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PROXIMATE AND MINERAL PROFILING OF INDIGENOUS GRAINS: A COMPARATIVE ANALYSIS OF *TRITICUM AESTIVUM* L., *PENNISETUM GLAUCUM*, AND *SORGHUM BICOLOR* L. FROM KOGI STATE MARKETS

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ABSTRACT

This study aimed to evaluate and compare the proximate composition and mineral content of grains from *Triticum aestivum* L, *Pennisetum glaucum* and *Sorghum bicolor* L, all collected from Kogi State, Nigeria, using standard analytical methods. Each analysis was conducted in triplicate, and differences among samples were evaluated using one-way ANOVA at a significance level of $P \leqslant 0.05$. The results revealed significant nutritional differences across the grains. Notably, *Pennisetum glaucum* exhibited the highest levels of ash content (2.90±0.15%), crude fat (3.53±0.16%), fibre (8.80±0.33%) and the lowest moisture content (7.23±0.43%). In contrast, *Triticum aestivum* had the highest crude protein (12.43±0.55%) and carbohydrate content (70.74±0.55%). In terms of mineral content (mg/100g), the grains contained significant levels of essential minerals. *Pennisetum glaucum* had the highest concentrations of calcium (44.24±0.28 mg/100g), potassium (462.65±0.56 mg/100g), sodium (10.58±0.24 mg/100g) and zinc (2.88±0.24 mg/100g). Meanwhile, *Triticum aestivum* demonstrated the highest phosphorus concentration at 338.23±0.54 mg/100g, and *Sorghum bicolor* had the highest magnesium content at 162.48±0.21 mg/100g. Although all grains were nutritionally rich, their compositions varied significantly, highlighting their complementary roles in human diets. These findings support the dietary relevance of these indigenous grains in food fortification and nutritional interventions.

Keywords: Proximate composition, Mineral composition, *Triticum aestivum* L, *Pennisetum glaucum, Sorghum bicolor* L

INTRODUCTION

Cereal grain is one of the oldest components of human diet across many regions of the world, especially in sub-Saharan Africa, where it makes up a primary source of energy, protein, vitamins and minerals. Cereals, such as wheat, rice, barley, maize, rye, oats, millets and guinea corn, make up the most widely produced and consumed grains, with significant socio-economic and nutritional implications in Nigeria (Biel et al., 2020).

Kogi State in north-central Nigeria possesses a diverse agroecology, with ferruginous tropical soils, fertile alluvial floodplains, and a humid tropical climate that collectively influence the mineral composition of local cereals (Emurotu et al., 2024). Ferruginous soils enhance iron and manganese levels, while floodplains favour potassium and phosphorus accumulation in grains. Nigeria's ongoing dietary transition toward refined wheat and rice in urban areas, contrasted with rural reliance on millet and sorghum, has reduced dietary fibre and micronutrient intake, prompting the 2021 Nigerian Dietary Guidelines to emphasise indigenous grains. Recent meta-analyses and post-2020 grain fortification programs, including iron and folate enrichment, underscore the need for region-specific nutrient profiling to inform dietary recommendations and combat micronutrient deficiencies (Dorbu et al., 2025).

Wheat (*Triticum spp*.), millet, and sorghum are some of the most ancient and globally significant cereal crops, each with unique agronomic and nutritional characteristics that are essential for food security. Common wheat (*Triticum aestivum* L.), the most widely cultivated species of wheat, is valued for its high yield, nutritional quality, baking properties, and disease resistance. It contains 7.0–18.0% protein, 1.5–2.5% fat, 0.9–2.8% crude fiber, 60.0–75.0% total carbohydrates, 55.0–68.0% starch, and 1.2–2.0% total ash, along with significant levels of B vitamins, iron, and zinc (Ocheme et al., 2018). Millets, especially pearl millet (*Pennisetum glaucum*) and finger millet (Eleusine coracana), are drought-tolerant cereals that primarily originate from Africa. They are gaining renewed interest due to their adaptability to semi-arid climates and their increasing relevance in sustainable agriculture (Hassan et al., 2021). Millet grains are nutritionally dense, containing 6.8–14.0% protein, 1.7–7.0% fat, 1.2–3.6% crude fiber, 60.0–73.0% total carbohydrates, 55.0–65.5% starch, and 1.3–3.6% total ash (Eduru et al., 2021). They are also excellent sources of calcium, iron, and antioxidant phytochemicals. Guinea corn (Sorghum bicolor L.), the fifth most important cereal globally, is used for food, animal feed, and biofuel production. It is rich in protein (4.4–21.1%), fat (2.1–7.6%), crude fibre (1.0–3.4%), total carbohydrates (57.0–80.6%), starch (55.6–75.2%), and total ash (1.3–3.5%). It also contains various minerals and health-promoting phytochemicals such as phenolic acids and flavonoids, making it a valuable grain for both nutritional and industrial applications (Khalid et al., 2022).

Nutritional assessment of these grains involves the systematic evaluation of their macro and micronutrient content. These include the analysis of components such as carbohydrate, proteins, fats, fibre, moisture, ash and essential minerals like iron, calcium, phosphorus, potassium and zinc. Having a knowledge of the nutritional profile of millet, guinea corn and wheat cultivated in Kogi State not only provides valuable information for public health nutrition but also informs policymakers, food processing industries and food fortification initiatives aimed at fighting malnutrition.

This research intends to carry out a nutritional assessment of millets, guinea corn and wheat, sourced from various locations in Kogi State, Nigeria. By analysing their nutrient profiles, the research aims to contribute to the body of knowledge on indigenous grains and promote their utilisation in improving dietary quality and food security within the region and beyond.

MATERIALS AND METHODS

Sample Collection

Samples of wheat (*Triticum aestivum* L.), millet (*Pennisetum glaucum*) and guinea corn (*Sorghum bicolor* L.) were randomly collected from the International market (GPS: 7.8339° N, 6.7456° E), Lokongoma market (GPS: 7.8117° N, 6.7367° E) and Mami market (GPS: 7.8046° N, 6.7474° E) in Lokoja, Kogi State, from January 15th to 29th 2025. Triplicate samples of each grain type were collected from each market, then pooled and homogenised to form composite samples for laboratory analysis. This pooling approach minimised within-market variability while ensuring representative nutrient profiling. The samples were cleared of soil particles and transported to the laboratory for analysis at a tropical ambient temperature.

Sample Preparation

The wheat, millet and guinea corn seeds were sorted, and foreign objects and rotten grains were eliminated. The seeds were hand-separated from their shells and allowed to air dry for three days at ambient temperature. The dried wheat, millet and guinea corn grains were then crushed into a powder using a pestle and mortar and sieved into fine flour using a 250 µm sieve.

Determination of Proximate Composition

Standard analytical techniques as described by the Association of Official Analytical Chemists (AOAC, 2006) were applied to ascertain the moisture content, ash content, crude protein, crude fiber and percentage of fat. The carbohydrate content was determined by difference. Using the formula:

$$\%\ Carbohydrate\ content = 100 - (\%\ moisture + \%\ ash + \%\ crudeprotein + \%\ crudefiber + \%\ crudefat)$$

Determination of Mineral Concentration

Samples were digested according to the AOAC (2006) protocol for mineral analysis. After the sample was pulverised and weighed, 1.00 g was added to a 250 mL beaker. The beaker was filled with a strong acid mixture of 15.00 mL HNO_3 and 5.00 mL perchloric acid. The mixture was thoroughly mixed to ensure proper mixing and digested in a fume hood with acid-resistant lining until a clear solution was obtained. After letting the digest cool, it was quantitatively filtered and diluted to 100 mL with deionised water for analysis. Procedural blanks and spiked samples were processed alongside test samples. Spike recovery ranged from 90–105% for all minerals, and blank readings were negligible, confirming method reliability. All digestions were conducted in compliance with laboratory safety protocols for perchloric acid handling. To prepare the filtrate for trace metal analysis using the Scitek Atomic Absorption Spectrometer (Model SP-AA3618), the total volume needed to be brought up to 100 mL. The analyses were performed under the following conditions: Sodium (Na) was measured at a wavelength of 589.0 nm, Potassium (K) at 766.5 nm, Calcium (Ca) at 422.7 nm, Magnesium (Mg) at 285.2 nm, Zinc (Zn) at 213.9 nm and Phosphorus (P) at 213.6 nm. The detection limits of the AAS for the elements analysed include: Sodium (Na): 0.01 mg/L, Potassium (K): 0.05 mg/L, Calcium (Ca): 0.02 mg/L, Magnesium (Mg): 0.01 mg/L, Zinc (Zn): 0.005 mg/L and Phosphorus (P): 0.02 mg/L. Calibration curves were generated using certified standard solutions, and all elements showed excellent linearity ($R^2 \geq 0.998$).

RESULTS AND DISCUSSION

Table 1: Proximate Composition (%) of *T. Aestivum*, *P. Glaucum* and *S. Bicolor* grain Samples

Sample	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	Carbohydrate (%)
T. aestivum	8.51±0.11	2.82±0.22	2.40±0.08	3.10±0.24	12.43±0.55	70.74±0.55
P. glaucum	7.23±0.43	2.90±0.15	3.53±0.16	8.80±0.33	8.26±0.43	69.28±0.39
S. bicolor	10.11±0.52	2.40±0.10	3.51±0.12	2.05±0.14	12.40±0.25	69.53±0.48

Note: mean ± standard deviation

The Proximate Composition of Samples

The proximate composition of *T. aestivum, P. glaucum* and *S. bicolor* reveals important nutritional variations among these cereal grains that impact their dietary and industrial uses.

The moisture content ranged from 7.23±0.43 % in *P. glaucum* to 10.11±0.52 % in *S. bicolor*. Lower moisture content is desirable for longer shelf life and storage stability (FAO, 1995). The relatively high moisture in *S. bicolor* (10.11%) could make it more prone to microbial spoilage unless properly stored. These values are consistent with previous reports by Mepba et al. (2007), who noted moisture levels between 8% - 12% for common cereal grains.

Ash content, indicative of total mineral content, was highest in *P. glaucum* (2.90±0.15 %) and lowest in *S. bicolor* (2.40±0.10 %). This supports the findings by Saleh et al. (2013), who reported that pearl millet generally contains a richer mineral profile than other cereals. Wheat also showed a reasonably high ash content (2.82%), aligning with values reported by Devi et al. (2011) for whole wheat.

Fat content ranged from 2.40±0.08 % for *T. aestivum* to 3.53±0.16 % for *P. glaucum*. This corresponds with earlier studies by Taylor (2003) and Belton and Taylor (2002), which identified sorghum and millet as relatively high-fat cereals compared to wheat. Higher fat content in millet and sorghum enhances their energy density, making them suitable for weaning and therapeutic diets.

A remarkable difference was observed in fibre content that ranged from 2.05±0.14 % for *S. bicolor* to 8.80±0.33 for *P. glaucum*. This supports previous findings by Adéoti et al. (2017), who reported high dietary fibre in millet varieties. High fibre contributes to digestive health and may help in managing blood glucose levels (Culetu et al., 2021).

T. aestivum and *S. bicolor* showed similar protein contents (12.43±0.55 % and 12.40±0.25 %, respectively), while *P. glaucum* was lower (8.26±0.43 %). This is consistent with the report by Rumler et al. (2021), which noted *T. aestivum* and *S. bicolor* as good sources of protein, though their amino acid profiles differ. While *T. aestivum* provides gluten, *S. bicolor* and *P. glaucum* are gluten-free, which may benefit individuals with celiac disease or gluten intolerance.

All samples were high in carbohydrates, typical of cereal grains. *T. aestivum* had the highest (70.74±0.55%), while *P. glaucum* had the lowest (69.28±0.39 %). These values agree with earlier studies (FAO, 1995; Belton and Taylor, 2002), showing cereals as dominant energy sources in human diets (Eneogwe et al., 2023).

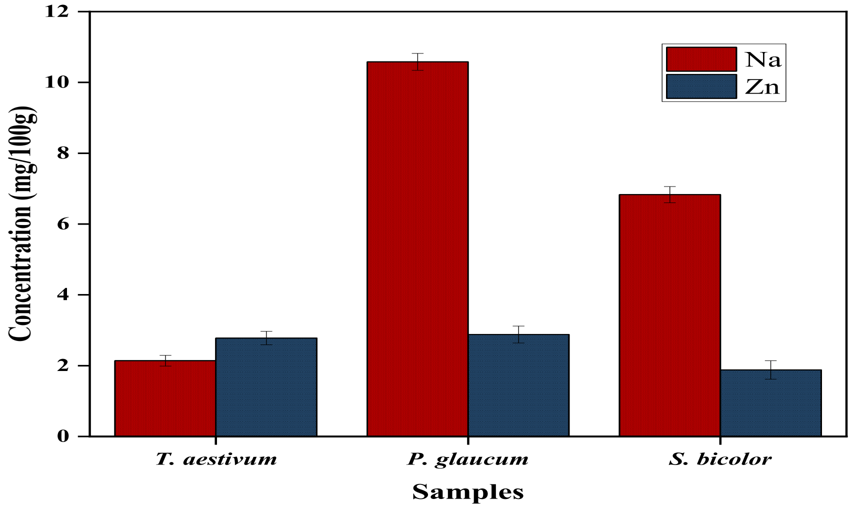

Figure 1: Sodium and zinc content of *T. aestivum, P. glaucum* and *S. bicolor* grain samples

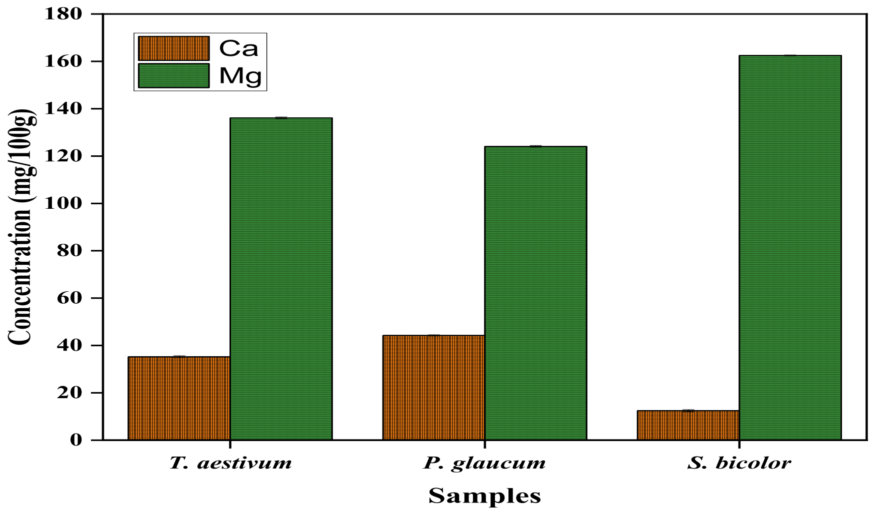

Figure 2: Calcium and magnesium content of *T. aestivum, P. glaucum* and *S. bicolor* grain samples

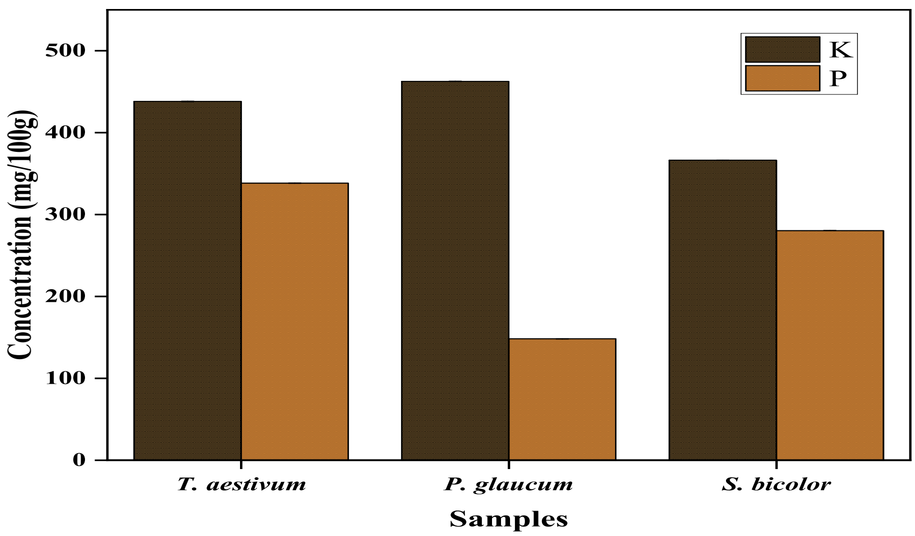

Figure 3: Potassium and phosphorus content of *T. aestivum, P. glaucum* and *S. bicolor* grain samples

Mineral Composition of Samples

The mineral composition of cereals is an important aspect of their nutritional quality, as minerals play key roles in metabolic processes, bone development, nerve function and enzyme activation. The current results reveal significant variation in mineral concentrations among *T. aestivum, P. glaucum* and *S. bicolor*.

Sodium levels ranged from 2.14±0.15 mg/100g in *T. aestivum* to 10.58±0.24 mg/100g in *P. glaucum*. Although cereals are not typically major sources of sodium, the elevated level in *P. glaucum* suggests possible environmental or varietal influences. FAO (1995) noted that sodium content in cereals is generally low unless enhanced by external contamination or soil composition. Higher sodium levels could contribute to electrolyte balance, but must be moderated in hypertensive individuals (Nishimuta et al., 2018).

P. glaucum recorded the highest zinc concentration (2.88±0.24 mg/100g) and *S. bicolor* contained the least (1.88±0.26 mg/100g). Zinc is vital for immune function and wound healing. These findings align with observations by Mertz et al. (1984), who identified pearl millet as a good source of bioavailable zinc, although phytates in cereals may hinder absorption (Gibson et al., 2010). Wheat's relatively high zinc is supported by data from Hussain et al. (2010), reporting zinc levels between 2.5–3.5 mg/100g in whole wheat.

Calcium levels varied significantly, with *P. glaucum* showing the highest value (44.24±0.28 mg/100g) and *S. bicolor* the lowest (12.48±0.46 mg/100g). This supports findings by Saleh et al. (2013), who noted that pearl millet contains more calcium than most common cereals, making it beneficial in bone health, especially in populations at risk of osteoporosis. Wheat's moderate calcium level (35.23 mg/100g) also aligns with standard values from McKillop (2021).

S. bicolor had the highest magnesium content (162.48±0.21 mg/100g), while *P. glaucum* had the lowest (124.08±0.41 mg/100g). Magnesium is crucial for enzyme activity and neuromuscular function (Rosanoff et al., 2012). Sorghum's high magnesium content was similarly reported by Awika and Rooney (2004), making it a valuable food for populations with magnesium-deficiency-related conditions.

Potassium content was highest in *P. glaucum* (462.65±0.56 mg/100g) and lowest in *S. bicolor* (366.23±0.34 mg/100g). Potassium plays a major role in blood pressure regulation and fluid balance (He & MacGregor, 2008). The high potassium content in pearl millet supports its use in cardiovascular-friendly diets.

Phosphorus was highest in *T. aestivum* (338.23±0.44 mg/100g) and lowest in *P. glaucum* (148.22±0.55 mg/100g). Phosphorus is essential for bone structure and energy metabolism (ATP production). The high phosphorus in wheat is consistent with literature from Shewry (2009), reflecting its prominence in whole grain wheat bran.

These mineral levels contribute meaningfully to the Nigerian Recommended Dietary Allowances (RDA) for children and adults. For instance, 100 g of P. glaucum can provide over 30% of the daily calcium requirement for children (FAO/WHO, 2011). However, mineral bioavailability may be limited by anti-nutritional factors. Despite *P. glaucum's* high calcium content, its estimated phytate:calcium molar ratio of 0.8 could reduce absorption efficiency (Wuni et al., 2025). This highlights the importance of processing techniques such as fermentation or germination to enhance mineral bioavailability. Therefore, claims regarding physiological benefits, such as bone health from calcium and blood pressure regulation from potassium, are conditional upon mineral absorption.

Beyond nutritional relevance, the grains have industrial potential. *P. glaucum* and *S. bicolor* are naturally gluten-free, making them suitable for specialised foods for gluten-intolerant individuals. Their high fibre and mineral content also position them as valuable ingredients for weaning foods, composite flours, and fortified cereal products.

CONCLUSION

This study aimed to investigate the nutritional composition of three types of grains: *Triticum aestivum, Panicum glaucum*, and *Sorghum bicolour*. The proximate composition analysis was used to determine the distribution of macronutrients in the grains, shedding light on their potential as dietary sources. The results showed that *P. glaucum* grains had the highest levels of ash, crude fat, crude fibre and the least moisture content, while *T. aestivum* grains had the highest protein and carbohydrate content. Regarding mineral content, *P. glaucum* had the highest concentration of sodium, zinc, calcium and potassium. Phosphorus was most abundant in *T. aestivum*, while magnesium was most abundant in *S. bicolor*. These disparities in mineral content provide valuable insight into the diverse nutritional benefits offered by these grains as well as the extent to which they play crucial roles in various physiological functions within the human body. While these grains are mineral-rich and industrially relevant, considerations of phytate-induced mineral limitation and bioavailability are essential.

The study recommends integrating *P. glaucum* and *S. bicolor* into school feeding programs, child nutrition initiatives, urban diets, and national fortification strategies to enhance public health and reduce dependence on refined cereals. Future research should prioritise bioavailability assays, assessment of anti-nutritional factors, and processing methods such as germination, fermentation, and extrusion to improve mineral absorption and develop functional, gluten-free and fortified food products.

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