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COMPARATIVE NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF *SORGHUM BICOLOR* (L.) MOENCH AND *ZEA MAYS* L.

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Abstract: This study was carried out to determine the nutritional and phytochemical properties of freshly harvested grains of *Sorghum bicolor* and *Zea mays* using standard biochemical procedures. Nutritional properties analyzed included proximate composition analyzed using Soxhlet extraction, AOAC Kjeldal methods. Mineral contents were determined using Atomic Absorption Spectrophotometry [AAS] while the phytochemicals were determined using standard procedures. All analyses were replicated three times. From the results, crude protein content was low, with values, 7.81% and 6.66% for *Sorghum bicolor* and *Zea mays* respectively. Lipid analysis showed that *Sorghum bicolor* had a higher lipid content of 16.57%. Crude carbohydrate content was higher in both seeds. Percentage of crude fiber was 11.20% and 8.11% for *Sorghum bicolor* and *Zea mays* respectively. Vitamin C analysis showed that *Zea mays* had a higher content of 122.14 mg/100 g. Available energy kj/100 g was also analyzed for *Sorghum bicolor* and *Zea mays* respectively. Significant differences ($P \leq 0.05$) was observed in crude lipid, crude fiber, vitamin C, and available energy between the two seeds. Mineral analysis revealed appreciable contents of minerals necessary for healthy growth and development. Calcium content was highest in *Sorghum bicolor*. Significant differences ($P \leq 0.05$) was observed in phosphorus, magnesium, calcium, and iron between the two seed types. Phytochemical contents of the seeds showed significant differences ($P \leq 0.05$) in tannins, nitrates and saponin with 12.57 mg/100 g, 18.18 mg/100 g and respectively in *Sorghum bicolor* and *Zea mays*. Nitrate and saponin content was higher in *Zea mays*. Alkaloid, flavonoids and phytate contents was detected in both seeds. Minute amounts of oxalate and cyanide were detected in both seed types. It is important to note that *Zea mays* is under pressure as one of formidable food source due to the increasing demand, and thus, increasing the cultivation of *Sorghum bicolor* could alleviate the over dependence on maize as the primary source of nutrition for humans and animal feed formulation.

Keywords: animal-feed, anti-nutritional, guinea-corn, maize, nutritional.

Introduction

Sorghum bicolor is the scientific name of guinea corn, in Hausa land, it is called Dawa Jan-Jare, is local name and is the one of the categories of guinea corn, which belongs to the family Poaceae. It is native to North Africa, where it is cultivated for its grains which are used for food for human beings and animals and for ethanol production. Guinea corn is a cereal grain that originated in Africa and is eaten throughout the world. It is especially valuable in arid terrain because of its resistance to drought, guinea corn is a nutrient rich grain that is often ground into flour to make bread, porridge and pancakes. Typical flowering plant placed in the grass family

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of Poaceae, seventeen of the twenty-five species are native to Austria 10th the range of some extending to Africa, Asia Mesoamerica and certain islands in the Indian and pacific oceans. One species is grown for its grains, while many others are used as fodder plants either cultivated in warm climates worldwide. *Sorghum bicolor* is an important food crop particularly in arid and semi-arid tropics. It is a dual-purpose crop providing staple food for humans and as a fodder for livestock, alcohol production as well as well as preparation of industrial; products 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 cereals can be cultivated. Altogether, *Sorghum* is one of the indispensable crops required for the survival of man. According to FAO (1995) report, sorghum was grown globally on area of about 46 million ha with a production of about 60 million tons. However, in India, sorghum is cultivated on an area of about 7.65 million tons. The role of plants in the maintenance of good health is well known. These plants constitute an enormous reservoir of wide varieties of compounds, which exhibit some medicinal and nutritive properties. The leading producers of this valuable crop include Nigeria (12%), USA (10%), Sudan (8%) and Mexico (8%) reported by USDA (2016). *Sorghum* food material is readily available in Nigeria and has promising nutritional attribute. Whole sorghum grain is an important source or B-complex vitamins and some minerals like phosphorus, magnesium, calcium and iron, the protein content of sorghum is similar to that of wheat and maize with lysine as the most limiting amino acid [FAO, 1995]. Maize (*Zea mays* L.), commonly known as corn. It is another important member of Poaceae family, is the third world most important cereal crop universally following wheat, rice, occupies a pivotal role in world's economy and is second among cereals for human consumption after wheat [MULI *&* al. 2016]. It is the main source of income for smallholder farmers in Africa in general [YAREGAL & FIREB, 2019]. Maize is the cereal widely grown for throughout the world in a range of agro-ecological environment; maize is produced annually than any other grain crops. In 2017, Africa produces 7.4% of the 1,135 million tons produced world-wide in 40 million hectares according to data from FAO (1995). Out fifty species of maize exist and consist of different colors, texture and grain shapes and sizes [AZEVEDO & LEA, 2005]. The white and yellow varieties are the most preferred by most people depending on the region. Maize was introduced in the 1500s and has since became one of African's dominant food crops. The grains are rich in vitamins A, C and E, carbohydrate as well as essential minerals. Maize is staple food for almost half the population of Sub-Saharan Africa and is important for carbohydrate, protein, iron, vitamin B and minerals. The produce, maize meal (ugali), porridge, pastes, and beer, and can be boiled or roasted as fresh as it comes from the farm. Maize is also produced to produce oils for cooking. It is also very important crop for animal feed. Most of maize production in Africa is rain fed. Over the years, maize has become an important crop taking over acreages from traditional crops such as millet and sorghum. In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa [FAO, 2018]. Research effort by breeders and agronomists have led to the production of many technologies including the breeding of high yielding varieties that are tolerant to drought, diseases and striga infestation [KAMARA & al. 2014]. Maize is grown both (as sweet corn) for human consumption and (as field corn) for other uses such as animal feed and biofuels. Worldwide, only around 15% of maize production is used for human consumption with most production going to animal feed. However, the production of maize production for food production in developing countries is higher at 25 and even higher in regions such as South East Asia where it is estimated to 30-40% whilst in parts of Sub-Saharan Africa, it can be as high as 70-80%.

Materials and methods

Sample collection and preparation

Fresh grains of *Sorghum bicolor* and *Zea mays* were procured from Sokoto Agricultural Development Project [SADP] in Sokoto, Nigeria. The two seeds were taken to the Departmental Herbarium, Department of Plant Science for authentication, where voucher specimens were deposited. The two seeds were separately ground into fine powders and kept in a cleaned bottle until required for analysis.

Proximate and Ascorbic acid composition analysis

The micro-kjeldal method was followed for the determination of crude proteins. Crude lipids, crude fibre, moisture % and ash % were determined using the methods of [AOAC, 2005], while carbohydrate was determined by difference. The calorific values in kilo joule (kj) were calculated by multiplying the crude fat, protein and carbohydrate by Atwater factors of (k) 4, 4 and 9 respectively. Ascorbic acid was determined according to the method described by MUSA & al. (2010).

Mineral composition analysis of *Sorghum bicolor* and *Zea mays*

The mineral composition of the samples was determined by first dry ashing the samples at 550 ºC in the muffle furnace. The filtered solutions were used to determine Na, K, Mg, Ca, Fe, Cu, Zn, Co, Cd, and Ni by means of Atomic Absorption Spectrophotometer [AAS] [Buck Scientific Model-200A/210, Norwalk, Connecticut [06855] and phosphorus was determined calorimetrically by Spectronic 20 (Gallenkamp, UK) using the phosphovanado molybdate method [AOAC, 2005].

Phytochemical screening of seeds of *Sorghum bicolor* and *Zea mays*

Alkaloid, tannin and flavonoid contents were determined according to the method of TREASE & EVANS (1989) while the phytate contents was determined using the method as described by VAN-BUREN & ROBINSON (1981). Oxalate composition was analyzed following the method as described by YOUNG & GREAVES (1940). Cyanide contents was determined using the method of DAY & UNDERWOOD (1986), the nitrate content was determined following the method of WANG & al. (2005). Saponin was determined using the method of EL-OLEMY *&* al. (1994) while flavonoid was determined using the method of BOHM & KOPACI (1994).

Data Analysis

The results obtained has been presented as Means ± SE of the means. The data collected was subjected to analysis of variance (ANOVA) using GenStat$^{(r)}$ 18th edition, where the treatments were found to be significantly different, mean separation was carried out using Duncan's multiple range test (DMRT) at 5% level.

Results and discussion

Proximate and ascorbic acid composition of *Sorghum bicolor* and *Zea mays*.

Proximate composition of *Sorghum bicolor and Zea mays* in Sokoto, Nigeria has been presented in Table 1 below. From the results, values for % crude protein contain were the least 7.81% and 6.66%, obtained in *Sorghum bicolor* and *Zea mays* respectively. Crude lipid (%) analysis revealed 16.51% in *Sorghum bicolor* while 17.18% was recorded for *Zea mays* respectively. Total carbohydrate (%) revealed the highest contents with 79.64% obtained in *Sorghum bicolor*, while 82.39% was recorded in *Zea mays*. Crude fibre (%) revealed 8.20% was recorded for *Sorghum bicolor* while 8.11% was obtained in *Zea mays* respectively. Vitamin C contents revealed appreciable contents of the valuable ascorbic acid in both the seeds with 98.62 mg/100 g obtained in *Sorghum bicolor* while in *Zea mays* 122.14 mg/100 g was recorded. Available energy (kj/100 g) revealed that the two seeds were loaded with 396.90 k/cal per 100 g in *Sorghum bicolor* while 462.42 k/cal per 100 g in *Zea mays* respectively. The values of crude protein, % ash and crude fibre contents of 28.00%, 9.28% and 12.57% reported on *Moringa oleifera* by OKIKI *&* al. (2015) were higher than the obtained values in the current study. The difference could be attributed to species variability. However, obtained values obtained in the current study were higher than the reported value by the same author as above. Low value of ascorbic acid was reported to be 0.72 mg/100 g on *Moringa oleifera* while vitamin C contents as reported by RAIMI & al. (2014) was higher with 189.53 mg/100 g in seeds of *Vitellaria paradoxa*. In another study by AFOLAYAN & al. (2014), reported value of 542.40 mg/100 g was highest than the obtained values in the current study. Low value of vitamin C was however, reported to be 0.72 mg/100 g on *Moringa oleifera* by OKIKI *&* al. (2015). More so, the protein with 28.54% and lipid 22.47% reported by HASSAN & UMAR (2004) on dehulled seeds of *Parkia biglobosa* were higher than obtained values in the current study. Low value of carbohydrate was reported to be 37.87 %. Higher protein, % ash and % crude fibre contents of 28.00%, 9.28% and 12.87% were reported higher than obtained in the current study as reported by OKIKI & al. (2015) on *Moringa oleifera* and in a study by JACOB & al. (2015) on melon seeds. In another report on proximate traits of the seed and seed cake of Shea butter tree (*Vitellaria paradoxa*) in Nigeria's savanna ecozone, the range of crude carbohydrate as reported by the same author as above was 64.0% to 68.0% while that of crude protein ranged from 8.8% to 9.3% respectively.

Table 1. Proximate and ascorbic acid composition of *Sorghum bicolor* and *Zea mays*

Parameters	Units	*Sorghum bicolor*	*Zea mays*
Moisture content	%	5.90±0.63[a]	6.11±0.49[a]
Crude protein	% DW	7.81±0.99[a]	6.66±0.96[b]
Crude lipid	% DW	16.51±1.17[a]	17.18±1.17[a]
Total carbohydrates	% DW	79.64±2.19[a]	82.39±.2.10[a]
Crude fibre	% DW	8.20±0.86[a]	8.11±0.99[a]
Ash	% DW	6.23±0.63[a]	7.16±0.76[a]
Vitamin C	mg/100 g	98.62±3.46[a]	122.14±3.19[b]
Calorific value	kj/100 g	396.90±4.26[a]	462.42±4.46[b]

Values are means ± standard deviation of three replications. Values within a row with different superscripts were significantly different ($p \leq 0.05$).

Results of mineral analysis have been presented in Table 2. The table revealed that there was significant difference ($P \leq 0.05$) in the composition of potassium, magnesium, phosphorus and iron. Calcium was the most abundant mineral with 116.64 mg/100 g and 132.54 mg/100 g in seeds of *Sorghum bicolor* and *Zea mays* respectively. Analysis for phosphorus revealed the highest contents of 116.74 mg/100 g obtained in *Zea mays* while 96.72 mg/100 g was recorded in *Sorghum bicolor*. Magnesium contents was 62.12 mg/100 g obtained in *Sorghum bicolor* while 41.64 mg/100 g was recorded in *Zea mays*. Analysis for potassium revealed the highest content 56.96 mg/100 g and 46.72 mg/100 g respectively recorded for *Sorghum bicolor* and *Zea mays*. Manganese analysis revealed 52.76 mg/100 g in *Sorghum* *bicolor* while 48.66 mg/100 g was recorded for *Zea mays* respectively. Other essential minerals were zinc and iron with appreciable composition in the two seed types. In a report by MUNAHIRA & al. (2022), low values of iron, manganese and zinc were reported 1.87, 0.26 and 3.77 mg/100 g on *Lagenaria siceraria*. Higher values were reported for *Sesamum indicum* and *Moringa oleifera* by KARAYE & al. (2022). More so, low values of zinc and calcium were reported to be 0.58 mg/100 g and 82.50 mg/100 g on *Moringa oleifera* as reported by OKIKI & al. (2015). Also, low values of 30.24, 6.24, 0.30, and 0.72 mg/100 g on calcium, magnesium, manganese and zinc as reported by RAIMI & al. (2014) on seeds of *Vitellaria paradoxa*. Overall, the two seed types could be considered too well in terms of proximate and mineral profile. In a study by OKIKI & al. (2015), low values of iron and calcium were recorded 0.58% and 82.50%. However, higher values of zinc, magnesium and potassium were reported 64.17%, 643.33% and 430.00% reported by the same author as above. More so, higher iron and zinc contents of 144.70 mg/100 g and 21.05 mg/100 g as reported by JACOB & al. (2015).

Table 2. Mineral composition of the of seeds of *Sorghum bicolor* and *Zea mays*

Mineral (mg/100 g)	Symbol	*Sorghum bicolor*	*Zea mays*
Sodium	Na	7.72±0.93[a]	5.23±0.53[a]
Potassium	K	56.96±2.69[a]	46.72±2.26[b]
Magnesium	Mg	62.12±2.86[a]	31.64±1.62[b]
Phosphorus	P	76.72±2.99[a]	116.74±3.83[b]
Manganese	Mn	32.76±1.05[a]	48.66±276[b]
Calcium	Ca	116.64±3.14[a]	132.54±3.98[b]
Iron	Fe	23.06±1.62[a]	15.07±1.02[b]
Cupper	Cu	0.24±0.06a	0.31±0.04[a]
Chromium	Cr	0.06±0.03[a]	0.02±0.01[a]
Zinc	Zn	13.36±1.09[a]	11.74±0.98[a]
Nickel	Ni	0.07±0.04[a]	0.09 ±0.02[a]

Values are means ± standard deviation of three replications. Values within a row with different superscripts were significantly different ($p \leq 0.05$).

Results on phytochemical screening of *Sorghum bicolor* and *Zea mays* has been presented in Table 3. The results show a significant difference ($P \leq 0.05$) in the contents of tannins, nitrates, flavonoids and saponin between the two species. For instance, tannin was 12.51% DW in *Sorghum bicolor* while 18.18% DW in *Zea mays*. Nitrate content was 16.62% DW in *Sorghum bicolor* while it was 22.14% DW in *Zea mays*. Flavonoid content was 24.56% DW while it was 13.63% DW recorded in *Zea mays.* Saponin content was 22.23% DW obtained in *Sorghum bicolor* while it was 15.67% DW recorded in *Zea mays* respectively. In a report by KARAYE & al. (2013) on evaluation of selected Nigeria cucurbits, low values of phytate, cyanide and oxalate, compared to the obtained values in the current study, were reported on *Lagenaria aegyptiaca*, *Citrullus lanatus* and *Momordica balsamina* seeds. In another report by NWEZE & NWAFOR (2014), alkaloids were reported to be 3.56% DW and flavonoids 3.36% DW. However, it has been reported that climatic factors and stages of maturity could cause variation in the distribution of phytochemicals BAMISHAIYE & al. (2011) as well as the choice of solvent as different solvents have different extraction capabilities and spectrum of solubility for phytoconstituents [HANDA & al. 2008]. Low values of tannins, oxalate, saponin were reported to be 0.32, 0.93 and 1.67% DW as reported by AFOLAYAN & al. (2014) were lower than the obtained values in the current study. In a study by NWEZE & NWAFOR (2014).

Phytochemicals such as alkaloid was reported to be 3.56% DW, saponins 1.41% DW, tannins 9.36% DW and flavonoids 3.56% DW the values were lower than obtained in the current study. In addition, 19.1% DW and 13.80% DW were reported by FAGBEMI & al. (2005) to be higher than obtained in the current study. However, higher tannin and oxalate contents of 26.40% DW and 39.40% DW as reported on melon seeds by JACOB & al. (2015).

Table 3. Phytochemical composition of the seeds of *Sorghum bicolor* and *Zea mays* (presented as % DW)

Parameters	*Sorghum bicolor*	*Zea mays*
Alkaloids	11.23±0.78[a]	12.66±1.17[a]
Tannins	12.51±1.16[a]	18.18±1.42[b]
Phytate	9.64±0.94[a]	6.39±0.35[a]
Oxalate	6.12±0.46[a]	8.11±0.69[a]
Cyanide	0.03±0.07[a]	0.06±0.05[a]
Nitrate	16.62±1.36[a]	22.14±1.19[b]
Flavonoid	14.56±1.24[a]	13.63±1.11[a]
Saponin	22.23±1.78[a]	15.67±1.32[b]

Values are means ± standard deviation of three replications. Values within a row with different superscripts were significantly different ($p \leq 0.05$).

Conclusion

In conclusion, it is importantly pertinent to note that *Zea mays* is under pressure as one of the main foods used by man from time immemorial. There is nowadays, an immense pressure on maize as the food source and for use as a formidable source of feeds for fish and poultry. More so, due to the fluctuating weather conditions occasioned by less downpour, there is the urgent need to get alternative food source that may augment the maize used. Therefore, increasing the cultivation of *Sorghum bicolor* could alleviate the over dependence on maize as the primary source of nutrition for humans and animal feed formulation strategies.

Conflict of interest

The authors affirm that there is no conflict of interest amongst them.

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