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Proximate and Mineral Composition of Some Selected Sorghum Varieties in Kano Metropolis

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Abstract Sorghum is a major food source in the arid and semi-arid parts of the world especially among people with low socioeconomic status. It is a good source of energy, protein, minerals, dietary Fibre. The study revealed a high nutritional quality in terms of macro elements of the studied sorghum varieties which are locally sourced and relatively cheaper sources of food for a teeming population like ours. The sorghum varieties were obtained from Kano State Agricultural and Rural Development Authority (KNARDA)kano state, Nigeria. The sorghum varieties (samsorg-41, samsorg-45, and samsorg-46) were cleaned by washing in water, de-watered, sun-dried, milled into flour and stored in transparent plastic buckets container. The standard method was used to determine the proximate and mineral composition data were analyzed by one-way analysis of variance (ANOVA) using STAR software.The result of the moisture content for sorghum varieties ranged between 3.30% - 7.05% with a mean of 5.83% and a coefficient of variation of 0.71%. The ash content is an indication of the mineral content of a sample. Ash content of a sample cultured in 3 different varieties was found in the ranged 0.95 - 2.43% with a mean of 1.46% and coefficient of variation of 0.68%. The ash content of the sample may be affected by the nature and amount of ion present on the soil from which plants draw their food. The lipid content ranging from 2.44% - 2.66% with a mean of 2.53% and coefficient of variation of 0.39%.The low level of lipid in the samples attests to the suitability of the sample for baking in terms of good keeping quality while sufficient enough to participate in the formulation of dough structure. The high rate of nitrogen fertilizer was reported to reduce seed oil content in India. Fat is more concentrated energy food than carbohydrates. The energy value of fat 9-kilo calories per gram compared to 4-kilo calories per gram of carbohydrates. The results of the protein content obtained in this study ranged between 10.39% - 11.33% with a mean of 1.24% and coefficient of variation of 0.80%.The variations in protein content of the various varieties are primarily due to the nature and deficiency of essential elements required for plant life. The quality of a protein is determined by the varieties of the amino acid which it contains and which in consequence it can give to the body protein of vegetable origin, however, does not in general, provides all the necessary amino acid and hence it has limited biological value and it is referred to as second class 10-20% protein content required for good baking quality. The crude fiber as contained in this study ranges between 1.08%-1.50%, with a mean of 1.24 and a coefficient of variation of 0.80% respectively. the mineral content of each essential elements followed the sequence of K > Mg > Ca in all the three sorghum varieties/cultivars in the analyzed samples as confirmed by the percentage of elements with respect to the ash content, the content of Zinc as a micro-element followed the sequence samsorg-41 = samsorg -45 > samsorg-46 respectively,the trace elements lead and cadmium was minimally observed in all the sorghum varieties.

Keywords: *samsorg-41, samsorg-45, samsorg-46, chemical composition, sorghum*

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1. Introduction

Nigeria as a country is faced with the problem of feeding its teeming population; therefore it is important to explore local biodiversity such as millet which are at present underutilized. In many developing countries such as Nigeria, malnutrition is an endemic dietary problem characterized by protein-energy malnutrition and micronutrient deficiency (WHO, 2005). The determination of the nutritional composition of these sorghum varieties resolve a long way in providing information (nutritional data) about the selected sorghum varieties, which in turn will create awareness about the underlying potentials of this under-utilized cereal, hence increasing utilization both industrial and household levels, hereby going a long way in achieving the core objectives of this country in feeding its teeming populace with safe and nutritious food.

Sorghum (Sorghum bicolor) is an important food crop, particularly in arid and semi-arid tropics. It is a dual-purpose crop providing staple food for human consumption (35%) and the rest as a fodder for livestock, alcohol production as well as preparation of industrial products [1]. Many people in Africa and Asia depend on sorghum as the stuff of life. Being a drought-tolerant crop, it can give dependable and stable yield in both raining and post raining seasons. It thrives with less rainfall than is needed for rice and maize and can be grown where no other major cereal can be cultivated. Altogether, sorghum is one of the several really indispensable crops required for the survival of man. According to [2] report, sorghum was grown globally on an area of about 46 million ha with a production of about 60 million tons. The role of plants in the maintenance of good health is well known. These plants constitute an enormous reservoir of a wide variety of compounds, which exhibit some medicinal and nutritive properties [3]. Sorghum food material is readily available in Nigeria and has promising nutritional attributes. Whole sorghum grain is an important source of B-complex vitamins and some minerals like phosphorous magnesium, calcium, and iron [2]. The protein content of sorghum is similar to that of wheat and maize, with lysine as the most limiting amino acid [2]. Sorghum, guinea corn or great millet (sorghum bicolor) is the world's third important food grain being exceeded in utilization for food by wheat and rice. It is the chief grain food in much of Africa, Asia and South America. In Nigeria, sorghum is also known as guinea corn. The composition of sorghum grain is similar to maize in many respects. Typical analytical figures for the grain are starch 68-80%, protein 1015%, moisture 11-12%, fat 3%, fibre 2%, ash 2% food energy 394 calories. It ranks second to maize in total available energy among the cereal grains [4]. Nutritionally, sorghum has high carbohydrate content in the form of starch. The protein content is significant and comparable to that of wheat and maize but its digestion is an obstacle to its nutritive value. It has a high-fat content than wheat or rice, but, it is lower than that of maize. Some varieties of sorghum have high dietary fiber content. Unfortunately this tends to have adverse effect on the availability of some nutrients. Sorghum is also known to be a rich source of B-complex (β-carotene), but its quantity also varies with the environment in which the sorghum was grown [4]. Proximate analysis is the most common analysis done for nutrient testing. Proximate testing includes fats, proteins, moisture, fibre, ash and carbohydrate. Each of the proximate test has testing varations that are applied to specific food types [5]. An element is essential when it is consistently determined to be present in all healthy living tissues and when its deficiency symptoms are noted, with depletion or removal, which disappears when the elements are provided to the tissues [6]. Of the essential metals, iron, copper, and zinc are well known for their biochemical role in the human body. Iron is an essential metal in the biochemical system, i.e. hemoglobin in blood, which is the most important iron complex consisting of the globin protein with four heme units attached to it. Likewise, copper is found in enzymes capable of carrying oxygen as hemoglobin does, and it is actually required in the formation of this substance. Zinc, another essential element is approximately100 times as abundant as copper in the human body. It has the ability to occupy low symmetry sites in enzymes [7]. As far as non-essential elements are concerned, chromium is known to cause lung cancer. Lead accumulation results first in reduced functioning of kidney, liver and brain cells and later incomplete breakdown of the tissue. Cadmium and its compounds are also toxic to humans. They produce acute and chronic symptoms varying in intensity from irritation to extensive metabolic disturbance [8]. Minerals are a large family of nutrients essential to the human body, although some of them are present in the body in very small amounts, probably several part per million. They are designated as essential trace elements because most of them are the core elements of thousands of enzymes displaying various functions or acting as catalysts, for certain enzymes. They are also components of hormones and certain factors with special physiological function [9].

2. Materials and Methods

All the containers, glassware used were cleaned thoroughly with detergent, rinsed in tap water and finally distilled water. The reagents used throughout the analysis were of analytical grade. Three different samples were collected from Kano State Agricultural and Rural Development Authority (KNARDA) in a cleaned plastic bucket container. The samples were sorted, cleaned and ground separately using a very thoroughly clean milling machine to a powder form; they were stored in plastic containers for analysis.

2.1. Proximate Analysis of Some Selected Sorghum Varieties

Proximate analysis of food is the determination of the major components of food which includes moisture, lipids (fats), ash (mineral), protein, carbohydrate, and fiber. The procedure used for the determination are as follows:

2.2. Determination of Moisture Content

Moisture Content was determined by the method of [10] Three grams of the samples was weighed into the moisture cans. The dish and its sample content were dried in an oven at 105oc for 3 hours in the first instance. The dish was removed, cooled in a desiccator and reweighed. The weight was recorded. The drying, cooling, and weighing were continued repeatedly until a constant weight was obtained by the difference. The weight of the moisture loss was determined and expressed in percentage. The procedure was repeated for all the samples. It was calculated as shown below:

% moisture content: Moisture (%) =(W1-W2) × 100 /W1

where: W1 = weight (g) of sample before drying

W2 = weight (g) of the sample after drying.

Determination of Fat content (Ether extract): The fat content of the samples was determined by the continuous solvent extraction method using a soxhlet apparatus. The method is described by [11]. A soxhlet extractor with a reflux condenser and a small round-bottomed flask (250ml) was fixed up. The flask was weighed after washing, dried and half-filled with normal hexane, Five grams (5.0g) of each sample was wrapped in a porous paper. The sample was put into a soxhletinflux flask containing 200ml of petroleum ether. The upper end of the reflux was connected to a condenser. By heating the solvent in the flask through an electric- thermal heater, it vaporizes and condensed into the reflux flask. Soon the wrapped sample was completely immersed in the solvent and remained in contact with it until the flask filled up and siphoned over thus carrying oil extract from the sample down to the boiling flask. This process was allowed on repeatedly for about 4 hours before the defatted sample was removed and reserved for crude fiber analysis. The weighed round-bottomed flask containing the lipid was dried in an oven at 60oc for 3 minutes. This is done to remove any residual solvent. The flask was later cooled in a desiccator and reweighed. This procedure was repeated for all the samples.

The weight of the fat (oil) extracted were determined and calculated in percentage as follows: % fat = W2-W1 x 100 W

Where W2 = weight of the flask and oil extracts

W1 = weight of empty extraction flask W = weight of sample

Determination of crude fiber: This was determined by the Wende method [11]. Five grams (5g) of the sample weredefatted during fat analysis. The pre-extracted sample was placed in fiber tech crucible, which was in turn placed in beaker contain 200ml of sulphuric acid (1.25% H2SO4) and heated on a steam bath at 950c for 2 hours. The acid was removed by suction and washed several times with boiled distilled water using two-fold muslin cloths to trap the particle. The washed samples were carefully transferred quantitatively back to the flask and 20ml of 1.25% NaOH solution was added to it and heated again on the steam bath for 30 minutes. The sample was washed as before with boiled water and was carefully transferred to a weighed porcelain crucible and dried in the oven at 105ocfor 3 hours. After cooling in a desiccator, it was reweighed (W2) and then put in a muffle furnace and burned at 550oc for 2 hours (until it became ash). Again it was cooled in a desiccator and reweighed. This procedure was repeated for all the samples. The crude fiber contents were calculated in percentages.

Crude fiber (CF) = Amount of crude fiber x 100 /Weighed of sample

Determination of Protein: The protein content was determined by the Kjeldahl method described by [11]. The total nitrogen was determined and multiplied with the factor 6.25 to obtain the protein. Then 0.5g of each sample was accurately weighed into a Kjeldahldigested flask and mixed with 10ml of concentrated sulphuric acid (H2SO4) that is Analytical Reagent Grade. A tablet of selenium catalyst (CuSO4 and Na SO4) was added to it and the mixture was digested (heated) under a fume cupboard until a clear solution was obtained in a separate flask. The acid and other reagents were digested but without a sample to form the blank control. All the digests were carefully transferred to 100ml volumetric flask using distilled water and made up to a mark in the flask. A 100ml portion of the digest was mixed with equal volume of 45% NaOH solution in the Kjeldahl distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% Boric acid solution containing three drops of mixed indicator (bromocresol, green and methyl red) and ammonia gas was released. The distilled sample was titrated against a 0.02MH2SO4 solution. Titration was done from the initial green color to a deep red endpoint. The nitrogen content was calculated in percentage. % Nitrogen (N2) = (100 x N x14 Vf) T W 100 Va

Where W = weight of the sample analyzed

Vf = Total volume of filtrate

Va = Volume of digest distilled of the assay

N = Normality (concentration of H2SO4 titrant)

T = Titre value - Blank.

Determination ofTotal ash: This was done using the furnace incineration gravimetric method [10]. Porcelain crucible was weighed and 5g of the sample was measured and put into a weighed porcelain crucible. The sample in the crucible was put in muffle furnace set at 550oc and allowed to burn for 2-3 hours. It was incinerated until light gray ash was obtained. The sample was cooled in a desiccator and reweighed. The procedure was repeated for all the samples. The weight of the ashes were obtained and calculated in percentage. % Ash = (W3-W2) x 100 W

Where W2 = original weight of crucible + sample

W3 = weight of crucible + crucible content after Ashing

W = weight of the sample.

Mineral analysis: The mineral analysis was carried out using Microplasma Atomic Emission Spectroscopy, Agilent Technologies 4210 MP-AES, FDGS Innovative Gas Company, at the Center for Dryland Agriculture Central Laboratory of Bayero University Kano.This was determined by the dry ash extraction method following, which specified mineral element. 2.0g of the sample (seed) was burnt to ashes in a muffle (as in ash determination) the resulting ash was dissolved in 100ml of dilute hydrochloric acid (1ml HCL) and the diluted to 100ml in a volumetric flask using distilled water. The digest so obtained was used for the various analyses. The procedure was repeated for all the samples.

3. Result and Discussion

3.1. Proximate Composition of Sorghum Varieties

Table 1 shows the result of the proximate composition of the Sorghum varieties used in this study where the moisture content of ranged between 3.30% - 7.05% with a mean of 5.83% and a coefficient of variation of 0.71% that agrees with the literature value reported by Mustapha and Magdi (2003) reported 8.33%8.58%. The ash content is an indication of the mineral content of a sample. Ash content of a sample cultured in 3 different varieties was found in the ranged 0.95 - 2.43% with a mean of 1.46% and coefficient of variation of 0.68%. The ash content of the sample may be affected by the nature and amount of ion present on the soil from which plants draw their food [12]. Mustapha and Magdi (2003) reported the ash content of 1.90% - 1.97% which is within the range obtained in this study but Abu (2001) reported ash content of 1.01% - 1.56% which also agrees with the result obtained in this work. The lipid content ranging from 2.44% - 2.66% with a mean of 2.53% and coefficient of variation of 0.39% which is similar to Abu, (2001) 2.22% - 3.65%. The low level of lipid in the sample attest to the suitability of the sample for baking in terms of good keeping quality while sufficient enough to participate in the formulation of dough structure (Martin et al., 1991). The high rate of nitrogen fertilizer was reported to reduce seed oil content in India [2]. Fat is more concentrated energy food than carbohydrates. The energy value of fat 9 kilocalories per gram compare to 4 kilocalories per gram of carbohydrates [13] The results of the protein content obtained in this study ranged between 10.39% - 11.33% with a mean of 1.24% and coefficient of variation of 0.80% which is in accord with the works of Torres et al., [14] of 9.01% - 11.43%; Asha et al .,[15] of 10.40% protein contents. The variations in protein content of the various varieties are primarily due to the nature and deficiency of essential elements required for plant life [16]. The quality of a protein is determined by the varieties of the amino acid which it contains and which in consequence it can give to the body [16] protein of vegetable origin, however does not in general, provides all the necessary amino acid and hence it has limited biological value and it is referred to as second class [17] 10-20% protein content required for good baking quality. The crude fiber as contained in this study ranges between 1.08%-1.50%, with a mean of 1.24 and a coefficient of variation of 0.80%.

Table 2 shows the Mineral composition of the macro-elements, micro-element and trace- elements of the sorghum varieties used in this study. Concerning ash content, the data in Table 1 showed that ash ranged from 0.98% to 2.43% with samsorg-41 exhibiting the highest value. These results are also in agreement with Moharram and Youssef [18] mentioned that the ash of sorghum grains differ from 1.30% to 3.40%.

3.2. Macro-Elements Content in the Sorghum Varieties Used in This Study

Calcium,Potassium and Magnesium analyses of the three sorghum varieties are reported in Table 2,the content of each essential elements followed the sequence of K > Mg > Ca in all the three sorghum varieties/cultivars in the analyzed samples as confirmed by the percentage of elements with respect to the ash content in Table 1. The most abundant mineral element was Potassium followed by Magnesium and Calcium respectively, a fact that is consistent with the literature data [19]. The potassium content of the samples varies from 98.98 mg Kg-1 to 110.09 mg Kg-1 which was relatively lower than 3434.46 to 6957.67 mg Kg-1the result obtained by Paola pontieri et al.,2014 even though, this may be due to the fact that there result is for a hybrid sorghum and this may have resulted to the higher concentration obtained in there study. The magnesium content varied from 16.06 to 17.01 mg Kg-, and, in particular, samsorg-45 contained higher amounts of magnesium (17.01 mg Kg-1). The magnesium content in all the three varieties was lower than that of corn flour (470 mg Kg-1) and wheat flour (250 mg Kg-1) as reported in Danish Food Composition Databank [20]. Calcium contents varied from 13.05-15.07 mg Kg-1, However, the calcium level obtained in the current study was lower than that reported by Shegro et al. [21], although Samia et al. [22] also recorded low values.

3.3. Micro-Elements Content in the Sorghum Varieties

Results obtained for the Zinc micro-element analysis were reported in Table 2, The content of Zinc as a micro-element followed the sequence samsorg-41 = samsorg -45 > samsorg-46 respectively. Zinc concentration varied from 0.32 to 0.40 mg Kg-1 which was relatively lower than the result obtained by [23].

Also the concentration of the trace elements analysis was presented in Table 2, but the result indicate a relatively very low traces of this elements in the current study, the levels do not exceed the maximum permitted by Regulation (CE) n. 1881/2006 that fixes a limit of some contaminants.

Table 1. Proximate composition of Sample Analyzed

Variety/Cultivar	Proximate composition (%)				
	Ash	MC	CP	CF	Ee
Samsorg-41	2.43±0.01^{a}	3.30±0.01^{b}	11.33±0.10^{a}	1.08±0.00^{c}	2.44±0.00^{c}
Samsorg-45	0.98±0.00^{b}	7.15±0.07^{a}	10.39±0.00^{b}	1.13±0.00^{b}	2.66±0.00^{a}
Samsorg-46	0.95±0.00^{b}	7.05±0.00^{a}	10.43±0.01^{b}	1.50±0.01^{a}	2.50±0.01^{b}
Mean	1.46	5.83	10.72	1.24	2.53
CV(%)	0.68	0.71	0.11	0.80	0.39

Values are mean of duplicate analysis. Mean ± standard deviations in the same column followed by the letter are not significantly different according to the new Duncans Multiple Range Test (MRT) at p≤0.05.CV=coefficient of variation, MC=moisture content, CP=crude protein, Ee=etherextract.

Table 2. Mineral composition of Whole Sorghum Varieties

Variety/Cultivar	Mineral composition (mg Kg-1)					
	Zinc	Cd	Ca	Pb	K	Mg
Samsorg-41	0.40±0.00^{a}	-0.26±0.00^{a}	15.07±0.00^{a}	0.01±0.00	98.98±0.00^{c}	16.43±0.38^{b}
Samsorg-45	0.40±0.00^{a}	-0.25±0.00^{b}	13.69±0.01^{b}	0.00±0.00	110.09±0.00^{a}	17.01±0.00^{a}
Samsorg-46	0.32±0.00^{b}	-0.26±0.00^{a}	13.05±0.00^{c}	0.00±0.00	105.39±0.01^{b}	16.06±0.07^{c}
Mean	0.37	-0.25	13.94	0.00	104.82	16.50
CV(%)	1.09	-1.58	0.06	0.00	0.00	1.36

[1]Values are mean of duplicate analysis.
[2]Mean ± standard deviations in the same column followed by the same letter are not significantly different (p≤0.05)
[3]CV=Coefficient of variation, Cd=Cadmium, Ca=Calcium, Pb=Lead, K=Potassium,Mg=Magnesium

4. Conclusion

The current analysis revealed that sorghum varieties contain appreciable nutrient contents eventhough there were variations in the nutritional profiles of the three sorghum varieties evaluated in the current study, which could be attributed to factors such as genotype, environment and growing conditions. Consequently, these selected sorghum varieties when properly utilized through effective product expansion programs have the potential of helping in overcoming malnutrition and hunger among the vulnerable groups in Nigeria. It can therefore be concluded that nutrient content and nutritive value should both be considered when selecting sorghum varieties for better nutrients utilization.

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