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EFFECT OF DIFFERENT PROCESSING METHODS ON THE AMINO ACID PROFILE, MINERAL AND ANTI-NUTRIENT CONTENTS OF *Detarium senegalense* (Tallow) SEED FLOUR

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ABSTRACT

Detarium senegalense seed known as Tallow in English, is used traditionally as a soup thickener in Eastern Nigeria. Despite its high protein contents its seed is underutilized due to the presence of anti-nutritional compounds such as oxalate, phytate, tannin and trypsin inhibitor which reduces their bioavailability of nutrients. Therefore, the effect of different processing methods on the amino acid profile, minerals and anti-nutritional properties of *Detarium senegalense* seed flour was investigated. Freshly purchased seeds were washed and portioned into unprocessed (raw) and processed (soaked, boiled, roasted, autoclave and microwave) seed flour. The samples were analyzed using standard procedures. Data obtained were statistically analyzed using Analysis of variance (ANOVA). Duncan's multiple range tests was used to compare the means. Significance was evaluated at ($p \leq 0.05$). The result showed that the amino acid profile was significantly ($P \leq 0.05$) increased by boiling method. Mineral composition indicated that all the processing methods significantly reduced the minerals content when compared to the unprocessed sample and varied between zinc 0.01 to 0.07mg/100g, iron 0.15 to 0.51mg/100g, calcium 0.14 to 0.22mg/100g; magnesium 1.09 to 1.19mg/100g, potassium 2.16 to 3.26mg/100g and sodium 0.15 to 0.20mg/100g, respectively. The anti-nutritional factors of the samples were significantly ($P \leq 0.05$) reduced by boiling and roasting method than by soaking, autoclaving and microwaving methods. It was found that among the different method investigated, boiling has the highest amino acid profile and reduced anti-nutrient contents.

Key words: Amino acid; mineral; anti-nutrients; *Detarium senegalense.*

INTRODUCTION

Detarium senegalense is an important legume found in West and Central Africa; belonging to the family *Caesalpiniaceae, Phylum spermatophyte* and the order *Fabaceae* (Adekunle *et al*., 2011; Akah *et al*., 2012). It is known in english as sweet detar, sweet dattock or tallow (Abdalbasit *et al*., 2011; Contu, 2012). In Nigeria it is known as 'Ofor' (Igbo), 'Taura' (Hausa) and 'Ogbogbo' (Yoruba) (Nwozo *et al*., 2016).

Detarium senegalense contains a large amount of water – soluble, non – starch polysaccharide, zyloglucan which makes it a useful plant that finds applications in food, drug and other commodities (Wang *et al*., 1997). In rural communities, the leaves and flowers are eaten as condiments or vegetables. The leaves are used to thatch roofs of houses while the fruits are eaten mainly in the form of a drink, marmalade, sorbet or fresh (Dossa *et al*., 2020). The fruit pulp very rich in vitamins (Oibiokpa *et al*., 2014) is used as local sweetener or can be transformed into flour.

The seeds are majorly used as soup thickener, locally for the treatment of skin diseases and attack from a poisoned arrow (Sowemimo *et al*., 2011). Decoctions or infusions of different parts (root, stem, bark, fruit, leaves) of this plant are used traditionally for the treatment of varying kinds of diseases ranging from syphilis, dysentery, bronchitis, leprosy, sore throat to malaria and meningitis (Akah *et al*., 2012; Dossa, 2020).

Nutritionally, *Detarium senegalense* seed constitute a major source of nutrients such as proteins, lipids, carbohydrates, and other important substances such as fibre, minerals and vitamins (Sowemimo *et al*., 2011) which are necessary for human and animal health. Similarly, just like all legumes, they contain anti-nutritional components such as tannins, phytates, oxalates, anti-trypsin factors, hydrogen cyanide among others which hinder the body from digesting the nutrients in legumes. According to Olusanya, (2008) and Geil and Anderson, (1994), anti-nutrient components such as anti-trypsin factors impair the digestion of proteins and hence prevent its efficient utilization. Phytates, oxalates and cyanides cause various physiological disorders like increase in relative weight of pancreas and liver, and also diarrhea (Arija *et al*., 2006). Fortunately, many of these toxic components are destroyed by different food processing methods such as soaking, boiling, roasting, microwave and autoclaving (Olusanya, 2008). These processing methods increase the nutritional quality of food plants and are also effective in eliminating the anti-nutritional factors in them and thus the need for their proper processing to levels where they are safe for human and animal consumption (Hotz and Gibson, 2007; Nzewi and Egbuonu, 2011). This experimental study was therefore carried out to determine the effect of soaking, boiling, roasting, autoclaving and microwave on the amino acid composition, minerals and anti-nutritive value of *Detarium Senegalense* seed flour.

MATERIALS AND METHODS

Sources of material:

The seeds of *Detarium senegalense* were obtained from a private farm in Umuaga, Udi Local Government Area of Enugu State, identified and authenticated at the herbarium Unit Botany Department, Ahmadu Bello University, Zaria, Kaduna State with Voucher Number 028234.

Sample preparation:

The seeds were hand-sorted to remove wrinkled, moldy seeds and foreign material. The sorted seeds were then divided into six portions of 500g and each washed with 1.5liters of distilled water. Five portions of 500g were subjected to different processing treatments (soaking, boiling, roasting, autoclaving and microwave) while the sixth portion of 500g was left unprocessed (raw).

Soaking: The soaked *Detarium senegalense* seed flour was prepared according to the method of Peter and Olapade, (2018). During preparation, 500g seed were soaked in de-ionized water (1:3) in an aluminum bowl for 12hour at room temperature. Soaking treatment is to allow the seeds to imbibe water. The water was decanted at 6hour intervals.

Boiling: The boiled *Detarium senegalense* seed flour was prepared according to the method of Peter and Olapade, (2018). During preparation, 500 g of seeds were boiled with 1 liter of distilled water at 100°C in the ratio of 1:10 (w/v) for 30 min.

Roasting: The roasted *Detarium senegalense* seed flour was prepared according to the method of Peter and Olapade (2018). During preparation, 500g of seeds were placed in a beaker and roasted at a temperature of 120°C for 40 minutes in a hot air oven (Model DHG 9101 ISA).

Autoclaving: During preparation 500g of seeds were placed in a beaker and autoclaved at a temperature of 121°C and pressure of 15 atmospheres in distil water (1:10, w/v) for 20 minutes in an autoclave (Model 75HG, Britain, UK). (Akande and Fabiyi, 2010).

Microwave cooking: During preparation 500g of seeds were placed in a glass pot with distil water (1:10, w/v), then cooked in a microwave oven (Model 4915, Philips) for 20 min (Akande and Fabiyi, 2010).

All six 500g (raw and processed) *Detarium Senegalense* seeds were each dehulled, spread on the trays and dried in hot air oven (Model DHA 9101 ISA) at 60°C for 8 hours with constant turning of the seeds at intervals for 30 min to ensure uniform drying. The dried seeds were milled in an attrition mill and sieved through a 500-micron mesh sieve. The flour produced were packaged in a high density polyethylene bag and stored under refrigeration temperature (4±2 °C) until needed for further laboratory analysis.

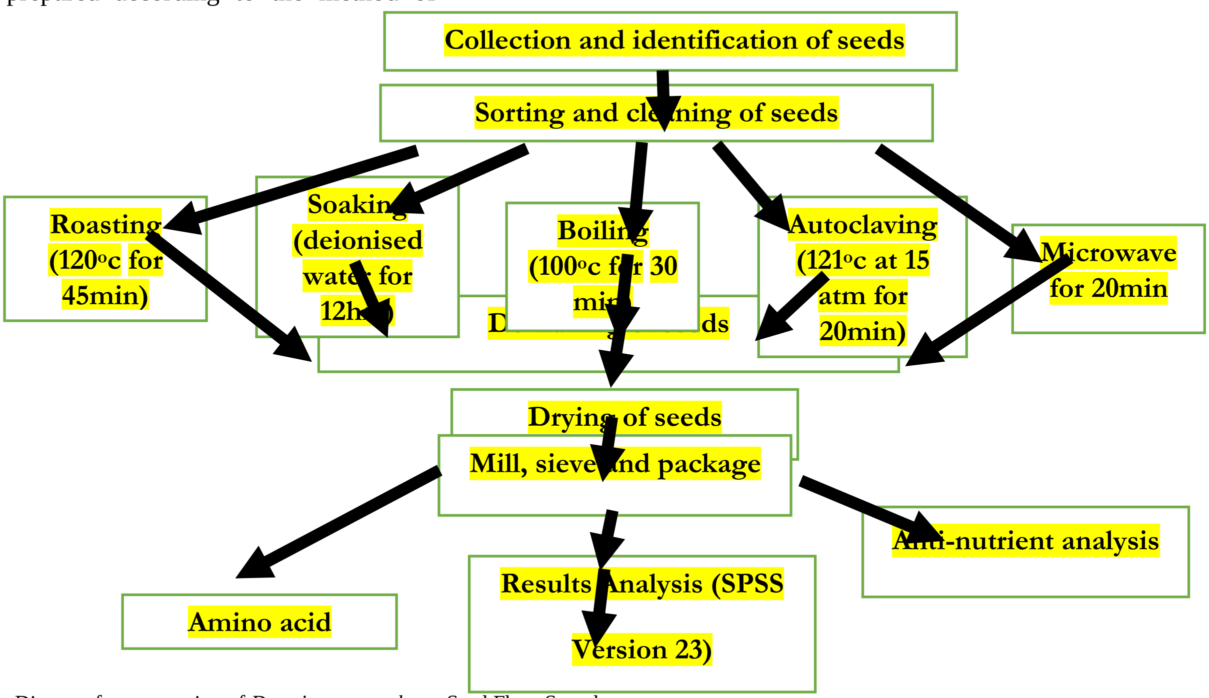

Figure 1: Flow Diagram for preparation of *Detarium senegalense* Seed Flour Samples

Determination of amino acid profile: the amino acid of the unprocessed and processed *Detarium senegalense* samples were determined using the method of FAO/WHO (1991). The samples were dried to constant weight, defatted, hydrolyzed and evaporated in a rotary evaporator and then loaded into the Technicon Sequential Multi sample amino acid analyzer (TSM) model 120a PTH. The period of analysis was 76min for each sample. The gas flow rate was 0.50ml/min at 60°C with reproducibility consistent within ±3%. The net height of each peak produced by the chart recorder of the PTH (each representing an amino acid) were measured and calculated. The amino acid values reported were the average of triplicate determinants.

Determination of Minerals: Ash was determined by combustion of the sample in a muffle furnace at 550°C for 12 h (AOAC, 2005). The residue was dissolved in HNO3 with 50 g/l of LaCl3 and the mineral constituent's calcium, magnesium, iron and zinc were analysed separately by atomic absorption spectrometry. Sodium and potassium were determined using flame photometry as described by the AOAC, (2005).

Determination of anti-nutritional compounds: The phytate, tannin and trypsin inhibitor contents were determined by method of AOAC, (2006).

Statistical analysis

Statistical analyses were carried out in triplicates using the computer software, Statistical Package for Social Sciences (SPSS program version 23.0 SPSS Inc., Chicago, IL, USA). Results were expressed as mean ± standard deviation (SD). The data were analyzed by the one-way analysis of variance (ANOVA). The Duncan multiple range test was used to determine the level of significance. p value less than 0.05 was considered as significant ($p < 0.05$).

RESULTS AND DISCUSSION

Effect of Processing on the Amino Acid Profile of *Detarium senegalense* Seed Flour

Result of the effect of processing on the amino acid profile of *Detarium senegalense* seed flour (Table 1) indicates that the amino acid profile of *Detarium senegalense* seed flour for unprocessed and all the processed samples demonstrated that they were generally high and rich in amino acids when compared with the FAO/WHO reference (Aremu *et al*., 2006). Glutamic acid is the most abundant amino acid in all the samples evaluated with microwave having significantly ($p<0.05$) high value while autoclave had the lowest value. The abundance of glutamic acids in *Detarium senegalense* samples evaluated agrees with the findings of Ade-Omowaye *et al*. (2015) and Vadivel and Janardhanan (2005) who reported similar abundance in Indian wild legumes and under exploited legumes of South West Nigeria. Leucine was also abundant in *Detarium senegalense* agrees with the observations made by some studies that leucine is one of the most concentrated essential amino acid in legumes (Aremu *et al*., 2010; Ade-Omowaye *et al*., 2015; James *et al*., 2020) however it was significantly ($p<0.05$) high in boiled method and low in microwave method. The result indicated that unprocessed and all the processed sample of *Detarium senegalense* seed flour were limited in the sulphur containing amino acids (methionine and cysteine) agrees with the finding of James *et al*. (2020) in their study of some selected lesser known legumes indigenous to Nigeria. Processing significantly ($P\leq0.05$) reduced the overall amino acid profile of *Detarium senegalense* seed flour except boiled method of processing which graced the cumulative best amino acid content due to increase in protein solubility, indicating that protein is less denatured by boiling (Afify *et al.*, 2012). This is in agreement with the report of (Alajaji and El-Adawy, 2006; Ari *et al*., 2012) who reported better essential amino acid values for boiled soybean than the other methods used.

Table 1: Effect of Processing on Amino Acid Profile of *Detarium senegalense* Seed Flour

Amino Acids (g/100g)	SFUS	SFSS	SFBS	SFRS	SFAS	SFMS	FAO/WHO
Leucine	5.72±0.02[e]	5.31±0.09[c]	6.87±0.05[f]	5.59±0.08[d]	5.07±0.09[b]	4.97±0.04[a]	4.8
Lysine	4.64±0.01[d]	4.11±0.14[c]	4.88±0.06[e]	4.37±0.07[c]	3.92±0.03[d]	3.94±0.09[a]	4.2
Isoleucine	3.62±0.02[d]	3.50±0.09[c]	4.22±0.05[e]	3.61±0.01[d]	3.22±0.07[b]	3.13±0.03[a]	4.2
Phenyalanine	3.38±0.04[b]	3.19±0.11[ab]	3.81±0.07[c]	2.98±0.05[a]	3.18±0.06[ab]	3.03±0.08[ab]	2.8
Tryptophan	0.81±0.09[d]	0.71±0.03[b]	0.92±0.08[e]	0.76±0.01[c]	0.72±0.06[bc]	0.67±0.05[a]	1.4
Valine	4.22±0.01[d]	3.91±0.30[b]	4.62±0.07[e]	4.09±0.06[c]	3.83±0.09[a]	3.79±0.03[a]	4.2
Methionine	1.58±0.06[bc]	1.47±0.07[b]	1.74±0.08[d]	1.50±0.04[c]	1.39±0.09[a]	1.36±0.05[a]	2.2
Threonine	3.61±0.34[d]	3.30±0.24[b]	3.80±0.30[e]	3.50±0.20[c]	3.33±0.27[b]	3.25±0.25[a]	2.6
Arginine	6.18±0.06[e]	5.85±0.50[c]	6.87±0.01[f]	6.02±0.05[d]	5.77±0.10[c]	5.66±0.19[b]	2.0
Histidine	1.86±0.11[e]	1.66±0.03[c]	2.17±0.17[f]	1.83±0.01[d]	1.60±0.06[c]	1.56±0.09[b]	2.4
Proline	3.47±0.02[d]	3.25±0.15[ab]	3.46±0.06[d]	3.38±0.05[c]	3.27±0.01[b]	3.15±0.03[a]	
Tyrosine	3.43±0.10[b]	3.44±0.19[a]	3.77±0.15[c]	3.45±0.13[b]	3.27±0.17[a]	3.28±0.12[a]	
Cysteine	1.26±0.01[e]	1.09±0.01[c]	1.47±0.02[f]	1.22±0.06[d]	1.04±0.03[b]	0.96±0.05[a]	
Alanine	3.73±0.04[e]	3.60±0.20[ab]	3.91±0.09[f]	3.69±0.03[d]	3.47±0.05[b]	3.42±0.08[a]	
Glutamic Acid	1.29±0.09[a]	10.75±0.50[b]	11.27±0.05[b]	11.06±0.07[b]	10.61±0.02[b]	12.34±0.01[c]	
Glycine	3.32±0.05[d]	3.16±0.14[a]	3.28±0.02[c]	3.27±0.06[c]	3.03±0.01[a]	3.02±0.07[a]	
Serine	3.86±0.06[d]	3.59±0.30[ab]	4.03±0.09[e]	3.77±0.07[c]	3.44±0.14[a]	3.54±0.11[b]	
Aspartic Acid	8.62±0.03[d]	8.40±0.39[ab]	9.05±0.07[e]	8.66±0.04[d]	7.91±0.09[a]	8.06±0.05[b]	

Results are presented as Mean ± SD (n=3).
Values in the same row with different superscripts are significantly ($P < 0.05$) different. FAO/WHO value reference (Aremu *et al*., 2006)
SFUS= sample for unprocessed seeds SFSS=sample for soaked seeds
SFBS=sample for boiled seeds SFRS=sample for roasted seeds
SFAS=sample for autoclaved seeds SFMS=sample for microwaved seed

Effect of Processing on the Mineral Content of *Detarium senegalense* Seed Flour

Result of the effect of processing on the mineral content of *Detarium senegalense* seed flour (Table 2) showed that iron was generally high in all the samples similar to Sowemimo *et al*. (2011) report on the seed of *Detarium senegalense* being rich in iron when compared with other food seeds but the iron was significantly ($p<0.05$) higher in autoclave method which is in accordance with the work of Oraka and Okoye (2017) on lima beans. The calcium content of the samples were significantly ($p<0.05$) reduced by all processing methods. The decrease could be due to oxidation and leaching out of the minerals agrees with the finding of Oraka and Okoye, (2017). Magnesium was also appreciably detected in the microwave and very low in the roasted method of processing. Potassium was found to be most abundant macro element in all the samples evaluated agrees with the finding of James *et al*. (2020) who reported similar abundance in some selected lesser known legumes indigenous to Nigeria. All the treatments significantly ($p<0.05$) decreased the levels of potassium in the flour except roasting. Roasting may have concentrated the minerals by loss of moisture. The concentrations of sodium in all the samples were low which may explain previous reports on the usefulness of *Detarium senegalense* in the treatment of heart related diseases (Sowemimo *et* *al*., 2011). Generally, roasting had a greater effect on the improvement of mineral contents in *Detarium senegalense* flour than the soaked, boiled, autoclaving and microwave method is similar to the report of Amandikwa *et al*. (2015); El-Adawy (2002).

Table 2: Effect of Processing on the Mineral Content of *Detarium senegalense* Seed Flour

Elements (mg/100g)	SFUS	SFSS	SFBS	SFRS	SFAS	SFMS
Zinc	0.07 ± 0.01^{c}	0.02 ± 0.00^{b}	0.01 ± 0.00^{a}	0.02 ± 0.00^{b}	0.02 ± 0.00^{b}	0.02 ± 0.00^{b}
Iron	0.25 ± 0.04^{c}	0.35 ± 0.03^{d}	0.15 ± 0.03^{a}	0.18 ± 0.02^{ab}	0.51 ± 0.03^{e}	0.20 ± 0.02^{b}
Calcium	0.20 ± 0.04^{b}	0.22 ± 0.01^{b}	0.14 ± 0.01^{a}	0.20 ± 0.03^{b}	0.18 ± 0.02^{b}	0.20 ± 0.02^{b}
Magnesium	1.14 ± 0.02^{ab}	1.13 ± 0.05^{ab}	1.16 ± 0.06^{ab}	1.09 ± 0.04^{a}	1.16 ± 0.04^{ab}	1.19 ± 0.03^{b}
Potassium	3.15 ± 0.03^{d}	2.60 ± 0.05^{c}	2.46 ± 0.04^{b}	3.26 ± 0.04^{e}	2.57 ± 0.05^{c}	2.16 ± 0.04^{a}
Sodium	0.18 ± 0.04^{a}	0.17 ± 0.02^{a}	0.19 ± 0.02^{a}	0.18 ± 0.04^{a}	0.20 ± 0.02^{a}	0.15 ± 0.03^{a}

Results are presented as Mean ± SD (n=3).
Values across the rows with different superscripts are significantly different ($P < 0.05$).
SFUS= sample for unprocessed seeds
SFSS=sample for soaked seeds
SFBS=sample for boiled seeds
SFRS=sample for roasted seeds
SFAS=sample for autoclaved seeds
SFMS=sample for microwaved seed

Effect of Processing on the Anti-NutritionalFactors of *Detarium senegalense* Seed Flour

Result of the anti-nutritional factors (tannins, phytate, oxalate, hydrogen cyanide and trypsin) of the unprocessed and processed seed flours of *Detarium senegalense* is presented in (Table 3) which revealed that there was a significant decrease in the anti-nutritional factors of all processed seeds of *Detarium senegalense* when compared to the unprocessed sample. Anti-nutrients are natural compounds that interfere with the bioavailability of nutrients by interfering with their absorption in the gastrointestinal tract. Tanin, phytate, oxalate, hydrogen cyanide and trypsin are examples of anti-nutrients that interfere with some mineral components such as calcium, iron, zinc, and magnesium by forming insoluble complexes (Ijarotimi and Keshinro 2012). The boiled method had the highest significant decrease ($p<0.05$) in all the anti-nutritional factors examined except for oxalate where roasted method was lower. Diminishing percentage of anti-nutrient during processing could be as a result of leaching, inactivation and denaturisation of the anti-nutrient which was perceived during the study. Similar kinds of results of decreasing anti-nutrients were also observed by Yadav *et al* (2012) on cowpea seeds, Mada *et al.*, 2012 on Arachis hypogaea L and by Maheshu *et al* (2013) on pressure cooked field beans (Dolichos lablab). Thereby making the processed seeds nutritionally superior to the unprocessed.

Table 3: Effect of Processing on the Anti-Nutritional Factors of *Detarium senegalense* Seed Flour

Factors (mg/100g)	SFUS	SFSS	SFBS	SFRS	SFAS	SFMS	PL
Tannins	1.23 ± 0.09^{d}	0.48 ± 0.07^{c}	0.18 ± 0.02^{a}	0.35 ± 0.08^{b}	0.53 ± 0.07^{c}	0.50 ± 0.08^{c}	20mg/g
Phytate	1.48 ± 0.07^{c}	0.65 ± 0.07^{b}	0.26 ± 0.05^{a}	0.53 ± 0.06^{b}	0.63 ± 0.06^{b}	0.58 ± 0.14^{b}	250-50mg
Oxalate	1.58 ± 0.09^{d}	0.63 ± 0.06^{bc}	0.48 ± 0.13^{ab}	0.32 ± 0.04^{a}	0.76 ± 0.11^{c}	0.48 ± 0.08^{ab}	3-5mg/kg
HCN	5.47 ± 0.05^{f}	3.37 ± 0.10^{d}	1.24 ± 0.06^{a}	2.90 ± 0.12^{b}	3.15 ± 0.07^{c}	3.93 ± 0.23^{e}	50mg/kg
Trypsin	15.46 ± 0.27^{f}	7.61 ± 0.03^{c}	2.17 ± 0.12^{a}	6.36 ± 0.09^{b}	8.74 ± 0.07^{e}	8.47 ± 0.05^{d}	0.7-3.0mg/g

Results are presented as Mean ± SD (n=3).
Values across the rows with different superscripts are significantly different ($P < 0.05$).
HCN (hydrogen cyanide), PL (Permissible limits). Source: Ndidi *et al*. (2014) and Adegunwa *et al*. (2012)
SFUS= sample for unprocessed seeds
SFSS=sample for soaked seeds
SFBS=sample for boiled seeds
SFRS=sample for roasted seeds
SFAS=sample for autoclaved seeds
SFMS=sample for microwaved seed

CONCLUSION

In conclusion, *Detarium senegalense* seed flour is a potential protein source that could be explored for consumption in humans, animal feed and other industrial application. It could be supplemented with cereals or other amino acid sources rich in methionine and cystine, fortified with minerals to further enhance its utilization. Considering the processing methods, it was observed that boiling produced higher significant effect in the amino acid composition and reduction in the anti-nutritional factors than the other methods and proved as the most efficient method of processing the seeds.

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