



COMPARATIVE ANALYSIS OF NUTRIENT AND PHYTOCHEMICAL PROFILES OF FLOURS PRODUCED FROM THREE MAIZE (*ZEA MAYS*) VARIETIES

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ABSTRACT

The study compared nutrient and phytochemical profiles of flours from three maize varieties: yellow (YCF), white (WCF) and popcorn (PCF) maize. Specifically, the study analysed proximate (moisture, crude protein, fat, ash, crude fibre and carbohydrate) and phytochemical composition (carotenoid, alkaloid, flavonoid) of flours from three maize varieties. Samples were processed using different standard methods. Proximate and phytochemical contents of the samples were analysed using standard methods and data were expressed as mean \pm standard deviation. Analysis of variance was used to test for differences and Duncan's New Multiple Range Test was used to separate and compare the means. A probability level (p - value) of < 0.05 was considered statistically significant. Proximate analysis revealed that popcorn flour exhibited the highest protein (17.95%) and carbohydrate (24.64%) content, while white corn had the highest moisture content (57.13%). Yellow corn recorded the highest crude fiber content (3.36%). Phytochemical analysis indicated that yellow corn contained the highest levels of alkaloids (11.00 mg/100g) content. The yellow corn flour (YCF) had the highest flavonoid (1.77 mg/100g). The alkaloid content was highest (11.00 mg) in YCF and lowest (6.50 mg) in PCF. The carotenoid content was highest (3.54 mg) in WCF and lowest (1.05 mg) in YCF. The findings showed that these flours contain essential nutrients and phytochemicals. This suggests that consumption of these flours are important in prevention of mental health related diseases.

Keywords: Comparative, Analysis, Nutrient, Phytochemical, Maize, Varieties.

INTRODUCTION

Maize (*Zea mays L.*) is a vital staple crop consumed globally which serve as source of nutrients, and bioactive compounds with potential health benefits. These **properties** vary significantly across different varieties presenting a major challenge for food security, dietary planning, and industrial utilization. Addressing these challenges requires systematic characterization and evaluation of maize varieties in order to identify those with superior nutritional and bioactive qualities. Such efforts will enhance the effective utilization of maize in improving public health, supporting food industries, and advancing crop improvement strategies. **Protein-energy malnutrition (PEM) is a critical public health issue in Nigeria, contributing to nearly half of under-five child deaths, with over 2 million children suffering from severe acute malnutrition. Nigeria ranks second globally in stunting prevalence, making PEM a major barrier to child survival and national development** (United Nations International Children's Emergency Fund (UNICEF), 2025). Maize varieties rich in nutrients and phytochemicals can play significant roles in addressing malnutrition and chronic diseases. Corn flour contains several phytochemicals such as carotenoids, alkaloid and flavonoid which could enhance nutritional value and health benefits. Phytochemicals are biologically active compounds in plants which may offer health benefits, including antioxidant and anti-inflammatory effects, they contribute to plants' color, flavor, and disease resistance (Yang & Ling, 2025).

The nutritional and phytochemical properties of corn flour are influenced by various factors, including genetic, environmental, processing, and storage conditions. The genetic makeup of corn determines the concentration of flavonoids and phenolic compounds, which are essential for antioxidant activity and overall health benefits (Hernandez *et al.*, 2023). Moreso, advances in breeding programs aimed at enhancing these phytochemicals have resulted in varieties with improved nutritional profiles.



Recognizing and optimizing these factors can enhance the health benefits of corn flour and improve its application in diverse food products. Environmental conditions such as soil type, climate, and agricultural practices significantly impact the growth and development of corn plants, consequently affecting the nutritional composition of corn flour. (Nadeem *et al.*, 2023). The method of processing corn into flour has a profound effect on its nutritional and functional properties. (Singh & Singh, 2023). Furthermore, cooking methods such as boiling, roasting, or frying can alter the availability of phytochemicals.

There are different varieties of corn flour, including white corn flour, yellow corn flour, and popcorn flour. White corn flour is made from white corn kernels and is known for its mild, subtle flavor. It has a lighter color compared to yellow corn flour, making it preferable in applications where a neutral appearance is desired. White corn flour tends to have a slightly lower protein content than yellow corn flour, which can affect its binding properties in certain recipes (Rodriguez *et al.*, 2021). Yellow corn flour, derived from yellow corn kernels, has a more pronounced corn flavor and a distinctive golden hue. This variety is often higher in certain nutrients, particularly carotenoids like lutein and zeaxanthin, which contribute to its color and potential health benefits (Chen and Wang, 2022). The stronger flavor of yellow corn flour makes it a popular choice in traditional cornbread is less common but offers unique properties. It typically has a coarser texture compared to white and yellow corn flours, which can add interesting textural elements to baked goods. Popcorn flour is noted for its intense corn flavor and aroma, often described as nutty and slightly sweet (Thompson *et al.*, 2023).

Corn, or maize, is an essential crop with several key varieties, each offering unique characteristics and applications. White Corn is distinguished by its light-colored kernels and is predominantly used for human consumption, particularly in regions such as Africa and Latin America. This variety is commonly processed into products like cornmeal, tortillas, and grits. Nutritionally, white corn is similar to yellow corn but contains lower levels of carotenoids, such as beta-carotene, which gives yellow corn its vibrant hue. Research indicates that white corn has a favorable amino acid profile and is a good source of dietary fiber, making it beneficial for digestive health (López *et al.*, 2022; Verdusco *et al.*, 2023). Moreover, its relatively low glycemic index makes it a suitable option for individuals managing blood sugar levels (Hernandez *et al.*, 2023). Moreso, maize is rich in phytochemicals with antioxidant properties that help reduce the risk of chronic diseases by neutralizing free radicals. Research indicates that different maize varieties can offer varied phytochemical and nutritional benefits, emphasizing the importance of selecting the appropriate type for specific applications (Murtaza *et al.*, 2021; Yadav *et al.*, 2022). This study aims to conduct a comparative evaluation of the nutrients, phytochemicals and functional properties of corn flour produced from white maize, yellow maize and popcorn maize. By examining these three distinct varieties, the study seek to provide valuable insights into their unique characteristics and potential applications in food science, nutrition, and related industries. Insufficient data on the phytochemical composition of various maize varieties hinders the development of nutritionally optimized foods, which could contribute to improved food security (Yadav *et al.*, 2022).

Moreso, lack of comprehensive analysis on the differences in nutritional, functional and phytochemical properties of these corn flours affect their suitability for various food applications, and limit exploration of the potential health benefits associated with the consumption of corn flour from different maize varieties. Thus the study compared the nutrient and phytochemical properties of corn flour produced from three distinct varieties of maize. This will ultimately contributing to informed choices in food production and consumption, and enhancing the overall quality of maize-based products.

The broad objective of this study was to carry out comparative evaluation of corn flour produced from white, yellow and popcorn maize (*Zea mays*) flour.

Specifically, the study determined:

- i proximate composition (moisture, crude protein, ash, fat, crude fiber and carbohydrate) of three different varieties of maize flour;
- ii phytochemical content (flavonoid, alkaloid, carotenoid) of three different maize flour samples.



MATERIALS AND METHODS

Procurement of Raw Materials

Maize grains (*Zea mays*) was obtained from a local market (Orba main market) in Udenu local government area of Enugu state.

Processing of Maize Flour

The maize grains (1 kg) were processed into flour through several critical stages to ensure the production of high-quality flour. One kilogram of maize kernels was sorted and cleaned to maintain the purity and quality of the flour by carefully separating foreign materials. The maize was then conditioned by adding one cup of distilled water to the kernels to soften them, making it easier to remove the outer layers. It was subsequently milled or ground into flour, after which winnowing was carried out to separate the germ and the bran and remove other coarse particles and impurities. The grits were milled finely and sieved, and the flour was finally packaged in a well-labeled airtight container.

Chemical Analysis

All chemical analysis were carried out in duplicate determinations

Proximate analysis

Moisture content determination: The moisture content of flour samples was determined using the hot air oven method. (AOAC, 2010) A porcelain dish was thoroughly washed and dried in a hot air oven at 105°C for 10 minutes to a constant weight and then cooled in a desiccator for five minutes to remove surface moisture. The empty porcelain dish was weighed, and the weight was recorded. Exactly 2 grams of maize flour was placed into the dish, and it was weighed again to obtain the total weight of the porcelain dish with the flour. The dish with the flour was then placed in the preheated hot air oven set at 105°C (221°F) for five hours to ensure thorough drying of the flour. Once the drying process was complete, the porcelain dish with flour was carefully removed from the oven and placed in a desiccator to cool, preventing the flour from absorbing moisture from the air. After the container had cooled to room temperature, it was weighed again to determine the weight of the container with the dried flour, and the moisture content was calculated.

Ash content determination: Ash determination was carried out using the standard procedure of the Association of Official Analytical Chemist (AOAC, 2010). Two grams of the sample was placed in a silica dish which has been ignited, cooled and weighed. The dish and sample was ignited first gently and then at 600°C in a muffle furnace for 6 hours until a white or grey ash is obtained. The dish with the content was then cooled in a desiccator and weighed.

Crude protein content determination: The micro Kjeldahl method described by AOAC (2010) was used for crude protein determination. The protein determination process involved three main stages.

In the digestion stage, a 1-gram sample was digested with a mixture of 20 milliliters of concentrated sulfuric acid, a pinch of copper sulfate, and sodium sulfate crystals, which served as catalysts. The mixture was heated until the black liquid became clear, ensuring that the sample was fully digested. The digested mixture was then transferred into a 100-milliliter volumetric flask, which was rinsed to ensure complete transfer for the next stage.

During the distillation stage, 10 milliliters of boric acid, along with two drops of methyl blue and methyl red indicators, were placed in a 100-milliliter conical flask. This flask was positioned in the receiving section of the distillation setup using a clamp. Then, 10 milliliters of the digested sample were added to the distillation unit, followed by a gradual addition of 10 milliliters of concentrated sodium hydroxide. The distillation was conducted for 5 to 10 minutes, during which ammonia gas was absorbed by the boric acid solution. The presence of ammonia turned the boric acid indicator from purple to green, indicating the presence of alkaline gas.

In the final titration stage, the ammonia absorbed in the boric acid solution was titrated with 0.1 N hydrochloric acid (HCl). The crude protein content of the sample was then calculated based on these titration results using the appropriate formula.

Crude fiber content determination: Crude fiber was determined using the method described by AOAC (2010). A 5-gram sample was placed in a 500 ml beaker, and 200 ml of 1.25 N sulfuric acid (H₂SO₄) was added. The mixture was then boiled for 25 to 30 minutes on a hot plate and filtered through Whatman No. 1 filter paper. The residue was washed with hot water and filtered again. Following this,



200 ml of 1.25 N sodium hydroxide (NaOH) was added, and the solution was boiled for another 25 to 30 minutes. After filtering, the residue was treated with 50 ml of 1 N hydrochloric acid (HCl) and then with acetone before being transferred to a porcelain crucible for drying. Once dried, the residue along with the crucible was weighed (F1). The residue was then subjected to ashing, and the weight of the ash and crucible was recorded (F2). The crude fiber content was calculated based on these measurements.

Crude fat content determination: The AOAC (2010) method was used for crude fat determination. A 5-gram dry sample was weighed and placed into a thimble, which was then inserted into the Soxhlet extractor. An extractor with a 500 ml round-bottom flask containing anti-bumping granules was weighed, and 300 ml of petroleum ether was added to the flask fitted with Soxhlet extraction units. The solvent was heated and allowed to evaporate, then condensed and washed over the sample in the thimble. The extraction continued for 1 hour in the oven at 70°C to ensure thorough fat removal. After extraction was completed, the solvent was carefully removed from the flask using a rotary evaporator to evaporate the solvent, leaving behind the fat residue. The flask with the fat was allowed to cool and then weighed. The fat content was calculated as follows:

Carbohydrate content determination: The total carbohydrate was gotten by difference:
100 - (moisture content+ Crude protein+ crude fat + crude fiber + ash)

Phytochemical Analysis

Flavonoid content determination: The method of Ordonez *et al.* (2006) was followed to calculate the total flavonoid content. A mixture of 0.5 mL of the sample and 0.5 mL of 2% AlCl₃ ethanol solution was prepared. After one hour at room temperature, the absorbance was measured at 420 nm. The appearance of a yellow color indicated the presence of flavonoids. The sample extract was tested at a final concentration of 0.1 mg/mL

Carotenoid content determination: The method described by AOAC (2010) was used. Two grams of corn flour were weighed and extracted with 20 mL of acetone. The mixture was filtered to collect the extract, and the filtrate was diluted with 20 mL of hexane. The hexane layer was collected and evaporated to dryness. The residue was then re-dissolved in a suitable solvent, such as cyclohexane, for analysis.

The carotenoids were quantified using spectrophotometry, comparing the results against standard solutions to calculate the total carotenoid content in the 2 g sample.

Alkaloid content determination: The method described by AOAC (2010) was used. Two grams of corn flour were weighed and extracted with 50 mL of distilled water and 25 mL of ethanol at 60°C for 30 minutes. The mixture was filtered to collect the liquid extract, and the pH was adjusted to around 9 using a base. Then, 50 mL of chloroform was added, and the mixture was shaken gently to separate the layers, collecting the chloroform layer. The chloroform was evaporated to dryness, and the residue was re-dissolved in a small volume of ethanol. The alkaloids were analyzed using spectrophotometry, comparing the results against standard solutions to calculate the total alkaloid content in the 2 g sample.

Statistical Analysis

Data obtained in this study were analysed using Statistical Package for Social Science (SPSS) version 22. Descriptive statistics (means and standard deviation) were used to present the results. Analysis of variance was used to determine the significant differences between variables.

RESULTS

Proximate Composition of Flours Produced from three Varieties of Maize

Table 1 shows the proximate composition of flours produced from three varieties of maize. The result showed that, white corn flour (WCF) had the highest moisture content (57.13%) while yellow corn flour (YCF) had the lowest moisture content (50.00%). The crude protein content was highest (17.94%) in popcorn flour (PCF) and lowest (13.79%) in WCF. The crude fat contents ranged from 4.00% in WCF to 5.00% in YCF. The ash content ranged from 1.00% to 6.00%; PCF had the highest ash content while WCF had the lowest ash content. The crude fibre content was highest (3.36%) in YCF and lowest (1.00%) in PCF. The total carbohydrate content ranged from 18.93% in YCF to 24.64% in PCF. Statistically, significant ($p < 0.05$) difference was observed in the moisture and crude fibre contents of the samples. No significant ($p > 0.05$) difference occurred in the crude fat contents of the samples. No

significant ($p > 0.05$) difference was observed in the crude protein and crude ash contents of YCF and PCF as well as in the carbohydrate contents of WCF and PCF.

Table 1: Proximate Composition of Flours Produced from three Varieties of Maize (%)

Sample	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fibre (%)	Total Carbohydrate (%)
YCF	50.00 ^b ± 0.00	17.21 ^b ± 0.82	5.00 ^a ± 1.41	5.50 ^b ± 0.71	3.36 ^c ± 0.03	18.93 ^a ± 0.14
WCF	57.13 ^c ± 1.24	13.79 ^a ± 0.31	4.00 ^a ± 1.41	1.00 ^a ± 0.00	1.63 ^b ± 0.25	22.46 ^b ± 0.11
PCF	46.00 ^a ± 0.71	17.95 ^b ± 0.61	4.50 ^a ± 0.71	6.00 ^b ± 1.4	1.00 ^a ± 1.13	24.64 ^b ± 1.87

Values are mean ± standard deviation of duplicate determination. Mean values on the same column with different superscripts are significantly different at $p < 0.05$.

Key

YCF= Yellow corn flour; WCF= White corn flour ,PCF= Popcorn flour

Phytochemical Contents of Flours Produced from three Varieties of Maize

Table 2 shows the phytochemical contents of flours produced from three varieties of maize per 100g. The yellow corn flour (YCF) had the highest flavonoid (1.77 mg) while the white corn flour (WCF) had the lowest moisture content (1.24 mg).. The alkaloid content was highest (11.00 mg) in YCF and lowest (6.50 mg) in PCF. The carotenoid content was highest (3.54 mg) in WCF and lowest (1.05 mg) in YCF. Statistically, significant ($p < 0.05$) differences occurred in the flavonoid and alkaloid contents of the samples. No significant ($p > 0.05$) difference was observed in the carotenoid contents of WCF and PCF.

Table 2: Phytochemical Contents of Flours Produced from three Varieties of Maize per 100g

Sample	Flavonoid (mg)	Alkaloid (mg)	Carotenoid (mg)
YCF	1.77 ^c ± 0.00	11.00 ^b ± 1.41	1.05 ^a ± 0.05
WCF	1.24 ^a ± 0.02	8.75 ^{ab} ± 1.77	3.54 ^b ± 0.14
PCF	1.68 ^b ± 0.01	6.50 ^a ± 0.71	3.53 ^b ± 0.26

Values are mean ± standard deviation of duplicate determination. Mean values on the same column with different superscripts are significantly different at $p < 0.05$.

Key: YCF= Yellow corn flour; WCF= White corn flour; PCF= Popcorn flour

DISCUSSION

This study evaluated the proximate and phytochemical properties of flours produced from three maize varieties: yellow maize (yellow corn flour), white maize (white corn flour), and popcorn maize (popcorn flour). The findings revealed a significant variation in these properties, demonstrating that different maize varieties contribute unique nutritional and functional benefits.

Proximate Composition of Corn Flour

The findings in proximate analysis showed that the moisture content ranged from 46.00% (popcorn flour) to 57.13% (white corn flour), this is in contrary with the value (26.00% to 36.40%) reported by Zhang *et al.*, (2023), on varieties and moisture content of corn. The differences in moisture could be as a result of soil type. significantly higher moisture content in white corn flour suggests lower storage stability due to increased susceptibility to microbial spoilage (Adeyemi & Idowu, 2020).

The crude protein content varied between 13.79% (white corn flour) and 17.95% (popcorn flour), with popcorn maize flour showing the highest protein level. This finding aligns with previous studies by Onyeka *et al.* (2019) that reported popcorn maize as a superior protein source due to its genetic composition. Protein in this maize will be of great importance in providing energy and essential amino acids, it can also serve as a binder, texturizer, and coating agent in baked goods.

The crude fat content recorded in this study was found the highest in yellow corn flour (5.00%) and the lowest in white corn flour (4.00%). This is comparable with previous findings (Singh *et al.*, 2020), which reported that maize typically contains a relatively low-fat content, ranging from 3% to



6%, with the germ being the primary source of maize oil. Crude fat in this maize can serve as a concentrated source of energy, and supporting the absorption of fat-soluble vitamins.

The ash content, an indicator of mineral presence, was found to be highest in popcorn flour (6.00%) and lowest in white corn flour (1.00%). However, the white corn value is comparable with a study by Mansor *et al.* (2021) titled "Physicochemical Properties of Local White Corn Flour" which reported an ash content of 1.83% in white corn flour, (Mansor *et al.*, 2021), while the popcorn value is in contrary to a research by El-Sayed and Hassan (2020) in their study "Utilization of Popcorn for Gluten-Free Cake and Cookies" which found that popcorn flour had an ash content of 0.74%, suggesting a lower mineral presence compared to white corn flour (El-Sayed & Hassan, 2020). The difference in popcorn could be as a result of climate and environmental conditions.

The crude fiber content was significantly higher in yellow corn flour (3.36%) than in popcorn flour (1.00%), a study by Oladapo *et al.* (2017) on "The proximate, functional and anti-nutritional properties of three selected varieties of maize (yellow, white and popcorn) flour" found that yellow maize flour exhibited higher crude fiber content than popcorn flour. Reinforcing the role of yellow maize in dietary fiber intake, Okonkwo and Agu (2021) emphasized its significance in boosting dietary fiber consumption, which is essential for maintaining digestive health and preventing constipation.

The carbohydrate content recorded in this study was highest in popcorn flour (24.64%), indicating its potential as an energy source. However, this value is notably lower than what is reported by Elsevier (2022) that carbohydrates accounts for approximately 70-80% of its dry weight. The observed variations could be due to differences in processing methods, or analytical techniques.

Phytochemical Content of Corn Flour

The findings on phytochemical composition showed that flavonoids were highest in yellow corn flour (1.77 mg), consistent with a study highlighting yellow maize as a rich source of flavonoids (Oluwafemi *et al.*, 2022). Flavonoid in this corn helps to reduce oxidative stress. The alkaloid content was also highest in yellow corn flour (11.00 mg/100g), reinforcing its potential for medicinal and health-promoting properties. Carotenoid content, which influences maize color and pro-vitamin A activity, was highest in white corn flour (3.54 mg/100g) and lowest in yellow corn flour (1.05 mg). This result is in contrary with Kumar *et al.* (2023) who reported that yellow corn flour is particularly rich in carotenoids and flavonoids, enhancing its health-promoting properties. However, the presence of these phytochemicals across all maize flours demonstrates their potential as functional foods. Carotenoids, including lutein, zeaxanthin, and beta-carotene, are another essential class of phytochemicals in corn flour, especially in yellow corn varieties. Lutein and zeaxanthin are crucial for eye health, as they filter harmful blue light and protect against oxidative damage, potentially reducing the risk of age-related macular degeneration (AMD) and cataracts (Ali *et al.*, 2023). Studies suggest that diets rich in these carotenoids can enhance macular pigment density and improve visual function (Grassi *et al.*, 2022). Beta-carotene, a precursor to vitamin A, is vital for immune function, vision, and skin health. The incorporation of corn flour into the diet can, therefore, contribute to adequate carotenoid intake, which has been linked to reduced risks of chronic diseases (Martinez *et al.*, 2023).

Alkaloids, while less prominent in corn flour than flavonoids and carotenoids, can still offer notable health benefits. Alkaloids such as zeaxanthin, often discussed in conjunction with carotenoids, have shown potential in promoting eye health and enhancing cognitive function (Nadeem *et al.*, 2023). Moreover, certain alkaloids found in corn, like nicotine in trace amounts, have been studied for their effects on mood and cognitive enhancement, although the context of corn consumption does not typically contribute significant quantities (Zhao *et al.*, 2023).

In addition to these primary phytochemicals, corn flour contains other beneficial compounds such as phenolic acids (e.g., ferulic acid and caffeic acid), which also provide antioxidant properties. Ferulic acid is known for its anti-inflammatory effects and potential role in reducing the risk of chronic diseases (Akinmoladun *et al.*, 2022). Another noteworthy group is phytosterols, which are plant-derived sterols that may help lower cholesterol levels and support heart health. While corn flour does not contain as high a concentration of phytosterols as other grains, their presence contributes to its health-promoting properties (Kumar *et al.*, 2023). Additionally, saponins found in corn can exhibit antimicrobial and immune-boosting effects, further supporting health (Hernandez *et al.*, 2023).



CONCLUSION AND RECOMMENDATION

The study compared proximate and phytochemicals properties of different corn flours produced from three varieties of maize. The study revealed that maize varieties exhibit significant differences in their nutritional and phytochemical properties. In terms of proximate composition, popcorn flour had the highest protein and carbohydrate content, making it a good source of energy and protein. White corn flour had the highest moisture content, indicating lower storage stability. Yellow corn flour had the highest crude fiber content, emphasizing its role in dietary fiber intake. In terms of phytochemicals, yellow corn flour had the highest flavonoid and alkaloid content, highlighting its potential contribution to bioactive compounds in the diet. The distinct nutritional profiles of each maize variety suggest that different maize flours have specific nutritional and therapeutic properties. It suggests that they should be selected based on their intended use in food production and nutrition.

- The following recommendations are made based on the findings of this study:
- In dietary applications, popcorn flour should be promoted as a protein and carbohydrate-rich flour, ideal for energy-dense diets.
- Yellow corn flour, due to its high fiber and phytochemical content, may be suitable for functional foods targeting digestive and cardiovascular health.
- Yellow corn flour, with its high flavonoid and alkaloid content, can be used in the production of functional health foods.

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