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The Nutritive Value and Antimicrobial Property of *Sorghum bicolor* L. Stem (POPORO) Flour Used as Food Colour Additive and its Infusion Drink

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Abstract: The black purple sheath (stem) of *Sorgum bicolor* L., called Poporo used locally as food colour additives in cooking meals and its infusion drink commonly taken as beverages in Nigeria, was examined for its nutritive values and antimicrobial property. The medicinal potentials of the sorghum drink (fortified and unfortified) were determined with respect to their inhibitory effect on the growth of *Bacillus* sp., *Pseudomonas aeruginosa*, *Lactobacillus* sp. and *Corynebacterium* sp. Both the stem made into flour and the aqueous extract of the sorghum (drink) were found to be rich in energy (1121.3 KJ/100 g) and in some micronutrients such as Mg, Ca, K, Na and Fe. The high Mg content of stem (185.33/100 mg) may remove Mg deficiencies. The presence of Cu, Zn and Mn were also observed in the stem. The content of crude fibre (32.0%) and carbohydrate (44.50%) were high, making the stem a fodder for animal consumption. However, its protein content was low (3.20%) and the functional properties observed for the stem compared favorably well with other plants already reported by earlier workers for Pigeon pea flour, African yam bean and Wheat flour. The Fe content of both stem and drink met the daily-required intake (DRI) value for human being. The unfortified sorghum drink lack vitamin C but it inhibited the growth of the entire organism in this study having zones of inhibitions ranges from (3.0-5.0±0.2 mm). All these were however, increased when fortified with juice and lemon grass, with that of the pineapple juice having the highest inhibitory effect (11.00±0.2 mm) against *Pseudomonas aeruginosa*. In view of its richness in some micronutrients especially Mg and Fe and its manifested medicinal property, this cheaply produced drink from purely, underutilised local material, could serve as a safe good replacement particularly when fortified with pineapple juice and lemon grass for the expensive high sugar content carbonated drinks.

Key words: Functional properties, infusion drink, mineral content, medicinal property, nutritive value, sorghum stem flour

Introduction

Sorghum bicolor is most extensively cultivated in the drier Northern Guinea, Sudan Savannah and Greenland 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

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(Kochhar, 1981). It is a vastly complex genus, embracing hundreds of variants of different characteristics and adapted to different ecological riches and 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 stem. It also has a well-developed root/stem which is twice as efficient as that of maize although its leaf area is only half that of maize (Hartman *et al*., 1988).

Three major cultivars are grown in Nigeria: Guinea (red testa, white endosperm in the Southern Guinea Savannah, Kaura (yellow testa and endosperm and Farafara (white testa and endosperm) in the drier Savannah regions. However small scale farmers prefer Farafara to kaura, because the latter is believed to store less well. Despite this, there is a wide farming of Kaura by large-scale farmers for the brewing industries (Marley *et al*., 1997). The *Sorghum bicolor* L. stem is sweet taste and is found to contain some sugars and minerals; this sugary nature makes it to be easily chewed in Africa and Asia and is used for the manufacture of syrup (FAO, 1988). In the tropics, apart from the cereal being used as food (Ihekoronye and Ngoddy, 1992; Odetokun,1997) the mature black purple sheath (stem is generally sold in small bundles and is used as colour additives in cooking meals and also taken as beverages when steeped or boiled in water in many homes in Nigeria (Adetuyi, 2004).

In view of its usefulness as colour additives to food in Nigeria, we, therefore, deemed it fit to analyse the *Sorghum bicolor* L. stem for any nutritive value it may contain and its possible functional properties. Also the nutrient composition and the antimicrobial activity of the prepared infusion drink from the stem were also examined to ascertain its safety for the populace.

Materials and Methods

Collection and Treatment of Samples

The *Sorghum bicolor* L. stems used in this study were purchased in the dry forms 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. Also used, were fresh and unbruced Orange, Pineapple and Lemon grass and they were all thoroughly washed.

Analyses of The Raw Sorghum Stem Sample

The moisture, total ash, ether extracts and crude fibres were determined according to the method of the Association of the Official Analytical Chemists (AOAC, 1990). The nitrogen was determined by micro-kjeldahl method as described by Pearson (1976). Carbohydrate was determined by difference. The energy values were derived by multiplying the amounts of protein, carbohydrate and fat by the factors of 4, 4 and 9 (K cal and 17, 17 and 37 (KJ), respectively (EEC, 1990).

The minerals were analyzed from solutions obtained by first dry-ashing the sample at 550°C and dissolving the ash in standard flasks with 15 mL of 10% hydrochloric acid solution and the volume completed to 50 mL (Oshodi, 1992). Mg, Mn, Na, K, Ca, Fe, Cu and Zn were determined by means of atomic absorption spectrophotometer (Pye Unicam SP 9, Cambridge, UK).

Foam capacity and foam stability were studied by the method of Coffman and Garcia (1977): Total volume at interval between 25 and 1500 min was noted to study the foaming stability. To obtain the foaming capacity, volume increase (%) was calculated according to this equation:

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

The water and oil absorption capacity (WAC and OAC were determined by the method of Sosulki (1962) with some modification adopted 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 samples. The density of the Chef Executive brand oil used had earlier been 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 (Adeyeye *et al*., 1997). The result was expressed 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 Beuchart (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 SD and CV were calculated using methods mentioned by Chase (1996).

Preparation of the Infusion Sorghum Drink

Twenty grams of the dried black/purple Sorghum stem was boiled in 1200 mL of water for 30 μ min with or without lemon grass (50 g). The mixtures were subsequently sieved in a mesh (10 micro to get the Sorghum drink extract. This was mixed with the pre-extracted orange and pineapples juice at 50, 60, 70, 80 and 90% (v/v inclusion).

Sorghum Drinks Analysis and the Antimicrobial Activity

The taste panel composed of lecturers, non-teaching staffs and Students. The parameters assessed include the colour, taste, aroma and general acceptability. The nutritional beneficial and toxic metals that were assessed in the raw Sorghum stem were also repeated in the drinks using the AAS. Vitamin C content of the drinks was determined using the dichlorophenolindolephenol method as used and reported by Akanya *et al*. (1997) for sorrel drink. The antimicrobial activity of the extract was assayed using the agar well diffusion described by Schillinger and Lucke (1989).

Results

The proximate composition of Table 1 shows that stem flour is rich in carbohydrate (44.52 g/100 g and in crude fibre (32.02 g/100 g). Table 2 shows the mineral content in which Mg is the most abundant mineral in this stem flour (185.33 mg/100 g sample). Ca, K and Na are (151.70 mg/100 g) (138.87 mg/100 g) and (127.61 mg/100 g), respectively. Table 3 presents the functional properties of the sorghum stem flour. The emulsion capacity, EC, is 45.3%, while water and oil absorption capacities are 406.5 and 700.0%, respectively. Table 4 and 5 show the vitamin C and mineral content of the fortified and unfortified Sorghum drinks and the zones of inhibitions, respectively.

Table 1: Proximate composition of ***sorghum bicolor*** L. Stem flour % on dry weight basis

Parameter	Moisture	Protein	Crude fat	Total ash	Crude fibre	Carbohydrate**
Mean*	6.54	3.20	8.38	5.34	32.02	44.52
SD	0.03	0.26	0.34	0.17	0.49	0.67
CV (%)	0.46	8.13	4.06	3.18	1.53	1.51

* Mean of triplicate determinations, ** Carbohydrate determination by difference

Table 2: Mineral composition (mg/100 g) of sorghum bicolor l stem flour on dry weight basis

Minerals	Na	K	Ca	Mg	Fe	Cu	Zn	Mn
Mean*	127.61	138.87	151.70	185.33	10.98	0.47	7.15	2.83
SD	0.04	0.03	0.03	0.02	0.05	0.02	0.03	0.13
CV (%)	0.03	0.02	0.02	0.01	0.46	4.26	0.42	4.59

* Mean of triplicate determinations

Table 3: Functional properties of *sorghum bicolor* L. Stem flour

Functional properties (%)	OAC	WAC	FC	FS	EC	ES	LGC
Mean*	406.5	700.0	6.0	2.0	45.3	37.6	10.0
SD	0.39	5.77	0.50	0.20	0.51	0.40	0.20
CV (%)	0.15	33.3	0.25	0.04	0.26	0.16	0.04

* Mean of triplicate determinations

Table 4: The vitamin c, phosphorus and mineral content of sorghum stem fortified drinks

		Mineral content (ppm)			
Sample	Vit. C (mg mL^{-1})	Fe	Zn	Na	Ca
Sorghum extract	0.0±0.0	114.0±0.1	120.0±0.2	78 0.0±0.4	632.0±04
Orange juice added *					
50%	0.7±0.0	101.0±0.1	90.0±0.1	677.0±0.4	578.0± 0.3
60%	1.3±0.2	92.0±0.1	80.0±0.1	667.0±0.5	537.0±0.4
70%	2.1±0.1	89.1±0.3	70.0±0.2	640.0± 0.5	514.0±0.2
80%	2.8±0.1	73.0±0.2	60.0±0.1	640.0±0.2	481.0±0.9
90%	3.5±0.3	68.0±0.1	60.0±0.3	630.0±0.2	476.0±0.7
Pineapple Juice added *					
50%	0.5±0.3	54.0±0.1	70.0±0.1	750.0±0.12	901.0±0.1
60%	0.9±0.2	29.1±0.2	70.0±0.2	735.0±0.1	932.0±0.7
70%	1.2±0.2	25.0±0.2	60.0±0.2	725.0±0.4	996.0±0.8
80%	1.7±0.1	21.0±0.0	50.0±0.1	670.0±0.1	1061.0±0.3
90%	2.1±0.4	17.0±0.3	40.0±0.1	652.0±0.3	1185.0±0.1

Data are mean±SE values of triplicate determinations, Hg and Pb were not detected, *Percentage inclusion of the juice in the unfortified sorghum stem drink

Table 5: Zone of inhibition exhibited by sorghum stem drink against indicator bacteria

	Zone of inhibition (mm)			
Sample	*Pseudomonas aeruginosa*	*Lactobacillus* species	*Bacillus* species	*Corynebacterium*species
Sorghum stem extract	5.0±02	4.0±0.3	3.0±0.2	3.0±0.4
fortified with				
50% pineapple juice	10.0±04	6.0±6.2	7.0±0.1	6.0±0.1
50% pineapple juice and				
Lemon grass	11.0±0.1	9.0±0.1	6.0±0.4	6.0±0.3
Lemon grass	4.0±0.5	5.0±0.1	3.0±0.5	4.0±0.4
25% and 25%v/v orange				
and pineapple juices	7.0±0.1	8.0±0.5	5.0±0.1	5.0±0.0

Data are mean±SE values of triplicate determination

Discussion

In view of the negative effect of sugar on the human body, causing diabetics and other related diseases, the consumption of locally produced beverages is on the increase, with or without knowledge of the nutritional, safety and medicinal potentials of such drinks. This study sought to establish some of the potentials with regard to the nutritionally important mineral content, vitamin C and the medicinal potentials of Sorghum stem (called Poporo) and its popularly consumed drinks among the rural dwellers in Nigeria.

The stem flour is rich in carbohydrate Table 1 and hence could be used as fodder for animals. However, it is lower than that value reported for the sorghum grain by Ihekoronye and Ngoddy (1992) and Odetokun (1997). The calculated total energy for 100 g of the stem was 266.30 Kcal (or 1121.30) KJ, which shows it has high energy content.

The Mg in this stem flour (185.33 mg/100 g) sample is comparable to one of the range of values 0.11-0.21% (110 mg/100 g) to (210 mg/100 g) reported for a variety of *Sorghum bicolor* L. plant flour by Aganga *et al*. (1996). Our value for Mg (Table 2) also agrees with that reported for sorghum grain flour from small-scale farms in Kenya, which have between 0.3-2.8 g kg^{-1} (30-280 mg/100 g by

Jacob *et al*., 1997). However, the current result of stem Mg content was falls far below that reported (747 mg/100 g) by Olaofe and Sanni (1988). for sorghum grain flour in Ilorin, Nigeria and that may be due to differences in soil.

The main cause of low Mg intake has been hinged on high intake of poor nutritional quality products, high consumption of food rich in energy and poor in micronutrients such as Sugar, Sodas, white flour, white sugar (Lopez *et al*., 2002.) The *Sorghum bicolor* L. stem is rich in energy and also in some micronutrients, compared to the refined product. Hence, its consumption may aid in removing Mg deficiencies, which could lead to severe metabolic disorders and compromise the health of the organism.

Sorghum bicolor L. 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 are comparable with those reported by Aganga *et al*. (1996) in at least one of the varieties of *Sorghum bicolor* L. plant studied. The K value for this work is quite lower than that reported value by Aganga *et al*. (1996). *Sorghum bicolor* L. stem flour is richer in K than Lima bean flour reported by Oshodi and Adeladun (1993).

The Fe content in current work is 10.98 mg/100 g, which is quite higher than the values reported by Adeyeye (1997) for *Pyrus communis*, *Irvingia gabonesis* and *Magnifera indica* fruits consumed in Nigeria (1.86-4.49 mg/100 g Sorghum stem flour is also richer in iron than African yam bean (Adeyeye, 1996, pigeon pea and soya bean as reported by Holland *et al*. (1991). However, current result of stem Fe content was slightly comparable with that result obtained by Olaofe and Sanni (1988). The Dietary Reference Intake (DRI) for iron is 10 mg for an adult male and 19 mg for a female adult (ACU-CELL, 2004). This can be met in 100 g of the sample. A typical western diet contains an average of 7 mg of iron per 1000 kcal (Minihane and Rimbach, 2002). The mg of iron found per 1000 kcal of sorghum stem flour is 41.23 mg, which can be found in 375.5 g of the sorghum stem flour.

It is worth noting the iron present in plant products is the non-haem form, which is not easily absorbed as the haem form found in animal sources (Bender, 1992). Iron is an essential micronutrient for almost all organisms. Its deficiency is the most common micronutrient deficiency and its deficiency symptoms are anaemia, dizziness, amenorhea and fatigue. The intake of the drink made from sorghum stem flour or its incorporation in foods may greatly help in reducing iron deficiency. Zinc, Mn and Cu values are 7.15, 2.83 and 0.47 mg/100 g, respectively. The Zn and Mn content of present study are about 47.7 and 70.8%lower limit of DRI, respectively. However, the sample is poor in Cu. The Fe, Na and Ca contents of sorghum stem flour was higher than that reported by Oboh and Elusiyan, 2004 for Sorrel drink Fe 0.24, Na (0.59, Ca (0.60 mg/100 g) a locally produced infusion drink in Nigeria, obtained from the Roselle calyx (flowers of *Hibiscus sabdariffa*. The Zn content of the sorrel was higher 26.28 mg/100 g than the sorghum stem flour.

Result of the functional properties of the sorghum stem flour gave higher values for water and oil absorption capacities, respectively than the ones reported by some workers for some plants: Olaofe *et al*. (1999a) reported 298.6 and 245.6% for cowpea flour as water and oil absorption capacities, respectively; Oshodi and Ekperigin, 1989 reported 138 and 89.7% for WAC and FAC for pigeon pea flour, respectively and for Water melon seed protein concentrate, Oladimeji and Obaseki (2003) reported 152% for WAC and Akintayo *et al*. (2000), reported 138-200% as WAC and 120-175% as FAC for protein concentrates of some legume flours.

The emulsion capacity, EC, for the *Sorghum bicolor* L. stem flour is 45.3% Table 3 this value is comparable to the values of 49.40% reported by Oshodi and Ekperigin (1989) and 40.40% by Mtebe (1989), for pigeon pea and the white variety of hulled African yam bean reported by Adeyeye and Aye (1998), as 44.35%. The EC value for sorghum bicolor L stem flour is better than the report of Lin *et al*. (1974), whose values range between 7-11% for wheat flour and 18% for soy flour. Olaofe *et al*. (1998), reported 25.6% for variegated grasshopper, which is lower than 45.3% values for the sample in this current report. The values for hulled and dehulled Adenopus breviflorous benth flour 20.46 and 35.81%, respectively as reported by Oshodi (1992). are also lower than our observed EC value of 45.3% for *Sorghum bicolor* L. stem flour.

The emulsion stability for the sorghum bicolor L stem flour was observed as 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 watermelon seed protein concentrate at zero salt concentration.

Foaming Capacity (FC) and stability as further shown in Table 3 are 6 and 2%, respectively. The FC value of 6% is lower than those of full-fat fluted pumpkin seed flour (10.8%) reported by Fagbemi and Oshodi (1991). The low foaming capacity of 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 is 2% for 2 h this can not be comparable to 5% for fluted pumpkin flour by Fagbemi and Oshodi (1991), for the same time interval and 8.81-23.24% reported for varieties of Lima beans by Oshodi and Adeladun (1993), as these are protein rich seeds.

Least Gelation Capacity (LGC) for the sample is 10% and 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% LGC for sorghum stem flour is lower than the values obtained for other seeds reported earlier by other workers mentioned in this discuss. This low LGC for sorghum stem flour indicates that it can be used as firming or gel forming agent in food formulations and or in new products development for animals.

Table 4 shows the result of the mineral composition of the fortified and unfortified sorghum drink. There is little or no change in colour of the drink fortified with both orange and pineapple juice but becomes lighter as increase in quantities of the fortified juices increases Table 4 The pineapple juice-fortified sorghum drink had the best aroma, taste and generally acceptable among the unfortified and the orange juice-fortified. It also shows that the unfortified sorghum stem drink had no Vitamin C content but increases as increases in fortification of the drink with Orange and Pineapple juice which is higher in orange fortified than pineapple fortified drinks. The analysis also shown that the Vitamin C content of orange juice is higher than the pineapple juice. The juices added, therefore, improved the aroma of the drink, sweetened and serve as a Vitamin C supplement, which are very important in treatment of disease associated with Vitamin C deficiency.

Fortification of sorghum drink with either orange or pineapple juice reduced the level of the minerals, except Zn, present in the sorghum drink which, however, is higher compare with sorrel drink as determined by Oboh and Elusiyan (2004). The reduction was more obvious in sorghum drink fortified with pineapple juice. This indicated that the sorghum drink is richer in those minerals than either the orange or pineapple juice.

Toxic metals such as Hg and Pb are regarded being toxic were not detected in both the fortified and the unfortified drink. It could therefore be claimed that the drink is safe with regard to heavy metal toxicity. The drink could serve as refreshment drink and also used in the treatment of the diseases associated with mineral deficiency.

The extract displayed antimicrobial effects against the entire indicator bacteria used in this study. The zone of inhibition observed range from 3.0-11.0 mm Table 5. Sorghum stem extract fortified with pineapple juice and lemon grass had the highest inhibitory effect against *Pseudomonas aeruginosa*. The inhibitory effect of sorghum drink fortified with lemon grass observed in the study was however higher than the inhibitory effect of sorrel drink reported by Oboh and Elusiyan (2004). The *in vitro* antimicrobial property displayed by this Sorghum drink is an indication of its medicinal potential.

The study had unveiled some of the potentials of the *Sorghum bicolor* L. stem flour and its popular drink among the citizenry of Nigeria. The plant sample is rich in some micronutrients especially Mg and Fe, which makes it largely acceptable to our populace in Nigeria who infuses it to make drinks, which manifested medicinal property as local blood tonic. It serves as a cheap source of Iron. Also, by this study we have been able to observe that it has some good functional properties, which compare favorably with wheat, lima bean, Soya bean, melon, pigeon pea and sorghum grain itself. Conclusively, this cheaply produced drink from purely local material could serve as a safe good replacement for the expensive high sugar content carbonated drinks.

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