Physicochemical Properties of Local White Corn Flour

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Abstract. Corn is an important and widespread agricultural commodity used as food, feed, or as a raw material in preparing other viable products. The formation of flour from corn sources appears more flexible, with extensive usability. However, the chemical composition and functional properties are significantly influenced by the various processing methods and raw material origin. Local white corn from Wonosobo, Kebumen, Banjarneagra, Temanggung, and Magelang were cultivated in the Field Experimental Unit 2, Mercu Buana, Yogyakarta University. Subsequently, chemical content, including moisture, direct ash, protein, fat, starch, and amylose, as well as the physical properties, termed bulk and tapped-bulk densities, solubility, wettability, and color, in the form of red (a), yellow (b), and brightness (L), were critically observed. The results showed white corn with higher ash levels (1.83%), protein (16.45%), and fat (4.29%). Furthermore, lower amylose levels occurred in Wonosobo (13.5%) and Magelang (15.5%), while local samples from various regions, demonstrated varying moisture content (5.69 - 5.92%), based on SNI provisions. No obvious significant change was recorded in bulk density (0.46 - 0.49 g ml$^{-1}$), tapped-bulk density (0.54 - 0.58 g ml$^{-1}$), and solubility (14.65 - 16.43 %). Therefore, the fastest wettability sources were reportedly Kebumen and Banjarneagra, while Magelang's local white corn flour generated the most colour brightness.

Keywords: local white corn, grain chemical composition, flour physicochemical properties

1. Introduction

Cereals belong to the Poaceae family (formerly Gramineae). This staple food group offer significant value, with widespread cultivation. In general, the grains provide approximately 50% global daily calorie consumption. In general, the major cultivated cereals include wheat, rice, corn or maize, barley, oats, rye, and millets [3]. Evidently, corn is a multi-purpose plant, where the biomass and husk are used as animal feed. Furthermore, dry kernels are employed in the preparation of oil and flour, while corn cobs, rich in pentose, potentially serve as raw material in furfural production [2]. Based on the above-mentioned properties, various corn types, including dent, flint, floury, and popcorn are known to exist [Winarno]. Under the starch composition ratio of amylose and amylopectin, there is also an occurrence of normal, waxy (high amylopectin), and non-waxy (high amylose) corn, as well as a sweet variety, with high sugar content [4]. In terms of color, white, yellow, red/orange, and violet/ black corn are reported [2].

Indonesia’s corn production rate from 2014 - 2018 increases consistently every year. In 2018, 30 million tons were estimated, while the demand by animal feed and other industries, presently exists
between 7.8 - 11.1 million tons. In similar year, the country’s export was approximately 380,000 tons. However, imports reduced by 3.3 million tons, within 2014 - 2018.

Currently, corn is more applied as a raw material in food industries, specifically in form of starch and grits, although, with relatively underdeveloped potentials as a food ingredient. Therefore, the interest to explore the huge opportunities is fast rising. Flour preparation is greatly preferred, due to extensive resilience, easy to mix, high nutrient fortification, and the advantage for further processing. Indonesia’s quality specifications for corn flour are listed in SNI 01-3727-1995 [2].

The corn flour is prepared, using wet (soaking in water) or dry (dry flouring) processes, or by means of nikstamalization (soaking in lime solution). Also, the chemical composition is influenced by the sample varieties [12], [15], [7]. In addition, various production methods tend to generate separate chemical compositions [11] and [10]. As a consequence, diverse physical properties are formed, including color, density, gel flow [Kuntjahjawati et al., 2014], water and oil absorption, as well as emulsion [15].

Corn flour prepared from Bisma, Lamuru, and Arjuna varieties, are suitable in wet noodle processing, with elongation and cooking loss characteristics between 80.32 - 95.43%, and 5.06 - 5.66%, respectively [12]. Suarni et al. [2013] succeeded in categorizing several maize species, based on amylose content, termed low: 4 - 7% (Pulut), moderate: 23 - 25% (local Takalar, Anoman), and high: 46 - 48% (Palakka, Krisna, Bisma, Lamuru) [15]. The flour produced by wet method, using water immersion appears sufficient in preparing cookies [11]. This sample is slightly coarse, contains gluten <1%, and is inconvenient for high volume development, but the species, comprised of food fiber, are adequately enriched with pro-vitamin A (yellow corn flour), and Fe (corn red), absent in wheat flour. Substituting wheat with corn flour up to 50 - 80% results in pastries rated from being like – really like in the panelists' preference [8]. This study was, therefore, aimed at determining the physico-chemical characteristics of corn flour prepared using local white corn kernels obtainable from several regions in Central Java.

2. Materials and Methods
2.1. Materials
White corn varieties were accessed from 5 separate locations, including Wonosobo, Kebumen, Banjarnegara, Temanggung, and Magelang. These sites were also referred as the districts in Central Java province were planting at Experimental Field of Mercu Buana Yogyakarta University was conducted.

2.2. Methods
Several methods were engaged in evaluating the seeds’ chemical composition. The parameters include contents of moisture (thermogravimetric), direct ash, protein (micro Kjeldhal), fat (Soxhlet), starch, and amylose (IRRI method, AOAC, 1995). The treated corn kernels were soaked in water for 4-5 hours, and was then allowed 10 hours to drain. Subsequently, the samples were shed, using waring blender, followed by sieving with a 60-mesh size. The resulting flour was further dried in a cabinet dryer at 50°C for 12 hours [13]. Corn flour was analysed for bulk and tapped-bulk densities [Khalil, 1990], wettability, diffusivity (Hartomo and Widiatmoko, 1998), and colour (a, b, and L), using a Lovibond tintometer. This study incorporates the use of completely randomized design, where the reported data relate to the average of triplicate observations. The resulting data were further evaluated, using single factor analysis of variance (ANOVA). Also, Duncan’s test was applied to determine the most suitable research approach, compared to other means.

3. Results and Discussion
3.1. Chemical Composition of Local White Corn Kernels

The moisture, ash, protein and fat content of local white corn vary considerably, depending on the source location. Approximately, 70% carbohydrate concentration was incorporated in this study, while protein
and fat ranged between 10.34 - 16.54% and 3.55 - 4.29%, respectively. These compositions are virtually similar in rice and wheat, as reported by Kuntjahjawati et al. (2014). Wonosobo’s local white corn is a potentially suitable rice substitute, as a result of high protein content (16.54%, Table 1).

Table 1. Moisture, ash, protein, fat, starch, amylose, and amylopectin content of local white corn kernels from various regions

| The origin of local white corn | Water (%) | Ash (%) | Protein (%) | Fat (%) | Starch (%) | Amylose (%) | Amylopectin (%) |
|-------------------------------|-----------|---------|-------------|---------|------------|-------------|-----------------|
| Wonosobo                      | 12.14 c   | 1.83 b  | 16.54 c     | 4.29 c  | 72.34 a    | 13.5 a      | 52.96 a         |
| Temanggun                     | 12.44 d   | 1.48 a  | 11.97 b     | 4.11 b  | 69.60 a    | 14.3 b      | 49.51 a         |
| Kebumen                       | 11.51 a   | 1.25 a  | 11.97 b     | 3.75 ab | 71.44 a    | 16.9 d      | 49.09 a         |
| Banjarnegar                   | 11.76 b   | 1.28 a  | 10.34 a     | 4.14 bc | 69.53 a    | 16.8 d      | 47.46 a         |
| Magelang                      | 12.29 cd  | 1.35 a  | 12.45 b     | 3.55 a  | 67.01 a    | 15.5 c      | 46.12 a         |
| Sd                            | ± 0.07    | ± 0.09  | ± 0.27      | ± 0.18  | ± 3.29     | ± 0.22      | ± 2.90          |

Different notations occurring in similar column indicate a real difference, P<0.05

Table 1 reveals the seed content of starch (67.01 - 72.34%) and amylopectin (46.12 - 52.96%) of the 5 local white maize types from various regions did not observe any variation, but the amylose levels differed. Wonosobo’s cooked samples tend to produce fluffier rice, due to low amylose, while sources from Kebumen and Banjarnegara appear appropriate in preparing noodles, with sufficient amylose, compared to other 4 sources. However, Belitzt and Grosch (1999) reported normal composition of 28%. High amylose content plays an important role in the formation of the noodle’s gel tissue (Hormdok and Noomhorm, 2007). Based on Sandhu et al. (2005), the composition in starch granules depends greatly on the variety, climate growth, and soil conditions. In general, gelatinization is expected to occur over a range of temperatures, and is essential for starch species [5]. For instance, the gelatinization temperature range of potato and corn starch, were specified between 59 - 68°C and 62 - 72°C , respectively [1]. Noviasari et al. (2013) stated the significant influence of the kernel’s amylose content on the properties and analog rice manufacture. Furthermore, extensive amylose levels commonly result in a drier, tastier rice, and are a determinant of the cooking process and consumer acceptance (Qi et al., 2010). Meanwhile, Avaro et al., 2009 reported the amylose content in rice tends to affect the processing, utilization and quality, particularly in consumers’ acceptance. Therefore, corn starch shows a valuable ingredient in food industries, widely applied as thickener, in addition to gelling, bulking, and water retention agents [14].

3.2. Physico-chemical Properties of Local White Corn Flour

The white corn flour evaluated in this study matched the SNI 01-3727-1995 specifications, with a minimum of 99%, and a 60-mesh sieve. However, the sample’s moisture content using the dry flour method, varied considerably with the local maize varieties (Table 2 and Figure 2). In addition, the above criteria were also achieved, with maximum moisture content of 10% w/w.

The corn flour yield was influenced by the shading method and particle size, and the samples were passed through a 120-mesh sieve, after dry milling. This condition resulted to a 30.8% product by weight of shelled corn [16]. However, with a 100-mesh size, higher yield was obtained, including 54.4% (Fitriani, 2004) and 50% (Cynthia et al., 2009). Table 2 represents the yield of local white corn flour between 48.96 - 51.91%.
The results showed the density of Kamba corn species ranged from 0.46 - 0.49. Based on Kuntjahjawati et al. (2014), corn flour of 0.48 and 0.45-0.48 were obtained, using dry mill and wet methods, respectively.

**Table 2.** Moisture content (% kernel dry weight), flour yield, bulk density, tapped-bulk density, dispersibility, and wettability of local white corn flour from various regions

| The area of origin of local white corn | Moisture content (%) | Flour yield (%) | Bulk density (g/ml) | Tapped-bulk density (g/ml) | Dispersibility (%) | Wettability (g/sec) |
|--------------------------------------|----------------------|-----------------|---------------------|---------------------------|-------------------|---------------------|
| Wonosobo                             | 5.69 a               | 51.91 a         | 0.48 a              | 0.56 a                    | 16.43 a           | 0.0358 a            |
| Temanggung                           | 5.82 b               | 51.32 a         | 0.49 a              | 0.58 a                    | 15.55 a           | 0.0397 a            |
| Kebumen                              | 5.76 ab              | 51.14 a         | 0.46 a              | 0.54 a                    | 14.65 a           | 0.0629 c            |
| Banjarnegara                         | 5.81 b               | 50.69 a         | 0.48 a              | 0.55 a                    | 14.93 a           | 0.0556 be           |
| Magelang                             | 5.92 c               | 48.96 a         | 0.49 a              | 0.57 a                    | 15.02 a           | 0.0450 ab           |
| Standart Error                       | ± 0.04              | ± 2.56          | ± 0.01              | ± 1.48                    | ± 0.0057          |

Different notations occurring in similar column indicate a significant difference, P<0.05

Dispersion was reported to significantly impact the mouthfeel of liquid and dough. Flour dough with high dispersion rate and fast wettability achieves moisture more rapidly when tasted. This shows a quick sensation of either coarse, smooth, soft, or gritty. However, the wetting rate of local white corn flour is greatly influenced by the varying corn sources. Kebumen and Banjarnegara samples, with extensive amylose seeds, eventually showed swifter wettability, compared to other sources (Wonosobo, Temanggung, and Magelang). This situation is believed to match the research of Lalal et al. (2009), where Are Kea rice flour with high amylose content (33.21%), demonstrated a fast flour wetting rate (12.11 seconds) and high dispersion (2.50%).

Corn flour produced by from white kernels in various regions, tends to yield separate colors.

**Table 3.** The color of local white corn flour from various regions

| Origin of white corn | a | b | L |
|----------------------|---|---|---|
| Wonosobo             | 5.69 a | 51.91 a | 0.48 a |
| Temanggung           | 5.82 b | 51.32 a | 0.49 a |
| Kebumen              | 5.76 ab | 51.14 a | 0.46 a |
| Banjarnegara         | 5.81 b | 50.69 a | 0.48 a |
| Magelang             | 5.92 c | 48.96 a | 0.49 a |
| Standart Error       | ± 0.04 | ± 2.56 | ± 0.01 |

Different notations occurring in similar column indicate a real difference, P<0.05

White corn is comprised of minimal xanthophyl (yellow) and zeasantin (red) pigments. Magelang sample appeared extensively, with red and yellow coloration, and increased brighter, compared to other flour types. In addition, the protein content (12.45%) was lower in comparison with Wonosobo sources (16.54%). However, the drying process was assumed, in order to allow the occurrence of Maillard reaction, therefore, resulting in an enhanced brownish coloration in the local Wonosobo sample.

**4. Conclusions**

Based on results and discussions: 1) Local white corn kernels from various regions demonstrated separate chemical compositions. The samples from Wonosobo exhibited more abundant ash content (1.83%), protein (16.54%), and fat (4.29%), compared to Magelang (ash content 1.35%, protein 12.45%, 3.55% fat), but with minimal amylose (Wonosobo 13.5% and Magelang 15.5%); 2) Local white corn flour, prepared using dry flour method, was observed with separate moisture content, although the yield was not altered (48.96 - 51.91%). This situation was also able to match the SNI requirements.
Furthermore, wettability of local white corn flour was influenced by the disparities in sample sources. The corn flour from Kebumen and Banjarnegara, with higher amylose content, eventually revealed a faster wettability, compared to other sources (Wonosobo, Temanggung, and Magelang). Evidently, the abundant yellow, red, and brightest coloration occurred in the Magelang sources.

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