn-wheat flour blends were mixed with other ingredients for dough formation, as presented in table 1. The bread was produced using a straight dough process. The dough was mixed to optimum consistency using a bread maker (ECC Smart Bread Machine MB1000). Left the dough to ferment at room temperature (25-28 °C) for 30 minutes, then divided into pieces (each ±30 g). The baking sheet was smeared with butter, the dough pieces were arranged on it and were proofed for 20 minutes at the same temperature and then were baked at 150-170 °C for ± 20 minutes or until the golden brown color was formed. The loaves of bread were allowed to cool down before evaluation.
2.4. Proximate composition analysis and sensory evaluation
Proximate composition (moisture content, ash, fat, protein, and carbohydrate) analysis was carried out based on the method by Sudarmadji et al. [20]. 25 semi-trained panelists carried out the sensory evaluation of cornflour bread based on Lawless and Heymann [21] on a 5 point hedonic scale ranging from 1 (dislike) to 5 (like) for different sensory attributes such as color, texture, aroma, taste, overall appearance. Collected data were subjected to statistical analysis.

2.5. Statistical analysis
The data analyzed were carried out in triplicates. Analysis of variance (ANOVA) was performed, and separation of the mean values was by Duncan's multiple range test (DMRT) at p<0.05 using Statistical Analysis System (SAS) software.

Table 1. Formulation of bread dough.

| Ingredients         | Control | Mixture (1) | Mixture (2) | Mixture (3) |
|---------------------|---------|-------------|-------------|-------------|
| Corn flour (g)      | 0       | 20          | 40          | 60          |
| Wheat flour (g)     | 100     | 80          | 60          | 40          |
| Salt (g)            | 3       | 3           | 3           | 3           |
| Sugar (g)           | 50      | 50          | 50          | 50          |
| Powdered milk (g)   | 25      | 25          | 25          | 25          |
| Egg                 | 1       | 1           | 1           | 1           |
| Butter (g)          | 50      | 50          | 50          | 50          |
| Dry yeast (g)       | 5       | 5           | 5           | 5           |
| Bread emulsifier (g)| 5       | 5           | 5           | 5           |
| Cold water (ml)     | 100     | 100         | 100         | 100         |

3. Results and discussion

3.1. Proximate composition of bread substituted with corn flour
Statistical analysis showed that there is significant differences (p<0.05) in moisture content of the bread at 20% and 60% MCF using. The analysis showed that the increase in moisture content of the substituted bread (20% MCF and 40% MCF) was slightly different (p>0.05) from the control (100% WF) and the decrease in moisture content due to substitution with 60% MCF was also not significantly different (p>0.05) from the control. Moisture content is closely related to bread quality. It can affect the texture and shelf life of bread. The moisture content obtained from all substitution levels still meets the quality requirements based on SNI 01-3840-1995 (40%).

The ash content of the bread produced by substituting wheat flour using cornflour in this study increased along with cornflour. Based on SNI 01-3840-1995, the maximum ash content of sweet bread is 3%, and in this research, the ash content of the sweet bread produced follows the SNI. Significant differences (p<0.05) were found in the control treatment with MCF substitution of 40% and 60% (table 2). The more cornflour is used, the higher the ash content of the bread due to the increase of mineral content from ingredients using. This is following Setyani et al. [24] opinion that the more use of modified cornflour, the higher the ash content of the sweetbreads produced because the mineral content of cemented corn flour is more elevated than wheat flour.

These results show a better response than the use of soy-cheese flour by [25], where the substitution of wheat flour using soy-cheese flour did not give a significant difference to the ash
content of the bread. The higher ash content in bread with MCF substitution was mainly due to the higher content ash content of cornflour than wheat flour. Qamar et al. (2017) found that yellow corn flour has higher ash content than commercial white maize flour [26]. Ash content represents mineral content in general, so based on this result, it can be concluded that corn flour can increase the mineral content of flour-based products.

It is known that cornflour has higher fat content than wheat flour resulting in increased fat content as the flour used increased. This result is similar to those of [27], who worked on the effect of wheat flour supplemented with cornflour on balady bread quality. The fat content of bread in this work was higher than the fat content found in Chauhan D et al. (2018), who used wheat flour incorporated with oats to produce bread [28]. The control sample has higher protein content (9.51%) than substituted flour regarding the protein content. It might be caused by cornflour contain lower protein than wheat flour [29]. This research used modified corn because it has a better nutritive value than the usual cornflour [30]. The higher protein content obtained from substituted wheat flour by cornflour was found at a 40% level of substitution (8.75%). This is higher than reported by Rahmah et al. [31]. These special properties were obtained from the fermentation process of cornflour, which causes the increase of protein value of the flour, as claimed by Kurniawan et al. (2017) [32].

A positive impact on carbohydrate content was observed for 2 levels of modified cornflour substitution. The highest level was obtained from 20% MCF substitution (57.28%). It was affected by the carbohydrate content of cornflour, which is higher than wheat flour. Moses et al. [33] reported that the carbohydrate content of yellow corn starch ranging from 80.94% to 84.07%, which is higher than the carbohydrate content of wheat flour (78.80%) reported by Alviola et al. (2018) [34].

Table 2. Proximate composition of bread substituted with modified cornflour.

| Samples         | Moisture (%) | Ash (%) | Fat (%) | Protein (%) | Carbohydrate (%) |
|-----------------|--------------|---------|---------|-------------|------------------|
| Control (100% WF) | 24.68 ± 0.14<sup>a</sup> | 1.19 ± 0.01<sup>a</sup> | 11.78 ± 0.02<sup>a</sup> | 9.51 ± 0.02<sup>a</sup> | 52.96 ± 0.06<sup>a</sup> |
| 20% MCF:80% WF  | 26.43 ± 0.58<sup>b</sup> | 1.28 ± 0.07<sup>b</sup> | 6.61 ± 0.03<sup>d</sup> | 8.25 ± 0.08<sup>d</sup> | 57.28 ± 0.18<sup>a</sup> |
| 40% MCF:60% WF  | 26.08 ± 0.82<sup>b</sup> | 1.38 ± 0.01<sup>a</sup> | 12.86 ± 0.05<sup>d</sup> | 8.75 ± 0.04<sup>d</sup> | 51.64 ± 0.43<sup>d</sup> |
| 60% MCF:40% WF  | 24.47 ± 1.48<sup>b</sup> | 1.41 ± 0.03<sup>a</sup> | 12.48 ± 0.02<sup>b</sup> | 8.40 ± 0.02<sup>c</sup> | 53.68 ± 0.29<sup>b</sup> |

<sup>a</sup>Values in the table are presented in mean ± standard deviation.<br><sup>b</sup>Values with the same letters in the same column are not significantly different (p>0.05)<br><sup>c</sup>MCF: modified cornflour; WF: wheat flour.

Table 3. Organoleptic characteristics of bread substitute with cornflour.

| Samples         | Color          | Aroma         | Texture        | Taste          | Overall appearance |
|-----------------|----------------|---------------|----------------|----------------|--------------------|
| Control (100% WF) | 3.67 ± 0.75<sup>a</sup> | 3.97 ± 0.76<sup>a</sup> | 3.80 ± 0.89<sup>a</sup> | 3.90 ± 0.99<sup>a</sup> | 3.97 ± 0.89<sup>a</sup> |
| 20% MCF:80% WF  | 4.00 ± 0.74<sup>a</sup> | 3.57 ± 0.73<sup>a</sup> | 3.63 ± 0.81<sup>a</sup> | 3.67 ± 0.96<sup>b</sup> | 3.93 ± 0.84<sup>a</sup> |
| 40% MCF:60% WF  | 3.80 ± 0.76<sup>a</sup> | 3.57 ± 0.73<sup>a</sup> | 3.47 ± 0.86<sup>a</sup> | 3.57 ± 0.94<sup>b</sup> | 3.63 ± 0.72<sup>ab</sup> |
| 60% MCF:40% WF  | 3.73 ± 0.90<sup>a</sup> | 3.53 ± 1.11<sup>a</sup> | 2.83 ± 0.91<sup>b</sup> | 3.13 ± 1.01<sup>b</sup> | 3.33 ± 0.96<sup>b</sup> |

<sup>a</sup>Values in the table are presented in mean ± standard deviation.<br><sup>b</sup>Values with the same letters in the same column are not significantly different (p>0.05).<br><sup>c</sup>MCF: cornflour; WF: wheat flour.

3.2. Organoleptic evaluation

Bread prepared from different wheat-corn flour formulations was subjected to sensory evaluation for color, aroma, texture, taste, overall appearance, and their means score was collected (table 3). Panelists most preferred bread from the control treatment (100% wheat flour) in aroma, texture, taste, and overall appearance attributes, and from 60% MCF substitution was least preferred in general characteristics. There was no significant difference (p>0.05) in terms of color and aroma of all the samples, and its score ranging from 3.67 (moderately like) to 4.00 (like), which means that these samples are organoleptically acceptable. The fermentation process on corn flour making affects the
properties of flour, where according to Aini et al. (2016), the fermentation process resulting in low water absorbing capacity while high oil absorption. This allows the flour to optimally absorb additional ingredients such as eggs and margarine so that it has a lower product density [36].

Panelists gave a higher score for bread made from MCF than control (wheat flour). It might be caused by the yellowish color that comes from corn flour. The processing method can affect the color of the flour produced. Although the fermentation process can reduce the color intensity of corn flour, it is still able to give a better color when used for making bread. This is as described by Ntau et al. (2017), that the unfermented cornflour has higher brightness, red and yellow color than fermented cornflour, although it is not statistically significantly different, fermented corn flour still has good brightness [36].

The table shows that wheat flour substitution with 60% MCF reduced the sensory quality of bread. The score for texture taste and overall appearance of 60% MCF substitution was significantly different from other substitution levels and control. Some panelists mentioned that bread with higher corn flour substitution levels seemed to have a sandy, challenging, and less chewy texture. It may be due to the lack of gluten in this formulation, responsible for bread texture formation. Gluten is a unique protein in wheat flour, and gluten functionality is due to a disulfide bond's essential role. Dough elasticity is primarily associated with polymeric glutenins, which came from intramolecular and intermolecular disulfide bonds [37]. MCF’s addition significantly decreases panelists’ acceptance of its taste, and overall appearance, the added cornflour resulting in unique taste and flavor, and some panelists did not like it. Kontacila et al. (2008) found that the added cornflour had adverse effects on flavor, taste, and overall bread acceptance [38]. The sensory analysis shows that using 40% MCF to substitute wheat flour did not significantly affect the panelists’ acceptance, especially for texture, taste, and overall appearance.

4. Conclusions
The substitution of wheat flour using modified corn flour has a significant statistical effect on the nutritional composition, texture, taste, and overall appearance of bread. It was found that bread with 60% modified cornflour was significantly different from control (100% wheat flour) in most of the nutritional and sensory attributes. Using modified cornflour caused an increase in nutritional value except for protein content. The organoleptic scores showed that the panelists’ preference was decreased at 60% modified cornflour using, especially for texture attribute. These results indicate that the wheat flour could be substituted with a maximum of 40% of modified cornflour, and it is still meet the SNI requirement for the nutritional value of bread.

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