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Effects of Heat Treatments on Chemical Composition of Groundbean (*Kerstingiella geocarpa harm*)

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Abstract: This study evaluates the effects of heat treatments on chemical composition of Groundbean (GB). Groundbean seeds were cleaned, soaked, dehulled and cooked for varying periods. The samples were separately dried and milled into fine flours. The flour samples were analyzed for proximate, minerals and antinutrients composition using standard methods. Results showed that proximate composition of all samples varied. The Untreated Groundbean (UTGB) had the highest proximate composition which was significantly different from all nutrients tested ($p<0.05$) except for fibre (3.65%) in Undehulled Cooked Groundbean (UDCGB) and Carbohydrate (CHO) content (63.63%) in Soaked Dehulled Cooked Groundbean (SODCGB). SOGB had the highest iron (Fe) (6.80 mg), calcium (Ca) (52.53 mg), sodium (Na) (1.48 mg), manganese (Mn) (20.78 mg) and zinc (Zn) (2.34 mg) content which were significantly different from others ($p<0.05$). UTGB had the highest Copper (Cu) (3.89 mg), magnesium (Mg) (1.46 mg), Phosphorus (Ph) (345.45 mg), Potassiun (K) (263.80 mg) and Iodine (I_2) (102.18 mcg/g) which was significantly different from others ($p<0.05$). The antinutrient composition of all samples was low except for Trypsin Inhibitor (TI) where UTGB had the highest TI (29.45 mg) which was significantly different from the rest. The result indicates that groundbean is safe for human consumption and could be used in the formulation of diets for children and adults.

Key words: Groundbean, fat, fibre content, heat treatments

INTRODUCTION

Malnutrition specifically undernutrition as seen in Protein Energy Malnutrition (PEM) and micronutrient deficiencies is a major health problem in developing nations. It has been indicated that under-nutrition, together with micronutrients deficiencies are the leading risk factors for disease and death (ACC/SCN, 2006). FAO (2000) estimates show that 184 million people or 36.0% of the population of sub-Saharan Africa are chronically hungry or food insecure. Without good nutrition, infants, children and adults alike are more vulnerable to disease and death.

Protein Energy Malnutrition (PEM) has been estimated to affect 104 million persons in developing regions (Pellett, 1983). ACC/SCN (1997) report estimated that almost one-third of the population worldwide have a deficiency in one or more micronutrients.

Providing sufficient nutrients to meet people's needs for health, growth and development is a serious challenge in Africa. Nutrient inadequacy is a major problem in Nigeria today. This has precipitated large scale of malnutrition cutting across all the age groups and preventing individuals from attaining their potentials in life. It robs a country of its best minds and bodies and the lives of children. Malnutrition reduces intelligence, educability, disease resistance, productivity and activity (ACC/SCN, 1997).

Mulda-Simbada (1996) observed that malnutrition is a condition in which the physical activity of an individual is impaired to a point where he\she can no longer maintain adequate performance for growth, resisting and recovering from disease, pregnancy, lactation and physical work. It is associated with poverty, high population density, inadequate access to sanitary and health facilities. In sub-Saharan African, inadequate household food security appears to be the most important underlying cause of malnutrition (Smith and Haddard, 2000). Micronutrients, especially Vitamin A, iron and iodine deficiencies cause illness, death, learning disabilities and impaired work capacity (ACC/SCN, 1993).

Groundbean (*Kerstingiella geocarpa harm*) is a lesser known and under-exploited grain legume crop. It is said to have originated in the savanna areas of West Africa and has a very restricted range of cultivation being confined to tropical Africa, particularly Nigeria, Mali, Burkina-Faso, Upper Volta, Niger, Benin and Togo (Kay, 1979; Obasi and Agbatse, 2003) where it is grown at subsistence level.

Groundbean has a high nutritional value and comparable to that of most commonly eaten legumes. NAS (1979) reported crude chemical composition of the seed in 100 g portion as follows: protein 21.5 g, fat 1.2 g, fibre 6.1 g, ash 3.6 g, carbohydrate 73.9 and calories

386. However, higher crude protein (24.9%) than the protein values of other under-exploited legume crops have been indicated (Anon, 1979; Ravindran, 1988; Obasi and Agbatse, 2003). The Amino acid contents show that groundbean compared well with soybean and groundnut (Smith and Circle, 1981). Apart from lysine content which was below the limit set by the FAO/WHO amino acid standard, all other essential amino acids in ground bean were present in amounts equal to or more than the FAO/WHO (1973) reference pattern (Obasi and Agbatse, 2003). This finding is important because seed proteins are generally deficient in sulphur amino acid which is a primary constraint for food legumes in meeting the nutritional requirements in human beings (Ezedinma, 1975).

The major minerals content of the seed were 1.25 g potassium, 2.14 g calcium, 0.40 g magnesium, 3.32 g phosphorus and 0.87 g sodium per kilogramme. The trace minerals content were 14 mg zinc, 122 mg iron and 3 mg copper per kilogramme (Obasi and Agbatse, 2003).

MATERIALS AND METHODS

Sources of materials: Groundbean (GB) is not widely cultivated in Nigeria as well as in Enugu State. It was bought (10 kg) from Nrobo market in Uzo-Uwani L.G.A. of Enugu State, Nigeria, where it is commonly grown.

Preparation and treatment of samples: Ground bean seeds were sorted and cleaned to remove spoilt grains, stone and other foreign materials.

Untreated GB: The GB seeds were washed with clean tap water and dried in Carbolite moisture extraction oven at 50°C for 24 h. The sample was milled into fine flour, sieved with 70 mm-meshscreen in a laboratory Hammer-mill and stored in name labeled polyethylene bag inside a deep freezer for future analysis.

Undehulled cooked GB: The seeds were washed in tap water, cooked in boiling water (100°C) until soft for human consumption and the remaining little water was imbibed by the seeds. The sample was dried, milled and stored in name labelled polyethylene bag and put in a deep freezer prior to analysis.

Soaked GB: The seeds were washed in clean tap water and soaked in tap water in a ratio of 1:3 (w/v) for 8 h. After this period, the water was drained. The seeds were oven dried at 50°C for 24 h, hammer milled and stored in name labelled polyethylene bag for analysis.

Soaked undehulled cooked GB: The seeds soaked for 8h were cooked until soft for human consumption The remaining water was imbibed by the cooked grains, dried in moisture extraction oven at 50°C for 24 h, milled and stored in name labelled polyethylene bag and put in a deep freezer for analysis.

Soaked dehulled cooked GB: Soaked dehulled groundbeans were cooked in boiling water (100°C) till they were tender, dried at 50°C for 24 h, milled and stored as those of soaked, dehulled GB.

Chemical analysis: Proximate and mineral composition were determined by AOAC (1995). True protein was obtained by multiplying True Nitrogen (TN) by 6.25. Non-Protein Nitrogen (NPN) was determined by the method of Singh and Jambunathan (1981). True Protein Nitrogen (TPN) was obtained by difference i.e. TN-NPN. Trypsin inhibitor was determined by the method described by Kakade *et al.* (1974). Tannins content was determined spectrophotometrically using the method of Price *et al.* (1980). Phytate was estimated by modified method of Latta and Eskin (1980). Oxalate was determined by the method described by Oke (1978). Cyanide was determined enzymatically using the method of Cooke (1978).

Data analysis: Data were analyzed using the computer programme statistical software package (SAS, 2003). Analysis of variance (ANOVA), Standard Error of the Mean (SEM) and Least Significant Difference (LSD) were used to separate the mean differences among samples ($p<0.05$).

RESULTS AND DISCUSSION

Table 1 shows chemical composition of Untreated (UTGB), Soaked (SOGB), Undehulled and Cooked (UDCGB), Soaked, Undehulled and Cooked (SUDCGB), and Soaked, Dehulled and Cooked (SODCGB) groundbean. The moisture content differed and ranged from 7.96 in SUDCGB to 9.22% in UTGB ($p<0.05$). The SUDCGB had the least moisture content (7.96%) followed by SOGB (8.05%) and SODCGB (8.15%).

Crude protein values ranged from 21.31 in SODCGB to 23.79% in UTGB. The UTGB had significantly higher value (23.79%) ($p<0.05$) and followed by UDCGB (22.81%). The true protein values followed the same trend as those for crude protein. The values ranged from 20.03 in SODCGB to 22.38% in UTGB. The value for SODCGB (20.03%) was significantly lower than others ($p<0.05$). The true protein nitrogen values had similar trend as in crude protein and true protein values. The range was from 3.21% in SODCGB to 3.58% in UTGB. The non protein nitrogen values ranged from 0.20% in SODCGB to 0.23% in UTGB. The UTGB value (0.23%) was significantly higher than others ($p<0.05$).

Ash values varied and ranged from 2.58% in SODCGB to 4.25% in UTGB ($p<0.05$). The differences were attributed to treatment. Fat values for both untreated and treated samples were low. The values ranged from 1.03

Table 1: Proximate composition of untreated, undehulled, dehulled, soaked, cooked groundbean

Composition (%)	UTGB	UDCGB	SUDCGB	SOGB	SODCGB	±SEM
Moisture	9.22[a]	8.95[b]	7.96[e]	8.05[d]	8.15[c]	±0.016
Crude protein	23.79[a]	22.81[b]	22.33[c]	22.13[f]	21.31[d]	±0.094
True protein	22.38[a]	21.44[b]	20.99[c]	20.03[d]	20.81[C]	±0.096
True nitrogen	3.58[a]	3.43[b]	3.34[c]	3.33[c]	3.21[d]	±0.010
Non protein nitrogen	0.23[a]	0.22[b]	0.21[c]	0.21[c]	0.20[d]	±0.000
Ash	4.25[a]	4.12[b]	3.25[d]	4.05[c]	2.58[e]	±0.012
Fat	1.24[a]	1.03[d]	1.05[d]	1.18[b]	1.11[c]	±0.014
Fiber	3.57[b]	3.65[a]	3.35[c]	3.58[b]	3.22[d]	±0.010
CHO	57.94[e]	59.44[d]	62.05[b]	61.01[c]	63.63[a]	±0.078

Values are means of triplicate determinations ±SEM; Means bearing different superscripts on the same column are statistically different ($p<0.05$)

UTGB = Untreated Groundbean
UDCGB = Undehulled Cooked Groundbean
SUDCGB = Soaked Undehulled Cooked Groundbean
SOGB = Soaked Groundbean
SODCGB = Soaked Dehulled Cooked Groundbean

in UDCGB to 1.24% in UTGB. The untreated sample (UTGB) had significantly higher value ($p<0.05$) than the treated samples.

The fibre content for the treated and untreated samples ranged from 3.22 in SODCGB to 3.65% in UDCGB. The SODCGB had significantly lower value ($p<0.05$) than others. The carbohydrate content of the samples varied significantly ($p<0.05$). The values ranged from 57.94% in UTGB to 63.63% in SODCGB. The SODCGB had the highest value (63.63%) followed by SUDCGB (62.05%) and SOGB (61.01%).

The lower moisture content for SUDCGB (7.96%) (Table 1) when compared with others shows that it will have better keeping quality. Moisture content in excess of 14% in flours has greater danger of bacteria action and mould growth which produce undesirable changes (Ihekoronye and Ngoddy, 1985). The moisture contents are comparable to those observed earlier (Obizoba, 1991) but higher than that reported by Echendu (2004) for pigeon pea.

The Crude Protein (CP) values (22.13-23.79%) fell within those reported for edible legumes of 20-40% (Elegbede, 1998) but higher than 21.5% (NAS, 1979) and comparable to 19.91-22.36% (Chikwendu, 2007). The lower crude protein value (22.13%) in SOGB as compared with others might be associated with leaching of some nitrogenous compounds into the soaking water (Odenigbo and Obizoba, 2004). The UTGB and the UDCGB that had the highest crude protein also had the highest True Protein (TP). The higher CP for UTGB (23.79%) was because CP contains a lot of Non Protein N (NPN) as against true protein. On the other hand, the lower CP and TP of all treated samples were expected. This is because most of their NPN had been removed due to treatments. The NPN constitutes free amino acids, peptides and many nitrogenous compounds (Sathe, 1996). The higher protein values in the untreated sample may not be available as compared with those of the treated samples. It has been shown that TP of any given food is much more bio-available than their counterparts with higher protein contents mixed with NPN. The non protein N values that ranged from 0.21-0.23% were lower than those (0.42-0.70%) reported earlier (Chikwendu, 2007). The lower NPN and higher value of true protein nitrogen and total nitrogen indicate that groundbean protein is of high quality (Chikwendu, 2007).

The lower ash values recorded for the treated samples (2.58-4.12%) when compared with the untreated sample (4.25%) were because most of the ash might have leached into the treatment medium. The SODCGB that had the least ash might be due to the three domestic food processing techniques adopted which precipitated loss of ash through the vegetative parts of the grain (Obizoba and Atii, 1991). The values obtained compared with 3.6% reported previously (NAS, 1979). Fat values were low for both the untreated and treated samples (1.03-1.24%). This agrees with the value, 1.2% reported earlier (NAS, 1979). The lower values for treated samples might be due to leaching of nutrient in boiling water or loss of nutrient during dehulling (Nnam and Nwokocha, 2003). The low fat value in GB is because the cell walls of grains contain very small fat which merely is for maintenance of cell integrity and protection (Chikwendu, 2003).

Fibre values were lower than 6.1% (NAS, 1979) and comparable to 3.99-4.17% (Chikwendu, 2007). Soaking, dehulling and cooking had much more adverse effects on fibre when compared with others. It might be a synergistic effect of the different processing techniques. The comparable fibre values for untreated and SOGB (3.57 and 3.58%) appears to indicate that soaking alone did not reduce fibre content of the grain. The higher carbohydrate values for all the treated samples as compared with the control indicates that processing increased hydrolysis of complex carbohydrates to release more absorbable carbohydrate (Odenigbo and Obizoba, 2004). The low level caused by cooking agrees with the work of Ganesh Kumar *et al.* (1978) in cooked chickpea, green gram and cowpea.

Table 2: Mineral composition of untreated, undehulled, dehulled, soaked, cooked groundbean

Composition	UTGB	UDCGB	SUDCGB	SOGB	SODCGB	±SEM
Iron (mg/100 g)	5.02[b]	3.02[d]	4.25[c]	6.80[a]	4.77[b]	±0.124
Calcium (mg/100 g)	32.40[c]	36.89[b]	30.29[c]	52.53[a]	30.44[c]	±1.066
Sodium (mg/100 g)	1.30[b]	1.20[c]	1.07[d]	1.48[a]	0.99[d]	±0.028
Copper (mg/100 g)	3.89[a]	2.38[c]	1.20[d]	2.78[b]	1.14[d]	±0.040
Manganese (mg/100 g)	18.74[b]	16.77[c]	16.02[c]	20.78[a]	13.37[d]	±0.369
Magnesium (mg/100 g)	1.46[a]	1.20[b]	1.22[c]	1.25[b]	1.05[d]	±0.015
Zinc (mg/100 g)	1.12[c]	1.17[b]	1.11[cd]	2.34[a]	1.06[d]	±0.016
Phosphorus (mg/100 g)	345.45[a]	290.88[b]	200.05[d]	352.69[a]	230.38[c]	±2.551
Potassium (mg/100 g)	263.80[a]	245.43[b]	245.04[b]	249.11[b]	124.13[c]	±2.921
Iodine (mcg)	102.18[a]	102.05[ab]	101.44[c]	101.25[c]	101.88[b]	±0.068

Values are means of triplicate determinations ±SEM; Means bearing different superscripts on the same column are statistically different ($p<0.05$)

UTGB = Untreated Groundbean
UDCGB = Undehulled Cooked Groundbean
SUDCGB = Soaked Undehulled Cooked Groundbean
SOGB = Soaked Groundbean
SODCGB = Soaked Dehulled Cooked Groundbean

Table 2 depicts the mineral composition of untreated, undehulled, dehulled, soaked and cooked groundbean. The iron (Fe) content of the flours varied and ranged from 3.02 in UDCGB to 6.80 mg in SOGB. The variation was influenced by treatment. Soaking alone (SOGB) caused significantly higher Fe content ($p<0.05$). Calcium (Ca) values ranged from 30.29 mg in SUDCGB to 52.53 mg in SOGB. The variation was affected by treatment. Soaking alone caused higher Ca increase than others ($p<0.05$).

The Sodium (Na) content of the samples ranged from 0.99 mg in SODCGB to 1.48 mg in SOGB. The differences were a function of treatment. Soaking alone equally caused significantly higher Na content ($p<0.05$). The SUDCGB has lower Na (1.07 mg) than UDCGB (1.20 mg).

The Copper (Cu) content varied and ranged from 1.14 mg in SODCGB to 3.89 mg in UTGB. The untreated sample had significantly higher Cu content than others ($p<0.05$). All domestic food processing techniques and their combinations lowered Cu content when compared with the unprocessed (3.89 mg vs 1.14-2.78 mg). Manganese (Mn) values varied and ranged from 13.37 mg in SODCGB to 20.78 mg in SOGB. The variation was influenced by treatment. Soaking alone had significantly higher Mn content ($p<0.05$).

Magnesium (Mg) levels varied and ranged from 1.05 in SODCGB to 1.46 mg in UTGB. The treatments adopted lowered Mg values of the samples. The value for UTGB was higher than others ($p<0.05$). Zinc (Zn) values varied and ranged from 1.06 mg in SODCGB to 2.34 mg in SOGB. The variation was due to treatment. The value of soaked sample was significantly higher than others ($p<0.05$).

Phosphorus (P) values differed and ranged from 200.05 mg in SUDCGB to 352.69 mg in SOGB. Soaking alone had advantage over other processing techniques when compared (352.69 vs 290.09, 200.05 and 230.38 mg). However, the values for SOGB (352.69 mg) and UTGB (345.45 mg) were not statistically different ($p>0.05$). Potassium (K) values varied and ranged from 124.13 mg in SODCGB to 263.80 mg in the control (UTGB). All the domestic food processing methods lowered K levels when compared with the control which had higher K value than others ($p<0.05$). Iodine (1_2) levels differed and ranged from 101.25 mcg in SOGB to 102.18 mcg in UTGB. There were differences in values due to treatment although not significant among all the samples ($p>0.05$). The higher iron (Fe) content for SOGB as against other treatments indicates that soaking had an advantage over other treatments with respect to increase in Fe in GB. The lower Fe levels due to cooking might be due to leaching into cooking water (Giami *et al.*, 2003) The SUDCGB and SODCGB had least calcium (Ca) levels. This might be due to loss of the nutrient into cooking, soaking and dehulling media. The higher Ca for SOGB (52.53 mg) indicates that soaking alone hydrolyzed Ca and made it to have an edge over its combination with other processing methods. The lower Ca (32.40 mg) for the control as against the cooked sample (36.89 vs 32.40 mg) indicates that cooked GB had an advantage over untreated GB. The increase might be that cooking alone caused much more absorption of water by the cotyledon thereby increasing the release of free Ca (Obizoba and Atii, 1994). Processing of the samples had no beneficial effect on sodium values when compared with the control except for soaked sample (SOGB) (1.48 vs 1.30 mg). Combination of soaking, dehulling and cooking had adverse effects on sodium (Na) concentration of GB. The lower value (0.99 mg) in SODCGB might be associated with leaching of the nutrient into the processing media (Giami *et al.*, 2003). The higher SUDCGB Na value (1.20 mg) against 1.07 mg for UDCGB might be that undehulled GB lost less Na than soaked, undehulled and cooked GB. The low Na level is beneficial to GB consumers because of the health implications of high Na consumption.

Undehulled, cooked GB (UDCGB) and soaking alone (SOGB) appear to have an advantage over soaked undehulled and cooked GB (SUDCGB) and soaked, dehulled and cooked GB (SODCGB) (2.38 and 2.78 mg vs 1.20 and 1.14 mg, respectively). Combination of soaking and cooking caused decrease in Cu in the processing media which could be attributed to leaching. The high Mn value (20.78 mg) due to soaking alone indicates that this is the best domestic food processing technique to increase Mn in GB. The reduction recorded for cooked samples might be due to leaching into cooking water (Oliviera and Lamb, 1998).

The higher magnesium (Mg) value (1.46 mg) for the control shows that none of the processing methods had beneficial effect on Mg content of GB. However, combinations of soaking, dehulling and cooking (SODCGB) had much more adverse effect on Mg (1.46 vs 1.05 mg). The low levels of Mg might be because GB is not a good source of this mineral. The losses in treated samples might be due to leakage attributable to lack of membrane integrity (Ene-Obong and Obizoba, 1996). The low Zinc (Zn) values might be due to poor soil content of zinc. However, cooking (UDCGB) and soaking alone (SOGB) increased Zn in GB against the control (1.17 and 2.34 vs 1.12 mg). Combination of soaking and cooking decreased Zn in GB (1.11 and 1.06 mg). This could be due to combined effect of soaking and cooking which led to leaching (Oliviera and Lamb, 1998).

Soaking and its combinations with other processing techniques had adverse effects on Phosphorus (P) content of GB when compared with the control (200.05 and 230.38 vs 345.45 mg). However, GB is a good source of phosphorus. Lower levels in the processed samples might be due to leaching of nutrients during processing (Nnam and Nwokocha, 2003). All the domestic food processing techniques especially their combinations had adverse effect on Potassium (K) content of GB (Table 2). The reason might be due to leaching. The comparable values due to soaking and cooking indicate that any of these processes could be applied to obtain appreciable level of K in GB. The comparable iodine (1_2) values appear to suggest that 1_2 content of GB is not influenced by any of these processing techniques.

Table 3 shows anti-nutrient composition of untreated, undehulled, dehulled, soaked and cooked groundbean. The tannins concentration of both treated and untreated samples varied but were not significantly different ($p>0.05$). The range was from 0.12 mg in SODCGB to 0.15 mg in UTGB. Processing caused decreases in tannins level when compared with the control (0.15 vs 0.13, 0.13, 0.13 and 0.12 mg).

Phytate composition of the samples varied and ranged from 1.22 mg in UTGB to 1.40 mg in SUDCGB. Trypsin Inhibitor (TI) values of the samples differed significantly ($p<0.05$) and ranged from 1.05 mg in SODCGB to 29.45 mg in UTGB. All the domestic food processing techniques and their combinations lowered TI when compared with the untreated sample (1.05-2.44 vs 29.45 mg). Oxalate values ranged from 0.14 mg in SOGB to 0.18 mg in SUDCGB. Soaking alone caused significantly lower oxalate value ($p<0.05$). It reduced oxalate from 0.16 in UTGB to 0.14 mg. Cyanide content of GB ranged from 0.03 mg in SODCGB to 0.07 mg in SOGB. Processing had varied effect on cyanide levels. It increased the values in UDCGB and SOGB (0.05 and 0.07 vs 0.04 mg).

The differences in tannins content were comparable. The similarity in tannins contents of the samples appear to suggest that tannins are generally low in GB. The reduction due to processing (13-20%) might be because of leaching of tannins into processing media (Ene-Obong and Obizoba, 1996). Soaking and cooking (SOGB and SUDCGB) increased phytate in GB. On the other hand, cooking and its combinations with other processing techniques had almost equal concentrations of phytate in GB (1.35-1.40 mg) (Table 3). The higher phytate concentration in processed samples against their control has been observed in cultivated vegetables (Udofia, 2005; Mefoh, 2008). The increase might be due to reabsorption of this antinutrient in the processing media (Ene-Obong and Obizoba, 1996). The increase might also be due to hydrolysis of some related compounds that had some beneficial effects (lowering of cancer or cholesterol) (Graf and Eaton, 1993; Graf *et al.*, 1987). Processing drastically reduced Trypsin Inhibitor (TI) levels when compared with the control (1.05-2.44 mg vs 29.45 mg). Soaking, dehulling and cooking caused most TI reduction (1.05 mg). The probable reason for the increase observed in SUDCGB and SOGB (2.44 and 2.37 mg) might be that TI had other organic compounds associated with its existence. It could also be that the techniques used for its analysis might not be as accurate as intended. The lower oxalate

Table 3: Antinutrient composition of untreated, undehulled, dehulled, soaked, cooked groundbean

Composition	UTGB	UDCGB	SUDCGB	SOGB	SODCGB	±SEM
Tannins (mg/100 g)	0.15^a	0.13^a	0.13^a	0.13^a	0.12^a	±0.014
Phytate (mg/100 g)	1.22^d	1.35^b	1.40^a	1.28^c	1.35^b	±0.013
Trypsin-TI (mg/100 g)	29.45^a	1.66^c	2.44^b	2.37^b	1.05^d	±0.005
Oxalate (mg/100 g)	0.16^b	0.16^b	0.18^a	0.14^c	0.17^{ab}	±0.003
Cyanide (mg/100 g)	0.04^c	0.05^b	0.04^c	0.07^a	0.03^d	±0.005

Values are means of triplicate determinations ±SEM; Means bearing different superscripts on the same column are statistically different ($p<0.05$)

UTGB = Untreated Groundbean
UDCGB = Undehulled Cooked Groundbean
SUDCGB = Soaked Undehulled Cooked Groundbean
SOGB = Soaked Groundbean
SODCGB = Soaked Dehulled Cooked Groundbean

in GB due to soaking alone indicates that this method had advantage over its combination with other treatments in reducing oxalate. These values (0.14- 0.18 mg) compared with an earlier report (Chikwendu, 2007). The low cyanide (0.03-0.07 mg) appears to indicate that GB is safe for human consumption as far as cyanide concentration is concerned. The values (0.16-0.19 mg) reported by Chikwendu (2007) were higher.

Conclusion: Untreated Groundbean (UTGB) had the highest nutrient composition in most of the nutrients tested. The generally low anti-nutrient composition of groundbean indicates that the legume is safe for human consumption and could be used in the formulation of diets for babies.

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