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Nutritional contents of improved millet, maize, rice, beans and sorghum consumed around Challawa industrial area, Kano State

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Abstract

This paper evaluates the nutritional contents of improved millet, maize, rice, beans and sorghum consumed around Challawa industrial area, Kano State. In conducting this study, physicochemical analysis was performed. The results reveal that maize have higher moisture and energy, beans contain higher amount of fiber and protein while millet has higher amount of ash and fat. Carbohydrates represent the highest proportion of the dry matter of the crops with sorghum having the highest content. Zn, Cu, & Mg were high in millet, Ca, Na & K were high in beans with Sorghum having the highest Fe & P content The Na/K ratio is below the standard limit in all the crops indicating that they are good in the diets for good health. The crops are rich in phytochemical compounds such as phenolic acid, flavonoids, and tannins. It is also important to take into cognizance the presence of antinutritional compounds such as phytates and oxalates. The results show that all the crops studied represent potential sources of energy and also has significant sources of fibers and minerals.

Key words: Cereals, Nutritional Value, Energy, Antinutritional Compounds

INTRODUCTION

Nutritional content is a critical component of public health and economic development. Improved crop varieties, developed through biotechnology and advanced agricultural practices, can enhance nutritional composition, thereby providing a sustainable solution to nutritional inadequacies. Nutritional deficiencies, often resulting from inadequate dietary intake, impact millions worldwide, particularly in developing regions. Micronutrient deficiencies, commonly referred to as "hidden hunger," lead to detrimental health outcomes including anemia, weakened immunity, and developmental delays. According to the World Health Organization (WHO), nearly 2 billion people suffer from micronutrient deficiencies, highlighting the need for targeted interventions (WHO, 2020).

Improved crop varieties are developed through selective breeding, genetic engineering, and modern farming techniques to enhance yield, pest resistance, and nutritional value. These crops often boast higher levels of essential vitamins and minerals compared to their traditional counterparts. For instance, "Golden Rice," genetically engineered to produce beta-carotene, aims to combat vitamin A deficiency, particularly in regions where rice is a staple (Potrykus, 2001).

Crops such as iron-biofortified beans and zinc-biofortified wheat have shown increased levels of these essential micronutrients. A study by Stein *et al.* (2008)

demonstrated that biofortified beans significantly improved iron status in women of childbearing age. Improved varieties of crops contain higher protein and micronutrient content, promoting better dietary diversity (CIAT, 2018)

Nutrient-rich crops can diversify diets, combating malnutrition effectively. Improved crops can provide farmers with better income opportunities through higher market demand, further enhancing community nutrition (Fan *et al.,* 2016). Ensuring that these improved varieties reach smallholder farmers, particularly in remote areas, is crucial for their successful adoption. Improved crop harvests, with enriched nutrient compositions, offer promising substitutes to boost nutritional security. These crops can contribute significantly to global health outcomes by addressing micronutrient deficiencies and enhancing food diversity. Improved crop varieties offer the potential to enhance nutrient intake. This study aims to determine the nutritional composition of selected improved crops harvested by smallholder farmers and assess their potential as substitutes for traditional crops, contributing to nutrition security.

MATERIAL AND METHODS

Study area

The research was carried out in the Challawa industrial area of Kumbotso Local Government area of Kano State in the North-Western part of Nigeria which lies between latitude 120 37' North, 90 33' South and longitude 90 29' East and 70 43' West.

Samples and sample collections

Improved verities of harvested crop samples of millet, maize, rice, beans and sorghum were collected from the smallholder farmers under the Kano State Agricultural Development Project. The crops were weighed, dried in the oven (Gallenkamp Oven Model SA 9059 B) at 50^{o}C, ground into powder, and then sieved with No. 72 mesh size. The samples were stored in plastic containers with screw caps and kept in the freezer until use.

Proximate composition:

The moisture, ash, fiber, protein, and fat content was determined by the method of Official Analytical Chemists (AOAC (2000), and carbohydrate content was determined by difference.

Energy value was estimated by the Atwater principle of calculation based on 17kJ/g carbohydrate, 17kJ/g protein, and 37 kJ/g fat (James, 1986).

Mineral Analysis

The mineral contents (Mg, Ca, K, Na, Zn, and Fe) of the harvested improved crops were determined using an Atomic Absorption Spectrophotometer (AAS). Minerals were determined after wet digestion with nitric acid and perchloric acid mixture (HNO_3/$HClO_4$; 4:1, v/v) using the Alpha 4 Model Atomic Absorption Spectrophotometer, while sodium and potassium were determined with the Flame Absorption Photometer (Corning Ltd, England).

Phytochemical Contents Analysis

The polyphenols were determined based on the method of Singleton *et al.* (1999) using Folin-Ciocalteu's reactant on the methanolic extract. The optic density is read with a spectrophotometer at 725 nm against a blank.

The content in flavonoids were determined with the method of Meda *et al.* (2005), on the methanolic extracts, using the aluminum trichloride and sodium acetate as reactant. The absorbance is read with a spectrophotometer at 415 nm against a blank.

The assaying of tannins was carried out based on the method described by Bainbridge *et al.* (1996), and vanillin was used as reactant on the methanolic extracts. The absorbance is read with a spectrophotometer at 500 nm against a blank.

Antinutritional Contents Analysis

Phytates are quantified based on the methods described by Latta and Eskin (1980) under magnetic agitation which is associated with the reactant of Wade. The absorbance was read with a spectrophotometer at 490 nm against a control.

Oxalates were measured out using the method of Day and Underwood (1986). The sample was homogenized in the soda under magnetic agitation, filtered on Whatman paper and titrated immediately with a solution of potassium permanganate.

Statistical Analysis

Analysis was carried out in triplicate on the samples obtained, and the results were presented as the mean and standard deviation of all determinations. Analysis of variance was used to assess and compare results. Statistical analysis was carried out using Microsoft Excel Statistical Packages (Microsoft Corporations, USA) and Graph-Pad Instat-3 Packages (Graph Pad Software Inc, USA).

RESULTS AND DISCUSSIONS

Table 1. Proximate compositions of smallholder's harvested crops (% dry weight basis).

Samples/Compositions	Millet	Maize	Rice	Beans	Sorghum
Moisture	11.10±0.14	12.16±0.08	10.08±0.04	8.85±0.42	9.01±0.72
Ash	3.93±0.08	2.09±0.20	1.14±0.05	2.67±0.18	1.96±0.17
Fiber	**11.20±0.09**	**11.87±0.21**	8.52±0.10	14.87±0.12	**13.34±0.08**
Protein	12.47±0.14	9.75±0.06	5.22±0.05	21.92±0.46	11.87 ±0.14
Fat	4.85±0.10	**3.70±0.08**	1.12±0.30	3.58±0.93	3.87±0.09
Carbohydrate	67.45±0.79	77.06±0.68	50.63±0.61	42.72±0.14	75.02±0.56
Energy (kJ)	373.01±16.9	381.79±17.2	118.41±13.2	354.78±18.4	378.27±0.06

Mean ± SD of triplicate analysis

The result of proximate content is presented in Table 1. Moisture content is a measure of the bio-degradability of food due to the action of microorganisms afforded by water activity (Mariam, 2005). The percentage moisture content ranged from 8.87 to 13.76%, with beans having lower moisture while, maize have the highest content. Millet tends to have slightly higher moisture content than sorghum and beans, reflecting how grains are stored and processed. Njokuan *et al.* (2020) found moisture levels to be about 13% which is almost similar to the present study. The ash, which is a measure of mineral content ranged from 1.14 to 3.93% and was significantly higher ($p < 0.05$) in millet. Millet and beans have higher ash content compared to others, indicating a richer mineral profile. The range of ash reported compared favorably with 0.2 to 2.1 % ash reported for cereals (Tee *et al.,* 1989).

Fiber intake has been found to increase the process of digestion and bowel movement. Inadequate intake was reported to predispose consumers to cancer of the colon, constipation, irritable bowel syndrome, overweight and obesity, coronary heart disease, and diabetes (Wu *et al.,* 2003). The value reported for fiber (8.52 to 14.87%) was lower than the range of 16 to 32% reported by Mardukorsin *et al.,* 2009. Millet, maize, beans, and sorghum tend to have higher fiber content, contributing to better digestive health. Sharma and Gupta (2021) reported that rice varieties had higher total dietary fiber (4-5%) which is lower than the present study. Beans (42.72%) have low carbohydrate content because it is leguminous. Maize (77.06%) provides high carbohydrate content. This makes it a primary energy source in many diets. Mohan *et al.* (2019) demonstrated that maize can have significantly higher carbohydrate content (72-75%) but lower fat (3 - 4%) due to selective breeding.

The calculated energy (kJ) showed that maize (381.79%) has the highest value. The energy provided by maize is crucial for daily activities. This study is in agreement with the findings of Bowman *et al.* (2004) that grains foods are high-energy foods that have been reported to promote the occurrence of overweight and obesity among children. Patel *et al.* (2020) noted that energy content remained high and consistent (360-370 kJ) across both varieties. Kumar and Verma (2021) found that sorghum varieties yielded higher energy levels (350-370 kcal/100g) but reduced protein content (8-10%).

The protein content ranged from (5.22 to 21.92%) with the highest value reported for beans. The least protein content was reported for rice, this result is consistent with the observation that rice has low protein and amino acid composition (Nassar and Sousa, 2007). Beans and sorghum offer high protein levels, making them valuable for vegetarian diets. Khan *et al.* (2021) found that millet varieties showed increased protein content (12-14%) but varied fiber content depending on breeding methods.

Table 2. Mineral contents of smallholders harvested crops (mg/kg)

Samples/ Compositions	Millet	Maize	Rice	Beans	Sorghum	
Iron	7.98 ±0.03	2.32 ± 0.07	3.0 ± 0.4	6.6 ± 0.71	8.63±0.62	
Zinc	4.17 ± 0.08	1.25 ± 0.11	1.8 ± 0.9	2.1 ± 1.9	2.25±0.03	
Copper	2.28 ± 0.45	1.43 ± 0.11	0.74± 0.05	2.03 ± 0.4	1.63 ± 0.14	
Calcium	82.57 ± 1.83	25.68±3.12	20.0 ± 3.79	148.11±5	59.35 ± 2.84	
Magnesium	155.34±1.61	101.45±0.73	41.56±0.1	76.32±0.3	149.56±1.29	
Sodium	2.26 ±0.23	4.04 ± 0.67	69.45±8.6	76.34±33	9.87 ± 1.54	
Potassium	399.74±28.65	288.37±9.45	142.11±12	498±23.65	313.65±48.88	
Phosphorus	418.08±67.54	414.83±30.1	101.1±9.1	329.01±56	422.76±48.76	
Na/K Ratio	0.006	0.014	0.49	0.15	0.03	0.60

Minerals are known to play vital roles in the maintenance of human health (Uauy *et al.,* 1998). The result of iron content (Table 2) indicated that Sorghum (8.63%), Millet (7.98%) and Beans (6.6 %) recorded significantly higher value ($p < 0.05$) than Maize (2.32 %) and Rice (3.0%). The zinc, copper and magnesium were significantly ($p < 0.05$) higher in millet. Zinc is an important trace element whose function is associated with growth, normal embryogenesis, foetal growth and colostrum production during lactation. Studies in human and animals have shown that zinc is essential for normal and functional maturation of immune system. It also promotes the transport of lipid from the small intestine to the blood. In living tissue, zinc has been found to be essential for the mechanism of taste and smell. Copper has been known to be associated with lipid metabolism and deficiency of copper can significantly increase the plasma cholesterol concentration.

Calcium (20.0 – 148.1mg/kg), Sodium (2.26 – 76.34mg/kg) and potassium (142.11 – 498.23mg/kg) were higher in beans. Calcium is essential for bone development and prevention of osteoporosis and may also reduce the absorption of dietary fat thereby lowering serum total cholesterol and low- density lipoprotein cholesterol concentration (Vaskonen, 2003) while potassium is involved in both electrical and cellular function in the body. It has various roles in the metabolism, for instance it is essential for the regulation of acid - base balance and water balance in the blood and body tissues. Total body potassium is reported to be an index of the body's cell mass (He *et al.*, 2003). The sodium-potassium ratio ranged from (0.006 – 0.49) with millet having the least ratio and rice is having the highest. The standard ratio that favoured non-enhancement of high blood pressure disease is given as 0.60. The ratio in all the crops is below this ratio, this implies that they are good in the diets for good health

Beans exhibit the highest calcium content, essential for bone health. Millet and sorghum also provide good calcium supplies, advantageous for diets lacking dairy. Ghosh *et al.* (2021) report a high mineral content in millet varieties used in Indian diets, finding average calcium levels around 20-35mg/kg. Millet and sorghum stand out for their magnesium content, which is important for muscle and nerve function. Ghosh *et al.* (2021) report that millet can provide approximately 90-120 mg/kg of magnesium, making it a good source for dietary inclusion. Sorghum and beans are good sources of iron, which supports hemoglobin formation. Smith *et al.* (2022) show beans can have iron levels ranging from 2.5-5 mg, highlighting their importance in vegetarian diets. A study by Rojas *et al.* (2019) found that different maize varieties have low mineral content, particularly iron (0.5-1.5). A comprehensive analysis by Smith *et al.* (2022) indicates that beans are rich in calcium and iron, making them a crucial component of plant-based diets.

Table 3. Average content of phytochemical compounds in cereals (mg/100g)

Parameters	**Millet**	**Maize**	**Rice**	**Beans**	**Sorghum**
Phenolic acids	64.75±0.54	159.65±2.11	122.34±0.45	125.98±.77	98.65±0.89
Flavonoids	2.02±0.23	4.45±0.34	3.88±0.43	2.97±0.12	1.54±0.26
Tannins	68.33±0.45	39.78±0.87	19.98±0.89	32.09±0.98	62.97±0.74

The phenolic acids, flavonoids, and tannins (expressed in mg/100g) are high for all the crops under study (Table 3). The phenolic acids contents ranged from (64.75 – 159.65mg/100g) with Maize (159.65mg/100) having the highest content, while millet (64.75mg/100g) contain least phenolic acids than sorghum (98.65 mg/100g), rice (122.34 mg/100g), and beans (125.98 mg/100g). Sorghum (1.54mg/100g) contains the lowest amount of flavonoids, while maize (4.45mg/100g) has the highest content. For tannins contents the value ranged from 19.98 – 68.33mg/100g with millet (68.33mg/100g) having the highest content and rice is having the lowest. The analysis further revealed that they are rich in phytochemical compounds such as phenolic acids and tannins. The values found in this study are higher than the ones reported by Defan *et al.*, (2015) for maize and inferior to the content reported by N'Dri *et al.*, (2012) for sorghum, and millet. Those compounds give therapeutic properties, especially anti-inflammatory, antibacterial, antioxidant, antithrombotic, heart protection, and vasodilatory (Udeh *et al.,* 2017).

Table 4. Average content of antinutritional compounds in cereals (mg/100g of DM)

Parameters	**Millet**	**Maize**	**Rice**	**Beans**	**Sorghum**
Phytates	28.14 ± 0.43	17.93 ± 0.21	12.01 ±0.49 a	19.48 ± 0.32	15.99 ± 0.19
Oxalate	115.34 ± 1.54	108.87 ± 0.87	78.34 ± 0.34	76.45 ± 0.76	124.45 ± 1.43

Table 4 gives the values of antinutrional compounds expressed in mg/100g. The results shows that the content of phytates is higher in millet (28.14mg/100g) than beans (19.48mg/100g), maize (17.93mg/100g), sorghum (15.99mg/100g) and rice (12.01mg/100g). Meanwhile, sorghum contains more oxalates (124.45mg/100g) than millet (115.34mg/100g), maize (108.87mg/100g), rice (78.34mg/100g) and beans (76.45mg/100g). The values for the present study are in agreement with that of Ikram *et al.*, (2013). Phytates have a strong binding capacity and can make up insoluble complexes with proteins and some minerals such as iron and zinc.

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REFERENCES:

1. AOAC (2000). Official methods of analysis. Association of Official Analytical Chemists Edition, Washington DC, 684p
2. Defan, K. P., Akanvou, L., Akanvou, R., Nemlin, J. P. & Kouamé, P. L. (2015). Evaluation morphologique et nutritionnelle des variétés locales de maïs (Zea mays L.) produites en Côte d'Ivoire. Afrique Sciences, 11 (3):181-196.
3. Ghosh, D., et al. (2019). "Nutritional improvement of millet grains through plant breeding." *Journal of Cereal Science*, vol. 89, pp. 102-109.
4. Ikram, M. N., Isam, M. A., Suha, O.A., Mohamed, M. E. & Elfadil, E. B. (2013). Effect of processing methods on antinutritional factors, protein digestibility and minerals extractability of winter sorghum cultivars. Australian Journal of Basic and Applied Sciences, 7 (12): 229-237.
5. Meda, A., Lamien, C. F, Ronoto, M., Milogo, J. & Nacoulma, O. G. (2005). Determination and total phenolic, flavonoids and proline contents in Burkina Faso Honeys has well as their radical scavenging activity. Food Chemistry, 91: 571-577.
6. N'Dri, Y. D (2012). Potentialités nutritionnelles et antioxydantes de certaines plantes alimentaires spontanées et de quelques légumes et céréales cultivés en Côte D'Ivoire. Thèse de Doctorat des Sciences de la Vie et de la Santé Biologie médicale, pathologie humaine et expérimentale et environnement, università degli studi di parma facoltà di Agraria, 123
7. Padulosi, S., Mal, B., Bala Ravi, S., Gowda, J., Gowda, K. T. K., Shanthakumar, G., Yenagi, N. & Dutta, M. (2009). Food Security and Climate Change: Role of Plant Genetic Resources of Minor Millets. Indian. Journal of Plant Genetic. Resources. 22 (1): 1-16.
8. Platel, K., Eipeson, S.W. & Srinivasan, K. (2010). Bioaccessible mineral content of malted finger millet (Eleusine coracana), wheat (Triticum aestivum), and barley (Hordeum vulgare). Journal of Agricultural and Food Chemistry, 58: 8100-8103.
9. Singleton, V. L., Orthofer, R. & Lamuela-Raventos, R. M. (1999). Analysis of total phenols and other oxidant substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods Enzymology, 299: 152- 178.
10. Udeh, H.O., Duodu, K.G. & Jideani, A. I. O. (2017). Finger millet bioactive compounds, bioaccessibility, and potential health effects a review. Czech. Journal of Food Sciences, 35: 7-17.