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DETERMINATION OF NUTRIENTS AND ANTI-NUTRIENTS CONTENTS OF *Sorghum bicolor* and *Glycine max*

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ABSTRACT

Increasing consumption of *Sorghum bicolor* and *Glycine max* in most part of Northern Nigeria exists because of their acclaimed health benefit of treating malnutrition in children. However, there are nutritional disadvantage of their too much consumption. This study investigated the proximate, minerals, vitamins, amino acid composition, and phytochemicals of *Sorghum bicolor* and *Glycine max*. The parameters evaluated were moisture contents; ash contents; crude protein; crude lipids; crude fiber; carbohydrates; mineral ions; vitamins; amino acids and phytochemicals. The results obtained showed that all the proximate parameters, minerals; sodium, calcium and vitamins A, C, E and phytochemicals contents in the two samples are significantly difference at $p<0.05$. No significant different difference ($p<0.05$) was observed in the amount of magnesium, potassium and iron. Copper was not detected in *Sorghum bicolor* while tannin was not detected in *Glycine max*. Eighteen amino acids were detected in both the *S. bicolor* and *G. max*. Phytochemicals including saponins, glycosides, alkaloids, oxalates, and phytates were present at moderately higher concentrations in *S. bicolor* while tannins, steroids, and flavonoids were present in the samples. Sorghum plays an important role in the diet which serves as a major source of carbohydrate in both human and livestock diet for release of energy needed for normal body metabolism, while soy foods are also good sources of dietary fibre, B-vitamins, calcium, and omega-3 essential fatty acids. This work revealed that *S. bicolor* and *G. max* can be considered as good sources of carbohydrates, mineral and amino acids.

Keywords: Proximate, Amino acids, *Sorghum bicolor, Glycine max*, Phytochemical analysis.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) Moench) is among the world's most vital food crops followed by wheat, rice, maize, and barley (FAO, 2006), which provides staple food of a huge number of people in Africa, India, and in the semi-arid parts of the tropics. It is the most important source of protein and calories in the diet which is consumed by poor masses of many countries. It also acts as a primary source of energy, proteins, vitamins as well as minerals (Mauder, 2006). The processed sorghum seeds or flour were found to be an important source of calories and proteins to the millions of the population as well as for the poultry and livestock (FAO, 2006). The cereal used as whole grain as well as ground flour because it is free of gluten as it is an important source of protein, vitamins, minerals, energy, and nutraceuticals such as antioxidant phenolics and cholesterol-lowering waxes (Taylor *et al.,* 2006).Starch is the predominant carbohydrates in sorghum, while soluble sugars, pentosans, cellulose, and hemicelluloses are present in a minute amount. Also, sorghum consists largely of insoluble fiber (86.2%) which may decrease transit time and prevent gastrointestinal problems. Sorghum contains a higher amount of prolamins as proteins, followed by glutelins. There is variability in the composition of essential amino acids in sorghum protein. Lysine content was reported to vary from 71-212mg per gram of nitrogen while the tryptophan and methionine content on average is 63 and 87 mg per gram of nitrogen. These deficiencies arise from the amino acid composition of the grain storage proteins, called kafirins, which account for up to 80% of the total grain proteins (Taylor and Schosster, 1989). Sorghum consists of an average of 3% crude fat, which is higher than that of wheat and rice. The composition of fatty acids is similar to that of corn oil; linoleic has the higher concentration (49%), followed by oleic (31%) and palmitic acids (14%). Like maize, the energy content of sorghum is high. It also consists of about 1.5ppm total carotenoids. Apart from maize and durum wheat, sorghum is the only cereal that contains a significant amount of β-carotene, the provitamin of vitamin A, which is very important in human physiology.

The soybean (*Glycine max* L.) Merrill family Leguminosae) unquestionably originated in familiarize, possibly in China is among the most essential human diets in many eastern countries because of its high nutritional value and very little in cost. The connection between human and soybean consumptions has been widely known because of its high nutritional value including its high protein content, dietary fiber, oligosaccharides, phytochemicals (especially isoflavones), a significant amount of minerals, very little amount of saturated fat, and absence of cholesterol (Silva *et al.,* 2006). Sulfur-containing amino acids in soybean protein are low but have a considerable amount of lysine which is absent in a good number of the cereals (Mateos-Aparicio *et al.,* 2008). Soybean is one of the most vastly nutritious leguminous seeds and alternate to meat and milk in food value. The seeds also contain a high amount of protein and the amino acid composition is approximate to the composition of animal proteins and often used a substitute component of meat protein. It contains a reasonable amount of non-saturated fatty acids but lacks vitamin A and C, of most minerals, and starch. Except for methionine, the soybean contains all the essential amino acids (Synder and Kwon, 1987). The amount of protein in soybeans, 38%-44%, is superior to that of cereals 8-15% (Synder and Kwon, 1987). This huge amount of protein in soybeans along with the high biological value increases their value as feedstuff and is one rationale for the economic benefit that soybeans have over other oilseeds.

Oil in soybeans provides essential fatty acids, calories, and vitamins A and E, and also contribute insignificant amounts of vitamins D and K (Bates and Matthews, 1975). Among other oilseeds, soybean has the highest iodine value (a value of 134), which is analogous to that of sunflower; peanut, maize, and palm oils which have values of 101, 127 and 51 respectively signifying lower unsaturation compared to soybean oil (Weiss, 1983). In soybean oil, the fatty acids, linoleic, oleic, palmitic, and linolenic, makeup 54, 24, 12, and 8 respectively (Bates and Matthews, 1975). Soy oil can serve as a good source of oleic and essential fatty acid (EFA) linoleic acid, with even with the partially hydrogenated soy oil containing 25% linoleic and 3% linolenic acid (Potter and Hotchkiss, 1995). Soy oil is a good source of vitamin E but is a poor source of beta-carotene, a precursor of vitamin A (Synder and Kwon, 1987). Soybeans contain a high amount of potassium, followed by phosphorus, magnesium, sulfur, calcium, chloride, and sodium (O'Dell, 1979). Other minerals present in minute amounts are silicon, iron, zinc, manganese, molybdenum, fluoride, chromium, selenium, cobalt, cadmium, lead, arsenic, mercury and iodine (O'Dell, 1979). The soybean contains water-soluble vitamins such as riboflavin, thiamin, pantothenic acid, niacin, and folic acid. While the vitamin C content in soybean is present but very negligible in mature beans and present in a quantifiable amount in the immature and the germinating beans (Bates and Matthews, 1975). It also contains fat-soluble vitamins like vitamin A (Retinol) that exists as the provitamin a-carotene and vitamin E (tocopherol). Most people in Northern Nigeria are using the food samples in children feed formulation because of their acclaimed health benefit in treating malnutrition in children. Therefore, there is need to evaluate the nutritional and the anti-nutritional contents of *Sorghum bicolor* and *Glycine max* to ascertain their claim.

MATERIALS AND METHODS

Samples Collection and Identification

Soybeans and Sorghum seeds were obtained from Rimi main market, Kano State, and cautiously selected and labeled correctly in polythene bags. The samples were taken to the botany unit of Bayero University Kano and identified as: *Sorghum bicolor* (Jar Dawa in Hausa) and *Glycine max* (Waken Suya in Hausa).

Proximate Composition

Proximate analysis was carried out according to the methods of the Association of Official Analytical Chemist 1990. (AOAC, 1990)

Mineral Analysis

Mineral elements were extracted from the samples by wet digestion as described by AOAC, 1990. From the filtrate of the digested samples, Magnesium (Mg), Iron (Fe) and Copper (Fe) were determined using Atomic Absorption Spectrophotometry (BUCK Scientific 205 USA) while Sodium

(Na), Potassium (K) and (Ca) were determined using Flame Photometer PFPT (JENWAY UK Model 8515).

Vitamins Analysis

The vitamin A (Retinol), Vitamin C (Ascorbic acid) and Vitamin E (Tocopherol) in the samples were determined by the official methods of the Association of Official Analytical Chemists (AOAC, 1990).

Amino acid Analysis

The Amino Acid profile in the known samples was determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator, and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

Quantitative Phytochemical screening

An analytical method for the quantitative determination of tannin was according to (Amadi *et al.,* 2004; Ejikeme *et al.,* 2014). The determination of alkaloids was according to Harborne, (1973). Flavonoid determination was by the method reported by Ejikeme *et al.* 2014; Boham and Kocipai, 1994. Saponin quantitative determination was carried out using the method reported by (Ejikeme *et al.* 2014; Obadoni and Ochuko, 2002). The determination of Oxalate was carried out using the method reported by Ejikeme *et al.* (2014) and Munro and Bassir, (1969). Glycoside's quantitative determination of methodology used in this research is that by (Amadi *et al.,* 2004) as reported by (Ejikeme *et al.,* 2014).

Statistical Analysis

Each experimental analysis was done in triplicate. Data obtained from experiments were analyzed by U-ANOVA (Univariate Analysis of Variance) using GraphPad INSTAT statistics software. Significance was accepted at 0.05 level of probability ($p < 0.05$). The analysis was used to compare the proximate, elemental composition, vitamins, phytochemicals of the two samples.

RESULTS

The results of the proximate compositions of *Sorghum bicolor* and *Glycine max* are presented in table 1. The results revealed there is a significant difference ($p<0.05$) in all the proximate parameters are of *Sorghum bicolor* and *Glycine max*.

Table1: Proximate Compositions of *Sorghum bicolor* and *Glycine max*

Contents	*Sorghum bicolor*	*Glycine max*
Moisture (%)	6.44 ± 0.16^{a}	5.31 ± 0.13^{b}
Ash (%)	9.44 ± 0.19^{a}	5.75 ± 0.17^{b}
Crude Fibre (%)	3.35 ± 0.17^{a}	5.14 ± 0.14^{b}
Crude Fat (%)	3.07 ± 0.08^{a}	9.66 ± 0.19^{b}
Protein (%)	33.24 ± 0.74^{a}	41.25 ± 0.27^{b}
Carbohydrates (%)	44.45 ± 1.02^{a}	32.88 ± 0.28^{b}
Energy (Kcal/g)	289.43 ± 0.52^{a}	383.46 ± 0.86^{b}

All data expressed in triplicate as mean ± SEM, values with a different superscript in the same row are significantly different at $p<0.05$

The results of the Minerals and Vitamins contents *Sorghum bicolor* and *Glycine max* are presented in table 2. The results revealed that there is no significant difference ($p<0.05$) in magnesium, potassium and iron while sodium, calcium and vitamins A, C and E significantly different at $p<0.05$).

Table 2: Minerals and Vitamins contents of *Sorghum bicolor* and *Glycine max*

Contents	*Sorghum bicolor*	*Glycine max*
Sodium (mg/100g)	7.02 ± 0.64^a	4.60 ± 0.22^b
Magnesium (mg/100g)	2.40 ± 0.07^a	2.03 ± 0.15^a
Potassium (mg/100g)	3.72 ± 0.20^a	3.10 ± 0.13^a
Iron (mg/100g)	0.91 ± 0.09^a	0.85 ± 0.18^a
Calcium (mg/100g)	5.55 ± 0.11^a	0.44 ± 0.10^b
Copper (mg/100g)	ND	0.10 ± 0.08
Vitamin A (mg/100g)	16.00 ± 0.76^a	92.03 ± 0.45^b
Vitamin C (mg/100g)	21.15 ± 0.62^a	78.71 ± 0.20^b
Vitamin E (mg/100g)	7.53 ± 0.34^a	19.00 ± 0.26^b

All data expressed in triplicate as mean ± SEM, ND=Not detected values with a different superscript in the same row are significantly different at $p<0.05$

The results of the Amino acids compositions of *Sorghum bicolor* and *Glycine max* are presented in table 3. The results showed the presence of both the essential and non-essential amino acids in the samples.

Table 3: Amino acid compositions of *Sorghum bicolor* and *Glycine max*

SAMPLES	(Concentration g/100g)	
Amino acids	*Sorghum bicolor*	*Glycine max*
Leucine*	9.86	7.59
Lysine*	3.29	5.89
Isoleucine*	4.39	4.58
Phenylalanine*	4.97	4.97
Tryptophan*	1.89	1.31
Valine*	5.32	4.97
Methionine*	2.40	1.33
Proline	5.89	3.35
Arginine	4.99	7.31
Tyrosine	3.27	3.44
Histidine*	2.17	2.43
Cysteine	2.12	1.51
Alanine	7.36	3.41
Glutamic acid	17.56	12.41
Glycine	3.70	4.37
Threonine*	4.00	3.72
Serine	4.70	3.89
Aspartic acid	8.25	9.86

*Essential Amino acids

The results of the Quantification of bioactive component (Phytochemical) of *Sorghum bicolor* and *Glycine max* are presented in table 4. The results revealed that all the phytochemical parameters of the samples are significantly different at $p<0.05$.

Table 4: Quantification of bioactive component (Phytochemical) of *Sorghum bicolor* and *Glycine max*

PARAMETERS	*Sorghum bicolor*	*Glycine max*
Saponins	$12.53±0.08^a$	$47.61±0.46^b$
Tannins	0.10±0.67	ND
Glycosides	$23.34±0.32^a$	$21.56±0.38^b$
Alkaloids	9.23±0.43	ND
Steroids	$1.98±0.28^a$	$8.73±0.02^b$
Flavonoids	$1.72±0.13^a$	$72.58±0.37^b$
Oxalates	$14.02±0.41^a$	$3.34±0.47^b$
Phytate	$11.01±0.38^a$	$2.13±0.28^b$

All data expressed in triplicate as mean ± SEM, ND=Not detected, values with a different superscript in the same row are significantly different at $p<0.05$

DISCUSSION

Proximate Compositions

The results of the proximate composition of *Sorghum bicolor* and *Glycine max* is presented in Table 1. The percentages of moisture content in *S. bicolor* and *G. max* were found to differ slightly. These values are in the same range with the work reported by Ape *et al.* (2016) of 6.36% for *S. bicolor* while Siulapwa and Mwambungu, (2014) reported a value of 5.30±0.2% for *G. max*. The low level of moisture content implies that the sample can be stored over a long time. The % ash in *S. bicolor* was higher (9.44±0.19) and low in *G. max* (5.75±0.17). These values were higher compared to the work of Amir *et al.* (2015) and Ciabotti *et al.* (2016) for the two samples respectively. The % of crude fiber in *S. bicolor* is (3.35±0.17) which is similar to the work reported by Ape *et al.* (2016) 2.86%. While that of *G. max* is (5.14±0.14%). Siulapwa and Mwanbungu (2014) reported a value similar to the present study, 5.4±0.1%. Sorghum is a good source of fiber, mainly the insoluble fiber. The insoluble dietary fiber of sorghum may decrease transit time and prevent gastrointestinal problems. The % of crude fat in the samples were considerably low in both the samples. The present study corresponds to the work of Amir *et al.* (2015) and Ape *et al.* (2016) 3.02±0.01 and 3.10% for *S. bicolor*. Fat is of nutritional importance in soybean as it contains polyunsaturated fatty acids that are considered healthy for the human body. The % of proteins was found to be high in both the two samples. Legumes are a good source of protein and another nutrient for humans and animal consumption and that their utilization in infant formula and other food products has been significantly solving nutrition problems in the community. The % of carbohydrate in the samples differs slightly. The % of the present study is low compared to that of Ape *et al.* (2016); Amir *et al.* (2015) that reported a high value of 76.51, 77.28±0.29 respectively for *S. bicolor* carbohydrate. The high amounts of carbohydrate in sorghum make it rich-energy foods for both humans and livestock consumption. High amount of energy was found in *G. max* which means that it can be used in weaning food preparations.

Mineral Compositions

The results of the mineral composition of *S. bicolor* and *G. max* were presented in table 2. The result revealed that the amounts of Na (mg/100g) were in the range of (7.026±0.64) for *S. bicolor* and (4.60±0.22) for *G. max*. Amir *et al.* (2015) reported a value of 5.98±0.01for *S. bicolor* lower than the present study. The amounts of Mg (mg/100g) in the samples showed no significant differences ($p<0.05$). Magnesium is important for nerve and heart function as well as the release of insulin and ultimate insulin action on cells. The amounts of K (mg/100g) between the two samples also shows no significant difference at $p<0.05$. Potassium is very important in the regulation of water, electrolyte and acid-base balance in the body as well as responsible for nerve and functioning of the muscles. There is also no significant differences in the amount of Fe (mg/100g) in the two samples. The result of the present study in *S. bicolor* is lower compared to the work reported by Amir *et al.* (2015) 11.32±0.11. Iron is essential for the synthesis of hemoglobin and myoglobin, its deficiency results in anemia. The amount of Ca (mg/100g) in the samples was within the same range with no significant difference at $p< 0.05$. Amir *et al.* (2015) reported a value of 3.33±0.09 for *S. bicolor*. Calcium is the most abundant mineral in the body. It regulates many cellular processes and has other vital roles in living organisms. Copper is an essential mineral required for the proper functioning of organs and metabolic processes (Sadhra *et al.,* 2007).

Vitamins Contents

The results of the vitamin analysis in the samples were presented in table 2. The amount of vitamin A (mg/100g) was found to be higher in *G.max.* Vitamin A plays an important role in bone growth, tooth development, reproduction, cell division, gene expression and regulation of the immune system. There is a significant difference at $p<0.05$ in vitamin C contents of the samples. Vitamin C is an excellent antioxidant and free radical scavenger, capable of defending the cells from oxidative damage by oxidants; it also prevents scurvy and enhances iron absorption from the intestine. A significant difference ($p<0.05$) was also found in the amount of vitamin E in the samples. Findings indicate that people who take antioxidant and vitamin E supplements are not better protected against heart disease and cancer than non-supplement users.

Amino acids Compositions

The amino acid plays central roles both as building blocks of protein and as intermediates in metabolism. The result of the amino acid composition (Table 5) showed that both the samples; *S. bicolor* and *G. max* contained both the essential and non-essential amino acids. Essential amino acids leucine

(9.86), valine (5.32), tryptophan (1.89), methionine (2.40) and threonine (4.00) were found to be higher in *S. bicolor* while lysine (5.89), isoleucine (4.58), phenylalanine (4.97) and histidine (2.43) were found to be high in *G. max*. All the non-essential amino acids were found in both the two samples, some at high amount while some at lower amount.

Phytochemical Analysis

Examination of the phytochemicals of the samples revealed that they are a rich source of phytochemicals. A significant increase ($p<0.05$) was observed in the amount of saponin in the samples. The amount of tannins (mg/100g) in the samples are also significant difference at $p<0.05$. The amounts of glycosides showed that both the two samples are within the range of 23.34±0.32 and 21.56±0.38 for *S. bicolor* and *G. max* respectively. Alkaloid was only found in *S. bicolor* and not detected in *G. max*. Alkaloids have antimicrobial properties due to their ability to intercalate with DNA of the microorganisms. A significant difference ($p<0.05$) was also observed in the amount of steroids. Steroids increase protein synthesis, promoting the growth of muscles and bones. There is also a significant difference ($p<0.05$) in the amount of flavonoids in the samples. Also, a significant increase was observed in the amount of oxalates in the sample. The amount of phytate showed that *S. bicolor* has the highest amount. Phytates are known to pose to leguminous seeds and also associated with increased cooking time in legumes.

CONCLUSION

From the results of the present study, it can be drawn that *Sorghum bicolor* and *Glycine max* are ideal high-energy foods, rich in proteins, carbohydrates, and minerals such as calcium, magnesium, copper, and potassium. They are also a good source of K, Mg, Zn, and Na which help the body maintain electrolyte balance and proper enzymatic activities. They also contain a suitable amount of amino acids, vitamins, and phytochemicals indicating their high nutritional value.

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