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Effect of Processing on White Sorghum Variety Consumed in Sokoto

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Abstract
Background*: Sorghum is used primarily as animal feed and industrial raw material in most countries in the world, but in Africa it is used as human food, where it is a staple food for millions of people. With increasing dependence upon cereal grains to provide energy and protein requirements of human in developing countries, the need for raising the overall nutritional value of cereal grains has become increasingly important. Sorghum has high nutritional value but its nutritional quality is dictated mainly by the presence of considerable amounts of antinutritional factors which generally reduce the body's ability to absorb essential nutrients. Processing decreases the content of antinutrients, and has a positive effect on the availability of vitamins and minerals. This aroused the interest of the authors to investigate the effect of processing (soaking and dehulling) on the proximate composition, antinutrients and some minerals contents of a white sorghum variety (Farafara) which is widely consumed in Sokoto.*
Materials and Methods*: The sorghum grains were obtained from a local market. The flour obtained after soaking, dehulling and without being processed was used for analysis. Proximate (moisture, ash, lipid, crude protein, fibre and carbohydrate), minerals (sodium, potassium, calcium, magnesium, phosphorus, selenium and, zinc) and antinutrients (tannin, cyanide, nitrate and phytate) contents were determined using standard analytical methods. The parameters were compared between unprocessed and processed samples.*
Results*: The processed samples had significantly ($P<0.05$) lower level of crude protein, lipid, fibre and ash content when compared to the unprocessed sample with the exception of the ash content of the dehulled sample which decreased non significantly ($P>0.05$), while the carbohydrate content increased significantly ($P<0.05$). The antinutrients content of the processed sorghum were significantly lower ($P<0.05$) when compared to the unprocessed sorghum, with the exception of cyanide which decreased non significantly ($P>0.05$). However, the decrease was lowest in the dehulled sample. The minerals analysed (sodium, potassium, calcium, magnesium, phosphorus, zinc) decreased significantly ($P<0.05$) in the soaked sample but the decrease was not significant ($P>0.05$) in the dehulled sample with phosphorus and potassium being predominant. Selenium content in the processed samples was non significantly ($P>0.05$) lower than the processed samples.*
Conclusion*: Dehulling is a more efficient processing method.*
Keywords*: Sorghum; Processing; Antinutrients; Minerals.*

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I. Introduction

With continued increase in the world population and pressure in land use, man has been concerned not only about the quantity but also about the quality of his food. Both plant and animal sources need to be improved to meet the nutritional requirements of growing population. The production and distribution of plant foods, is economical because they exhibit better shelf life and can be stored and processed with less expensive methods[1]. Greater emphasis has to be placed on increasing the production of plant foods, improving their nutritional quality, and developing simple and economic methods for their storage and processing.

In most countries in the world, sorghum is used primarily as animal feed and industrial raw material, but in Africa it is used as human food, where it is a staple food for millions of people[2]. Nigeria accounts for about 65-75% of the total sorghum production in West Africa[3]. Its production is dominant in the northern part of the country, where it is cultivated for grains and as a major food crop. Sorghum has been for centuries, one of the most important staple foods for millions of poor rural people in the semi-arid tropics of Asia and Africa[4]. With increasing dependence upon cereal grains to provide energy and protein requirements of human in developing countries, the need for raising the overall nutritional value of cereal grains has become increasingly important. Sorghum remains a principal source of energy, protein, vitamins and minerals for some impoverished regions of the world.

Despite the potential, relative to other common cereals like maize and rice, sorghum has low nutritional value and inferior organoletpic qualities[5]. It is deficient in lysine and sulphur containing amino acids[6]. Sorghum is rich in mineral content but its nutritional quality is dictated mainly by the presence of considerable amounts of antinutritional factors such as tannin, phytic acid, oxalate and cyanide which are undesirable, and their content need to be eliminated or inactivated in the seed in order to improve nutritional quality of sorghum, and effectively utilize its full potential as human food through food processing. Phytic acid has a high capacity to form insoluble complexes (Phytates) with metal ions present in food[7]. Tannin complexes with protein and reduces its digestibility, act as enzyme inactivator and cause growth retardation[8].

Traditional technologies available for processing of Sorghum include, threshing, cleaning, washing, dehulling, soaking, germination, wet and dry milling and fermentation while roasting of cereals is rarely practiced[9]. Food is processed for preservation for use in times of shortage, removal of toxins and anti-nutrients, increase shelf life and improvement in palatability, digestibility and availability of nutrients[10]. Processing decreases the content of antinutrients and has a positive effect on the availability of vitamins and minerals[11]. This aroused the interest of the authors to investigate the effect of processing (soaking and dehulling) which are simple processing methods in our community on the proximate composition, antinutrients (Tannins, nitrate, cyanide and phytate) and some minerals (Calcium, Potassium, Magnesium, Phosphorous, Sodium, Zinc and Selenium) of a white sorghum variety (Farafara) which is widely consumed in Sokoto.

II. Materials And Methods

Sample Collection: The sorghum (Farafara) was obtained from Sokoto Main Market and identified at the Department of Biological sciences, Sokoto State University, Sokoto. The study was carried out at Department of Biochemistry, Sokoto State University, Sokoto, Nigeria between September 2019 and November, 2019.The sorghum grains (900 g) were sorted and cleaned. One third was grinded to flour using a grinding machine (unprocessed), one third was soaked in water for 14 hours after which the water was discarded and the sorghum grains were dried at room temperature. The dried grains were then grinded using a grinding machine to obtain flour. The last one third was dehulled traditionally by pounding in a wooden mortar and pestle, a little amount of water was used to aid the removal of the pericarp. The removed pericarp was separated from the grains, the grains was dried at room temperature and then converted to flour by grinding using a grinding machine. The flour was stored in labeled air-tight containers for analysis.

Chemicals and Reagents: The reagents used for the study included hydrochloric acid, chloroform, ferric chloride, sodium hydroxide and distilled water. All chemicals used were of analytical grade and purchased from standard manufacturers.

Proximate Analysis: Proximate analysis was carried out according to procedures recommended by AOAC[12] to estimate moisture, crude protein, fibre, lipid, carbohydrate and ash contents of samples. The nitrogen was determined by the micro kjedahl method described by Pearson[13] and the nitrogen content was converted to protein by multiplying by a factor of 6.25. Carbohydrate was estimated using the arithmetic difference method as described by James[14].

Determination of Mineral Contents: Calcium and Magnesium were estimated by EDTA titration method as described by Jenness[15] Sodium and Potassium were estimated by Flame Photometry as described by Ojeka and Ayodele[16]. Selenium and Zinc contents were assessed after the digestion of the sample by using Atomic Absorption Spectrometry (AAS) as described by AOAC[12]. The amount of phosphorus in the sample was estimated using tin (II) colorimetric method as reported by IITA[17].

Antinutrients Tests: Nitrate was estimated using the method reported by IITA[17]. The determination of the presence of tannin in the test sample was carried out using Ferric chloride test described by Van-Burden and Robinson[18]. Cyanide was determined according to the method of Bradbury et al.[19]. The phytate in the sample was estimated using the procedure described by Ola and Obah[20].

Data Analysis: The results were expressed as mean ± standard error of mean. *The results were analyzed using instat version 3.1.* The differences between the variables across the groups were compared using one-way analysis of variance (ANOVA) followed by Tukey multiple comparison. P value < 0.05 was considered statistically different.

III. Result

Table no 1shows the effect of processing on proximate composition of Sorghum (Farafara). Moisture (%), 6.45 ± 0.076, 8.00 ± 0.022, 6.83 ± 0.033, Ash (%), 2.10 ± 0.005, 1.00 ± 0.002, 2.00 ± 0.001, Lipid (%), 3.72 ± 0.008, 2.33 ± 0.006, 1.83 ± 0.006,Crude protein (%), 8.67 ± 0.005, 6.44 ± 0.005, 6.82 ± 0.004, Fibre (%), 6.60 ± 0.001, 5.50 ± 0.001, 4.51 ± 0.001, Carbohydrate (%), 71.46 ± 0.016, 76.73 ± 0.011, 78.01 ± 0.008 respectively of the samples of the three groups. The difference in the values of all the parameters in respect of the three groups was statistically significant ($P<0.05$).

Table no 1: Shows proximate composition of unprocessed and processed (soaked and dehulled) sorghum

Parameters (%)	Unprocessed	Soaked	Dehulled
Moisture	6.45 ± 0.076^{a}	8.00 ± 0.022^{b}	6.83 ± 0.033^{a}
Ash	2.10 ± 0.005^{a}	1.00 ± 0.002^{b}	2.00 ± 0.001^{a}
Lipid	3.72 ± 0.008^{a}	2.33 ± 0.006^{b}	1.83 ± 0.006^{c}
Crude protein	8.67 ± 0.005^{a}	6.44 ± 0.005^{b}	6.82 ± 0.004^{b}
Fibre	6.60 ± 0.001^{a}	5.50 ± 0.001^{b}	4.51 ± 0.001^{c}
Carbohydrate	71.46 ± 0.016^{a}	76.73 ± 0.011^{b}	78.01 ± 0.008^{b}

Values are Mean ± SEM from triplicate determination. Mean values in rows with different superscript are significantly different (P<0.05).

Table no 2 shows the effect of processing on antinutrients content of Sorghum (Farafara). Tannin (mg/100 g), 18.46 ± 0.002, 14.46 ± 0.001, 16.86 ± 0.002, Cyanide (mg/100 g), 0.027 ± 0.001, 0.025 ± 0.001, 0.025 ± 0.001, Nitrate (mg/100 g), 34.69 ± 0.003, 20.82 ± 0.001, 23.85 ± 0.001, Phytate (mg/100 g), 160.16 ± 0.004, 84.08 ± 0.002, 90.94 ± 0.002 respectively of the samples of the three groups. The difference in the values of tannin, cyanide and phytate in respect of the three groups was statistically significant (P<0.05), but cyanide reduced non significantly (P>0.05).

Table no 2: Shows antinutrients content of unprocessed and processed (soaked and dehulled) sorghum

Parameters (mg/100g)	Unprocessed	Soaked	Dehulled
Tannin	18.46 ± 0.002^{a}	14.46 ± 0.001^{b}	16.86 ± 0.002^{c}
Cyanide	0.027 ± 0.001^{a}	0.025 ± 0.001^{a}	0.025 ± 0.001^{a}
Nitrate	34.69 ± 0.003^{a}	20.82 ± 0.001^{b}	23.85 ± 0.001^{c}
Phytate	160.16 ± 0.004^{a}	84.08 ± 0.002^{b}	90.94 ± 0.002^{c}

Values are Mean ± SEM from triplicate determination. Mean values in rows with different superscript are significantly different (P<0.05).

Table no 3 shows the effect of processing on some minerals content of sorghum (Farafara). Sodium (mg/kg), 87.5 ± 0.001, 67.53 ± 0.001, 84.3 ± 0.001, Potassium (mg/kg), 1022.6 ± 0.030, 875.5 ± 0.025, 992.3 ± 0.031, Calcium, 100.42 ± 0.020, 62.96 ± 0.018, 97.16 ± 0.016, Magnesium (mg/kg), 655.65 ± 0.019, 507.82 ± 0.017, 649.30 ± 0.021, Phosphorus (mg/kg), 1245.72 ± 0.012, 1005.46 ± 0.008, 1229.20 ± 0.010, Selenium (mg/kg), 0.846 ± 0.001, 0.840 ± 0.001, 0.842 ± 0.002, Zinc (mg/kg), 10.91 ± 0.001, 7.03 ± 0.004, 10.12 ± 0.003 respectively of the samples of the three groups. The difference in the values of all the parameters with the exception of selenium was statistically significant (P<0.05) when unprocessed sample was compared with soaked sample. However, the difference in the values of all the parameters except phosphorus was not statistically significant (P>0.05) when unprocessed sample was compared with dehulled sample.

Table no 3: Shows mineral content of unprocessed and processed (soaked and dehulled) sorghum

Parameters (mg/kg)	Unprocessed	Soaked	Dehulled
Sodium	$87.50\pm\text{-}0.001^{a}$	67.53 ± 0.001^{b}	84.30 ± 0.001^{a}
Potassium	1022.60 ± 0.030^{a}	875.50 ± 0.025^{b}	992.30 ± 0.031^{a}
Calcium	100.42 ± 0.020^{a}	62.96 ± 0.018^{b}	97.16 ± 0.016^{a}
Magnesium	655.65 ± 0.019^{a}	507.82 ± 0.017^{b}	649.30 ± 0.021^{a}
Phosphorous	1245.72 ± 0.012^{a}	1005.46 ± 0.008^{b}	1229.20 ± 0.010^{c}
Selenium	0.846 ± 0.001^{a}	0.840 ± 0.001^{a}	0.842 ± 0.002^{a}
Zinc	10.91 ± 0.001^{a}	7.03 ± 0.004^{b}	10.12 ± 0.003^{a}

Values are Mean ± SEM from triplicate determination. Mean values in rows with different superscript are significantly different (P<0.05).

IV. Discussion

The moisture content of soaked sorghum (8.00 ± 0.022%) was found to be significantly (P<0.05) higher than that of the unprocessed (6.45 ± 0.076 %) and dehulled sorghum (6.83 ± 0.033 %). The increase in moisture in the soaked sorghum could be as a result of the soaking. The ash content of the soaked sorghum (1.00 ± 0.11%) was significantly (P<0.05) lower than that of unprocessed (2.10 ± 0.005 %) and dehulled sorghum (2.0 ± 0.001%). This indicates loss of inorganic materials after soaking. Falmate et al.[21] also reported a decrease in sorghum ash after processing. Low fibre content of the dehulled sample could be due to removal of the pericarp which has high crude fibre. High fiber content in food causes intestinal irritation and lower nutrient availability[22]. Intake of dietary fiber can lower the serum cholesterol level, risk of coronary heart disease, hypertension, diabetes and breast cancer. Crude fibre also adds bulk to food to facilitate bowel movements (peristalsis) and prevent many gastrointestinal diseases in man[23].

The Protein content of the soaked sorghum was found to be (6.44 ± 0.005 %) which is significantly (P<0.05) lower than that of unprocessed (8.67 ± 0.005 %) indicating that soaking reduces the protein content of sorghum. This result agrees with Afify et al.[24] who reported that nutrients loss might be attributed to the leaching of soluble nitrogen, mineral and other nutrients into desired solution. The protein content is significant and comparable to that of wheat and maize but its digestion is an obstacle to its nutritive value. These results are in agreement with Dicko et al.[25] who found that crude protein content in whole sorghum grain is ranged from 7 to 15 %.

The lipid content of dehulled sorghum (1.83 ± 0.016 %) was significantly (P<0.05) lower than the unprocessed (3.72 ± 0.008 %) and soaked sorghum (2.33 ± 0.008 %). This falls within the range (3.60 - 10.54 %) that was reported by Jimoh and Abdullahi[26] for unprocessed Sorghum varieties. Onesmo[27] stated that most of the lipids of sorghum are located in the scutellum and therefore can be significantly reduced when kernels are decorticated and degermed. The Carbohydrate content of the dehulled sorghum (78.01 ± 0.039 %) and the soaked sorghum (76.73 ± 0.011 %) was significantly (P<0.05) higher than the unprocessed (71.46 ± 0.016 %). The variation in the carbohydrate contents of the samples is probably due to the increases and decreases in the other components of the sample as a result of the processing variables, since carbohydrate values are obtained by difference. That means its values depend on factors responsible for the values of other components[28]. The results show that both unprocessed and processed sorghum are good sources of carbohydrate which may attribute to the body's energy.

The amount of tannin, cyanide, nitrate and phytate in the processed (soaked and dehulled) white sorghum (Farafara) was found to be significantly (P<0.05) lower when compared with the unprocessed and dehulled sorghum. Johanita et al.[29] reported that soaking reduced phytate content of sorghum and maize and hence increases mineral availability. Anti-nutrients generally reduce the body's ability to absorb essential nutrients, many antinutrients are water soluble, they simply dissolve when grains are soaked[30]. Tannins are phenolic compounds that precipitate protein and cause reduced protein digestibility[31]. Tannins are known to inhibit the activities of digestive enzymes. The nutritional effect of tannin is related to their interaction with protein[32]. Several studies including Elkhalil et al.[33], Eltayeb et al.[34] and Afify et al.[35] have implicated dietary phytate and oxalate in the impairment of the efficient utilization especially of divalent minerals such as calcium and magnesium and the subsequent development of rickets when certain cereals are fed. Phytic acid in the hulls of nuts, seeds, and grains has a strong binding affinity for calcium, magnesium, iron, copper, and zinc, preventing their absorption[36]. The result obtained of processed (soaked) sorghum is in line with the work of Schlemmer et al.[37] which stated that soaking reduces the concentration of antinutritional factors.

The calcium, magnesium, sodium, potassium and zinc content of unprocessed white sorghum (Farafara) were found to be significantly (P<0.05) higher than that of the soaked sorghum. However, the reduction was not significant (P>0.05) in the dehulled sorghum. Selenium content reduction was not significant (P>0.05) after processing. The amount of phosphorus in the processed sample was found to be significantly (P<0.05) lower than the unprocessed. This study reveals that white sorghum (Farafara) has high potassium and phosphorus content and this shows that sorghum can serve as a valuable source of these macro and essential mineral to humans. Potassium is an essential nutrient needed for maintenance of total body fluid volume, acid and electrolyte balance, and normal cell function[38]. Phosphorus may combine with calcium for bone and teeth development[39]. Magnesium provides bone strength, aids enzyme, nerve and heart functions[40]. Selenium was found in trace amounts. It can be termed a heavy metal and therefore can be toxic when in high concentration.

V. Conclusion

The result of the study provided information on the nutritive value of processed and unprocessed sorghum. Processing of cereal grains improved its nutritional quality by reduction in the antinutrients content and hence increasing bioavailability of minerals. It can be concluded that, dehulling is a more efficient processing method because antinutrients reduced significantly and the minerals content reduced nonsignificantly and this could increase great attention of sorghum as a source of food. Soaking does not seem to be a viable method to improve sorghum mineral availability because the loss in soluble minerals could have a greater negative effect on mineral availability compared to the positive effect of the antinutrients reduction.

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