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Effect of processing (sprouting and fermentation) of five local varieties of sorghum on some biochemical parameters

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ABSTRACT: The effect of processing (combined sprouting and fermentation) on chemical composition, tannin content, *in vitro* protein digestibility and mineral element composition of five local varieties were studied. The five varieties studied were: "chakalari white, chakalari red, yafimoro, tumbuna and mire". The parameters were assayed using standard methods (proximate analysis, tannin content, in-vitro protein digestibility and mineral element composition). The results for tannin content showed that processing decreased tannin content between the ranges of 2.08%-14.58% for the five cultivars. As for mineral composition, there was a general decrease in percentage mineral composition of most varieties when comparison was made between raw and processed samples. Processing increased protein digestibility which ranged between 93.78%-95.68% as compared to the unprocessed samples. These result hence showed that processing (combined sprouting and fermentation) decreases the tannin content of sorghum, increases in-vitro protein digestibility and decreases mineral element composition of sorghum.

Key words: Sorghum; Sprouting; Fermentation; Digestibility

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is considered as one of the most important food crops in the world, following wheat, rice, maize and barley (FAO, 2006). Sorghum provides the staple food of a large population in Africa, India and the semi-arid parts of the tropics. It is commonly consumed by the poor masses of many countries and it forms a major source of proteins and calories in the diet of large segments of the population of India and Africa. Processed sorghum seeds or flour were found to be important sources of calories and proteins to the vast majority of the population as well as for poultry and livestock (FAO, 2006). Sorghum acts as a principal source of energy, proteins, vitamins and minerals for millions of the poorest people living in Africa, Asia and the Semi-arid tropics worldwide (Mauder, 2006). Unfortunately, sorghum has low nutritional value and inferior organoleptic qualities due to the presence of anti-nutritional factors which forms complexes with food ingredients (Reed, 1995). In addition, *in vivo* and *in vitro* studies indicate that the proteins of wet cooked sorghum are significantly less digestible than the proteins of other similar cooked cereals such as wheat and maize (Davidson *et al*., 1979; Guathier *et al*. 1982). The factors responsible for poor sorghum protein digestibility are divided into exogenous factors (grain organizational structure, polyphenols, phytic acid, and starch and non-starch polysaccharides) and endogenous factors (disulphide and non-disulphide cross-linking, kafirin hydrophobicity and changes in protein secondary structure. Processing methods, such as soaking, sprouting and cooking has been reported to improve the nutritional and functional properties of plant seeds. There are a number of roles that microorganisms can play in food processing, either positive or negative. The positive effect is generally regarded as part of the fermentation

processing namely product preservation, flavour development and reduction of antinutrient. Furthermore, fermentation enhances the nutrient, vitamins, essential amino acids and protein, by improving proteins and fiber digestibility. The negative effect includes spoilage of food products and contamination by pathogenic microorganisms (Brune *et al*., 1989; Hurel *et al*., 1999; Lewis and Elvin, 1977). Processing of sorghum (boiling, germination, fermentation and cooking) greatly improved its nutritive value (Inyang and Zakari, 2008). However, combination of these processes further improved the quality of sorghum as a food by removing the antinutritional factors as well as by alleviating the effect of heating. Many workers reported reduction in major and trace elements in the soaked and cooked grains. As observed, cooking resulted in more significant loss in trace elements than soaking, which could be attributed to effect of heat on changing the insoluble chemical species of some trace elements into soluble ones; thus extracted more in the cooking water.

Objective of the Study

The objective of the study is to determine the effects of the various processing techniques (sprouting and fermentation singly) on tannin content, protein *in vitro* digestibility and mineral composition.

Materials and Methods

Source of Raw Materials

The sorghum grains used for this study were obtained at the open market (Monday Market, grains section). The five varieties of the sorghum used include (using local names) *Chakalari white*, *Chakalari red*, *Tumbuna*, *Yafimoro* and Mire. The sorghum varieties were authenticated by a seed breeder at the Lake Chad Research Institute, Maiduguri, Borno State, Nigeria.

Fermentation

The five varieties of sorghum were each weighed and 100g were collected in different flat bowls. Then 100g of each sample was then rinsed using water before it was drained. To these about 250ml of water was added. This was covered and kept for 72 hours away from light for fermentation to occur. After that, the fermented samples were washed thoroughly in water and dried for 94 hours (4 days approximately) as described by Pederson *et al*. 2000.

Proximate Analysis

The feed samples were analyzed to determine the Crude Protein (CP), Ether Extract (EE), Ash and Nitrogen Free Extract (NFE) using the method of A.O.A.C. (2000). The mineral element level was determined using Atomic Absorption method and *in vitro* protein digestibility was determined as described by Nills (1979).

Results

Physical Characteristics

All the five local varieties of sorghum used were dry and hard. Each of this cultivar had a unique colour characteristic that distinguished it from the other cultivars used. Averagely, they all had about the same size although “Mire” grains where slightly smaller than the others. For colour, “Chakalari white” had a white appearance, “Chakalari red” also appeared red in colour although having virtually the same characteristics as the Chakalari white except for colour. Mire had a blend of red and black colours but these grains were slightly smaller than all the other grains. Tumbuna was softer than all the grains and had a colour appearance of milkish white and little black spots at the tip of some of the grains. Yafimoro had a blend of colours to it, some of the grains had white, black and red spots on them with the white dominating while others had only the pure white and black colours in them. The grains looked thin and slim and it was a very hard grain.

Table 1 shows the results for the proximate analysis of the five varieties of sorghum that were analyzed. The percentage of dry matter ranged from 96.20 – 97.50 with raw Chakalari white having the highest value while raw Yafimoro had the lowest dry matter. Percentage crude protein ranged between 22.23 with raw Tumbuna having lowest percentage protein while processed mire had the highest percentage. Percentage crude fiber increased for all the processed varieties while percentage ash was relatively stable for all the varieties.

Table 1. Proximate analysis of the five local varieties of Sorghum

Variety/ Treatment	DM (%)	MC (%)	CP (%)	FAT (%)	CF (%)	ASH (%)
Chakalari white						
Raw	97.50	2.50	19.60	14.50	2.50	2.50
Processed	96.60	3.40	16.50	2.00	12.50	1.00
Chakalari red						
Raw	96.40	3.60	20.66	16.00	2.00	1.00
Processed	97.00	3.00	20.13	1.50	10.50	1.00
Mire						
Raw	96.00	4.00	18.73	15.00	1.50	2.50
Processed	96.50	3.50	22.23	1.00	9.50	2.50
Tumbuna						
Raw	96.40	3.60	9.97	13.50	3.50	1.00
Processed	96.60	3.40	18.20	2.00	14.50	1.50
Yafimoro						
Raw	96.20	3.80	22.23	13.50	4.00	1.00
Processed	96.80	3.20	18.03	2.00	12.50	1.00

DM = Dry Matter; MC = Moisture Content; CP = Crude Protein
CF = Crude Fibre.

Table 2 shows that for all the varieties, digestibility occurred above 90% but maximum increase in digestibility was recorded in 2 hours when raw tumbuna (91.27%) increased to 93.79% upon digestion (processed). For the raw varieties, protein invitro digestibility ranged from 91.27% to 97.35% while for processed, digestibility ranged from 93.79% – 95.68%.

Table 2: Protein digestibility of the five local varieties of Sorghum.

Variety	Raw (%)			Processed (%)		
	2 Hrs	4 Hrs	6 Hrs	2 Hrs	4 Hrs	6 Hrs
Chakalari white	34.65	47.35	46.43	95.26	95.26	95.26
Chakalari red	32.22	44.92	42.22	94.39	95.23	95.68
Mire	42.87	45.84	45.84	95.28	95.28	96.68
Tumbuna	31.27	41.27	42.18	93.79	95.22	93.79
Yafimoro	35.59	36.09	46.09	94.68	95.19	94.18

Table3 indicates the mineral element composition on the sorghum cultivars. These results showed that for each of the mineral assayed, there was a general decrease in composition when compared to both raw and processed varieties. The compositional range of the minerals was between 0.000% - 12.030%.

Table 4 shows the result for the determination of tannin content of the various cultivars. The tannin content for the raw variety ranged from 3.4 mg/g to 4.9 mg/g while that of the processed variety ranged from 3.2 – 4.7 (mg/g). The percentage reduction in tannin content ranged from 2.22% - 14.58 % with mire having the highest reduction in tannin content.

Discussion

Proximate analysis studies performed on the sorghum varieties vary slightly from that stated by Kent (1983). The observed differences could be due to difference in cultural practices, environmental conditions and in cultivars and varieties.

Proximate composition of a grain is important in that it helps in determining the quality and storage stability of grains. Protein digestibility studies conducted showed that processing increase protein in vitro digestibility as was stated by Pederson *et al*., (2000). It was also discovered that sorghum *in vitro* digestibility of protein all occurred at above 90% at 2 hours; this goes to show that sorghum grain is almost digested *in vitro* after 2 hours in normal conditions. Also based on the result obtained, the processing of sorghum significantly increased protein digestibility ($p < 0.05$), but with respect to time, after 2 hours, the level of significance of digestibility was not significant.

Processing of the sorghum grain, from the results obtained significantly reduced the tannin content of the grain. This is in agreement with the work of Hibberd *et al*., (2003). Processing method (combined sprouting and fermentation) significantly reduces tannin content more than the other previously known methods such as malting, steeping, fermentation, sprouting alone e.tc.

As for the mineral element level, the results showed a marked decrease in almost all the mineral compositional contents of the processed grains when compared with the raw. This is so because during the various processing techniques, the pericarps of some grains are removed while the grains (some) break open. Also the aleurone layers of some of these cereals are lost thus resulting in this massive decrease. This is so because almost mineral elements are found on either the pericarp or the aleurone layer of the grain. This work is in agreement with previous studies which reported that, processing of cereals depletes their tannin content (Gee and Harold, 2004).

Table 3: Mineral composition of the five local varieties of Sorghum.

Variety/ Treatment	Mg (%)	Na (%)	Ca (%)	K (%)	Zn (%)	Mn (%)	Fe (%)	Cu (%)	Si (%)	Al (%)
Chakalari white										
Raw	4.806	3.937	6.188	12.030	0.006	0.002	0.022	0.001	0.009	0.220
Processed	2.124	5.015	7.642	3.172	0.007	0.000	0.017	0.009	0.004	0.110
Chakalari red										
Raw	4.831	3.068	6.679	10.27	0.005	0.010	0.024	0.009	0.100	0.210
Processed	2.409	3.868	7.360	3.004	0.006	0.005	0.025	0.004	0.010	0.120
Mire										
Raw	3.702	3.875	7.551	9.310	0.004	0.004	0.025	0.004	0.090	0.250
Processed	2.798	3.307	7.796	3.087	0.001	0.000	0.018	0.002	0.020	0.120
Tumbuna										
Raw	4.610	4.629	8.448	11.030	0.005	0.000	0.024	0.006	0.080	0.200
Processed	3.057	4.047	12.610	3.409	0.130	0.000	0.020	0.002	0.030	0.100
Yafimoro										
Raw	4.094	4.227	7.475	10.350	0.008	0.000	0.023	0.005	0.080	0.190
Processed	2.180	4.400	8.270	3.160	0.001	0.006	0.015	0.004	0.020	0.120

Table 4: Tanin content of the five local varieties of Sorghum.

Variety	Raw (mg/g)	Processed (mg/g)	% Reduction
Chakalari white	3.4	1.2	5.88
Chakalari red	4.8	2.7	2.08
Mire	4.8	2.1	14.58
Tumbuna	4.9	2.7	4.08
Yafimoro	4.5	2.4	2.22

Conclusion

Based on the study carried out, it can be concluded that far above sprouting or fermentation singly, the combined processing of sprouting and fermentation, reduces tannin content, with a resultant increase *in vitro* protein digestibility. However, the mineral composition decreases and therefore the fortification of processed sorghum varieties to be consumed should be encouraged so as to replenish the nutrients that are lost during processing.

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