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The Nutritional Value of *Sorghum bicolor* Stem Flour Used for Infusion Drinks in Nigeria

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Abstract. The black purple sheath (stem) of *Sorgum bicolor,* used locally as colour additive in cooked meals and infusion drinks taken as beverages, was examined for its nutritive value. The stem made into flour, was found to be rich in energy (1121.3 kJ/100 g), and in some micronutrients (mg/100 g), such as Mg (185.33), Ca (151.70), K (138.87), Na (127.61), and Fe (10.98). High Mg content of stem may be useful for overcoming Mg deficiency. The Fe content was sufficient to meet the daily-required intake (DRI) value for human beings. The presence of Cu, Zn and Mn was also observed. The content of crude fibre (32.0%) and carbohydrates (44.50%) were useful for making the stem a fodder for animal consumption. However, the protein content of the stem was low (3.20%). The functional properties observed for the stem compared favourably with those already reported for some other plants such as pigeon pea flour, African yam bean, and wheat flour.

Keywords: functional properties, Nigerian infusion drinks, sorghum mineral content, nutritive value, sorghum stem flour, *Sorghum bicolor*

Introduction

Sorghum bicolor is extensively cultivated in the drier northern Guinea, Sudan savannah, greenlands of Africa, plains of India and the great plains of United State of America (FAO, 1988). It is known to be the fourth most important cereal crop after wheat, rice and maize, and is a dietary staple of millions of the World's poorest people in the sahelian zone of Africa, Middle East, India and China (Kochhar, 1986). *Sorghum* is a vastly complex genus, including hundreds of species and varieties of different characteristics, adapted to different ecological niches with a variety of economic uses. It resembles maize in its vegetative characters, but differs in having narrower leaves and a waxy bloom covering the leaves and the stem. It also has a well-developed root-stem system, which is twice as efficient as that of maize, even though its leaf area is only half that of maize (Hartman *et al.,* 1988).

Three major cultivars are grown in Nigeria, namely, Guinea (red testa, white endosperm) in the southern Guinea savannah, Kaura (yellow testa and endosperm), and Farafara (white testa and endosperm) grown in the drier savannah regions. Small-scale farmers prefer Farafara to Kaura, as the latter is believed to store less well. Nevertheless, Kaura is cultivated widely by the large-scale farmers for the brewing industries (Marley *et al.*, 1997). The *S. bicolor* stem is sweet in taste and is found to contain some sugars and minerals. The sugary nature makes it to be a popular chewing material for some population groups in Africa and Asia. On account of this attribute, it is used for the manufacture of syrup (FAO, 1988). In the tropics, apart from the cereal being used as food (Odetokun, 1997; Ihekoronye and Ngoddy, 1992), the mature black purple sheath (stem) is generally sold in small bundles for use as colour additive in cooked meals and is also consumed as a base for beverages when steeped or boiled in water, in many households in Nigeria (Adetuyi, 2004). On account of this usage, the *S. bicolor* stem was investigated for its nutritive value and functional properties. The results of this study are reported here.

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Materials and Methods

Collection and treatment of the material. The *Sorghum bicolor* stems used in this study were purchased in the dry form at Ojaoba, a local market in Akure, Ondo State, Nigeria. The stems were further sun-dried and pulverized, sieved and stored as flour in a dry container until used.

Analytical procedures. The moisture, total ash, ether extracts (fat) and crude fibres were determined using the AOAC (1990) standard analytical procedures. The nitrogen was determined by micro-Kjeldahl method (Pearson, 1976). Carbohydrate contents were determined by difference. The energy values were derived by multiplying the amounts of protein, carbohydrates and fat by factors of 4, 4 and 9 (kcal) and 17, 17 and 37 (kJ), respectively (Pearson, 1976).

The mineral contents (Mg, Mn, Na, K, Ca, Fe, Cu and Zn) were determined by atomic absorption spectrophotometer (Pye Unicam SP 9, Cambridge, UK), using standard procedures (Oshodi, 1992).

Foam capacity and foam stability were determined in accordance with Coffman and Garcia (1977). Total volume at intervals between 25 min, and 1500 min was noted to obtain the foaming stability. To obtain the foaming capacity, volume increase (%) was calculated according to the following equation:

$$\text{Volume increase (\%)} = \frac{\text{Volume after whipping - Volume before whipping}}{\text{Volume before whipping}} \times 100$$

The water absorption capacity and oil absorption capacity (WAC and OAC, respectively) were determined by the Sosulski method as modified by Adeyeye *et al.* (1997). The density of water was taken to be 19/cm^3. The excess water absorbed by the flour was expressed as the percentage water bound by 100 g flour samples. The density of the 'Chef Executive' brand oil used in the study was determined by the specific gravity bottle method (Helbing and Burkart, 1969).

Oil emulsion capacity was determined using the method of Inklaar and Fortuin (1969), with a slight modification (Oshodi *et al.,* 1997). The result was calculated as the percentage of the emulsified oil after separating the upper layer from the emulsion. The oil emulsion stability was determined by the method of Beuchat (1977). The least gelation capacity was determined as the concentration at which the flour, from an inverted test tube, did not fall down or slip according to the method of Coffman and Garcia (1977).

All the chemicals used were of analytical grade. Data were expressed as mean of triplicates, and standard deviation (SD) and coefficient of variation (CV) were calculated using methods of Chase (1976).

Results and Discussion

The proximate composition of *Sorghum bicolor* stem flour is presented in Table 1. The stem flour was rich in carbohydrates (44.52 %) and crude fibre (32.02%), which render it useful as fodder for animals. These values, however, are lower than values reported for the sorghum grain (Odetokun, 1997; Ihekoronye and Ngoddy, 1992). The total energy calculated for the stem was 266.30 kcal (or 1121.30 kJ) per 100 g, which indicate that the stem flour was a high energy source.

Table 2 presents the mineral contents of the stem flour. Magnesium was the most abundant (185.33 mg/100 g) mineral. This observation is comparable to the range of values 0.11-0.21% (110-210 mg/100 g) reported for a variety of *Sorghum bicolor* flour by Aganga *et al.* (1996). The observed value for Mg was also within the range reported for sorghum grain flour from small scale farms in Kenya, which ranged between 0.3-2.8 g/kg (30-280 mg/100 g) by Jacob *et al.* (1997). The value for magnesium, however, was below that reported (747 mg/100 g) by Olaofe and Sanni (1988) for sorghum grain flour from Ilorin, Nigeria.

The low Mg intake has been related to high intake of poor nutritional quality products (high consumption of foods rich in energy and poor in micronutrients, and to the increased intake of refined product available in the markets, such as (white flour, white sugar, etc.) (Lopez *et al.,* 2002). The *S. bicolor* stem is rich in energy and also in some micronutrients, as compared to the refined products. Hence, its consumption is likely to overcome Mg deficiencies, which may be a cause of severe metabolic disorders which compromise the health of individuals.

S. bicolor stem is also a good source of calcium (151.70 mg/100 g), potassium (138.87 mg/100 g) and sodium (127.61 mg/100 g). The Ca and Na values were comparable to those reported by Aganga *et al.* (1996). The K value obtained during the present studies was, however, lower than that reported by Aganga *et al*. (1996). Nevertheless, *S. bicolor* stem flour was richer in K than the lima bean flour reported by Oshodi and

Table 1. Proximate composition (%)* of *Sorghum bicolor* stem flour on dry weight basis

Constituent		SD	CV(%)
Moisture	6.54	0.03	0.46
Protein	3.20	0.26	8.13
Crude fat	8.38	0.34	4.06
Total ash	5.34	0.17	3.18
Crude fibre	32.02	0.49	1.53
Carbohydrates (by difference)	44.52	0.67	1.51

*mean of triplicate determinations; SD = standard deviation; CV(%) = percent coefficient of variation

Table 2. Mineral composition (mg/100 g)* of *Sorghum bicolor* stem flour on dry weight basis

Mineral		SD	CV(%)
Sodium	127.61	0.04	0.03
Potassium	138.87	0.03	0.02
Calcium	151.70	0.03	0.02
Magnesium	185.33	0.02	0.01
Iron	10.98	.05	0.46
Copper	0.47	0.02	4.26
Zinc	7.15	0.03	0.42
Manganese	2.83	0.13	4.59

*mean of triplicate determinations; SD = standard deviation; CV(%) = percent coefficient of variation

Adeladun (1993). The Fe content noted in the current work was 10.98 mg/100 g, which is higher than the values reported by Adeyeye (1997) for *Pyrus communis, Irvingia gabonesis* and *Mangifera indica* fruits consumed in Nigeria (1.86-4.49 mg/100 g). The sorghum stem flour was also richer in iron than the African yam beans (Adeyeye, 1996), pigeon pea and soya bean as reported by Holland *et al*. (1991). The value of 12.7 mg/100 g reported by Olaofe and Sanni (1988) for grain flour is slightly comparable with the value 10.98 mg/100 g for sorghum stem flour obtained during present studies (Table 2). The dietary requirement intake (DRI) for iron is 10 mg for an adult male and 19 mg for a female adult (ACU-CELL Nutrition, 2004). This can be met by consuming 100 g of the sorghum stem flour. A typical Western diet contains an average of 7 mg of iron per 1000 kcal (Minihane and Rimbach, 2002). The quantity of iron found per 1000 kcal of the sorghum stem flour was 41.23 mg, which can be obtained from 375.5 g of the sorghum stem flour.

However, it is noteworthy that the iron present in plant products is in the non-haem form, which is not easily absorbed; iron in the foods of animal origin is found in haem form, which is easily absorbed (Bender, 1992). Iron is an essential micronutrient for almost all organisms. Its deficiency is the most common micronutrient deficiency, leading to such deficiency symptoms as anaemia, dizziness, amenorrhoea, fatigue, etc. The intake of a drink made from the sorghum stem flour, or its incorporation in foods, may greatly help in reducing iron deficiency. Zinc, Mn and Cu values were observed to be 7.15, 2.83 and 0.47 (mg/100 g), respectively. The content of Zn in this study was about 47.7% of DRI in 100 g of the sorghum stem flour. The amount of Mn in 100 g meets the lower limit of DRI for this mineral. The study material was, however, poor in Cu.

Table 3 shows the observations obtained on the functional properties of sorghum stem flour. The observed values of 406 and 700% for water and oil absorption capacities, respectively, were much higher than the values reported by some workers for some plants: Olaofe *et al*. (1999) reported 298.6% and 245.6% for cowpea flour as water and oil absorption capacities, respectively; pigeon pea flour had 138% water absorption capacity, with 89.7% fat absorption capacity (Oshodi and Ekperigin, 1989); water melon seed protein concentrate had water absorption capacity of 152% (Oladimeji and Obaseki, 2003); defatted oil-seed flours had water absorption capacity of 100-266%, with the fat absorption capacity of 98.5-301.8%, and protein concentrates of some legume flours have been reported to have water absorption capacity of 138-200%, with the fat absorption capacity of 120-175% (Akintayo *et al*., 2000).

The emulsion capacity for *S. bicolor* stem flour was observed to be 45.3% (Table 3), which is comparable to the values of 49.40% reported by Oshodi and Ekperigin (1989) and 40.40% by Mtebe (1989) for pigeon pea, while the white variety of hulled African yam bean was reported by Adeyeye and Aye (1998) to have emulsion capacity of 44.35%. The emulsion capacity value for the sorghum stem flour was better than the report of Lin *et al*. (1974), which ranged between 7-11% for wheat flour and 18% for soy flour. Olaofe *et al*. (1998) reported emulsion capacity of 25.6% for variegated grasshopper, which is lower than 45.3% values for the sorghum stem flour used in the present studies. The values for hulled and dehulled *Adenopus breviflorous* flour were reported to be 20.46% and 35.81%, respectively, by Oshodi (1992), which are also lower than the emulsion capacity value of 45.3% observed during the present studies. However, this value for *S. bicolor* stem flour was lower than 91.2-138.6% recorded for the varieties of lima beans (Oshodi and Adeladun, 1993), 95.1% for sunflower (Lin *et al.,* 1974), and 66.4-85.3% for the water melon seed protein concentrate under the effect of various salts (Oladimeji and Obaseki, 2003).

The emulsion stability for the sorghum stem flour was observed to be 37.6% after 2 h. This value is comparable to 36.1% noted by Oladimeji and Obaseki (2003) for the stability of the emulsion formed by water melon seed protein concentrate at zero salt concentration.

Foaming capacity and stability were observed to be 6% and 2%, respectively (Table 3). The foaming capacity value of 6% is lower than 10.8% reported for full-fat fluted pumpkin seed flour (Fagbemi and Oshodi, 1991). The low foaming capacity of the sorghum stem flour indicates the presence of little or no flexible protein molecules, which can reduce surface tension as is corroborated by the protein composition of 3.20% observed in this study (Table 1). The foam stability for sorghum stem flour was 2% for 2 h, which is substantially less than 5% for fluted pumpkin flour reported by Fagbemi and Oshodi (1991) for the same time interval, and 8.81-23.24%

Table 3. Functional properties of *Sorghum bicolor* stem flour*

Functional properties	Change (%)
Oil absorption capacity	406
Water absorption capacity	700
Foaming capacity	6.0
Foaming stability	2.0
Emulsion capacity	45.3
Emulsion stability	37.6
Least gelation capacity	10.0

*determinations were in triplicates

reported for varieties of lima beans by Oshodi and Adeladun (1993) as these are protein rich seeds.

Least gelation capacity for the sample was 10%, which is similar to that observed by Sathe *et al.* (1981) for the great northern bean flour and some of the varieties of the African yam bean flour reported by Oshodi *et al.* (1997). However, the 10% least gelation capacity for sorghum stem flour was lower than the values obtained for other seeds reported earlier by other workers. This low value for sorghum stem flour indicates that it can be used as firming or gel forming agent in food formulations and or in the development of new products for animals.

Conclusion

It may be concluded that *Sorghum bicolor* stem flour is rich in some micronutrients, especially Mg, which has made it largely acceptable in Nigeria, where it is infused to make drinks. This study has further indicated that it has some useful functional properties, which compared favourably with wheat, lima bean, soya bean, water melon, pigeon pea and sorghum grain itself.

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