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Effect of processing methods on the nutritional and anti-nutritional value of *Detarium microcarpum* (Guill and Sperr) seed meals

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Abstract
The study was undertaken to analyze the effect of various processing methods: Raw, Boiled, Toasted, Soaked and Fermented meals from *Detarium microcarpum* (Tallow) on nutritional and anti-nutritional values of the unconventional legume seed meal. The applied methods were found to enhance the protein (12.54-16.83%) and lipid content (5.73-8.00%), fibre (4.85-7.13%), ash (4.50-7.22%), Nitrogen free extract (56.74-62.89%). There was an increase in the mineral composition with processing methods except with the case of boiled method; potassium (1.044-1.836g/100g), sodium (0.177-0.349g/100g) and calcium (0.185-0.291g/100g) were the most abundant minerals recorded. There was also an increase in the essential amino acids of the processed. Methionine content was improved due to toasted method (1.66g/100g) as compared to the raw (0.87g/100g). Vitamin A (986.32-5364.13IU/100g), B1 (0.18-0.36mg/100g), B3 (0.09-0.29mg/100g), B6 (0.04-0.21mg/100g), C (9.32-28.05mg/100g) and D (0.25-0.42mg/100g). There was decrease in vitamins content from boiled and toasted methods. Fatty acids: Capric (0.004-0.006g/100g), Lauric (0.004-0.0078g/100g), Myristic (0.003-0.0067 g/100g), Palmitic (0.012-0.019g/100g), Stearic (0.012-0.018g/100g), Oleic (0.014-0.023g/100g), linoleic (0.028-0.044g/100g) and Arachidic (0.003-0.007g/100g). All the methods significantly reduced the anti-nutrients. Tannins (0.021-0.080g/100g), phytic acid (0.05-0.025g/100g), Saponins (0.04-0.021g/100g), Oxalates (0.04-0.018g/100g), Terpenoids (0.04-0.015g/100g), Trypsin inhibitors (0.046-0.338g/100g), Glycosides (0.012-0.046g/100g), Flavonoids (0.013-0.047g/100g), Alkaloids (0.020-0.059g/100g). Toasted, followed by Fermented method gave the best processed form in nutrients and anti-nutrients reduction. Knowledge gathering and exploration of nutritionally balanced unconventional legumes would enhanced food and nutritional security.

Keywords: Processing, nutritional, anti-nutritional and legume

1. Introduction
Detarium microcarpum tree is a drought-resistant uncultivated annual plant with fruit yields estimated at 50-75 kg/stand/annum [1]; [2]. [3] reported that the tree height reaches up to 15 m and it can reach 25 m in moist areas; the tree can be easily distinguished by its broken grey bark, with dark green 8-12 cm leaves [4]. The tree is widely distributed in dry Savannah areas of Africa, and in Sudan it is found in Darfour, Blue Nile and Kordofan States, where it is locally known as Abu-laili in Sudan, 'dank' in Senegal, 'tamba dala' in Mali and ‘Taura’ in Nigeria. The roots, stems, bark, leaves and fruits are all used to treat ailments e.g. tuberculosis, meningitis, and diarrhea. The fruit is edible and rich in vitamin C and the leaves and seeds are also used in cooking. The pulverized seeds cotyledons are used as a thickener and emulsifier in traditional food preparations in some African countries. A compositional studies of this legume revealed that it is a rich source of polysaccharide gum [5]. The dehulled seed flour contained 3.5% moisture, 3.5% ash, 2.9% crude fiber, 15% crude fat, 37.1% crude protein and 39% carbohydrate [6].
[7] Reported that the analysis of nutritional value of wild plant materials attracted attention due to the fact that they contain significant amount of essential nutrients that can be used for both human consumption and in the formulation of animal feeds.

2. Materials and methods
2.1. Seeds collection and Identification
Matured fruits of *Detarium microcarpum* were collected from Girei and surroundings.

They were identified by plant Taxonomist in Forestry and Wildlife Department of Modibbo Adama University of Technology, Yola (MAUTECH). It is located on latitude 9.2^0 and 9.33^0N, longitude 12.3^0 – 12.50^0E and an Altitude of 185.9m. It has an average annual rainfall of about 759mm with the maximum temperature of 39.70C. The rainy season run from May through October, while the dry season commences November and ends in April. The driest months of the year are January and February when the relative humidity drops to 13% Canback Global Income Distribution Database [8].

2.2. Preparation of the legume seeds and Processing

D. microcarpum fruits were cracked open mechanically to remove the seeds. The seeds were clean of dirts by hand picking and winnowed, they were subjected to various processing methods according to [9].

1. Raw seeds were milled and tag raw seed meal (RSM)
2. Raw seeds were soaked in tab water to the ratio of 1:3 for 72hours, oven dried at 50ºC to constant weight then milled and tag soaked seed meal (SSM)
3. Raw seeds were boiled for 30minutes, oven dried at 50ºC to constant weight then milled and tag boiled seed meal (BSM)
4. Raw seeds were toasted at 70ºC using electric hot plate until seeds turn brown in colour then milled and tag Toasted seed meal (TSM)
5. Raw seeds were moistened with water, kept in a container with cover in a dark place to fermented for 72 hours under laboratory condition, oven dried at 50ºC then milled and tag fermented seed meal (FSM)

2.3. Laboratory analysis

The samples were packaged and send to animal nutrition laboratory, Adamawa State University Mubi for the analysis. Proximate, Minerals, Essential amino acids, vitamins, fatty acids and anti-nutrients were determined using standard methods AOAC, [10]. The aim of processing usually is to remove ANFs hence improving nutrient digestibility by animals.

2.4. Data analysis

The data collected were recorded as Mean ± standard deviation.

3. Results

Table 1 show proximate and mineral compositions of the raw and processed seeds of *D. microcarpum*. The processed seeds had the highest values of protein, crude lipid and ash while the raw seeds had more carbohydrate. Table 2 show the essential amino acids in this study were affected by processing methods. Table 3 shows the vitamins content of *D microcarpum* seeds and processing affects its compositions. Soaked and fermented methods improved the vitamins contents while a decreased was observed in boiled and toasted methods respectively. Table 4 shows the effect of processing on fatty acids profile of *D. microcarpum* seeds. There was decreased in the fatty acids compositions in toasted, soaked and fermented methods when compared to the control (raw), while boiled method had the highest compositions compared to other methods. Table 5 shows that the anti-nutrients were reduced by processing methods when compared to the control (raw) seeds. Toasted method was found to have greater efficiency in the reduction levels of all the anti-nutrients studied when compared with the other methods.

Table 1: Effect of processing methods on Proximate and Mineral Compositions of *Detarium microcarpum* seeds

Nutrients	Raw	Boiled	Toasted	Soaked	Fermented
Protein %	12.54±0.02	14.36±0.01	16.43±0.01	13.25±0.00	16.83±0.01
Lipid %	7.61±0.01	7.50±0.00	5.73±0.01	7.87±0.01	8.00±0.00
Fibre %	5.26±0.01	5.00±0.00	7.13±0.01	5.22±0.01	4.85±0.00
Ash %	4.50±0.00	4.72±0.01	7.22±0.01	4.63±0.00	5.25±0.01
Nitrogen free extract %	62.89±0.04	61.17±0.01	56.74±0.01	61.73±0.02	57.21±0.04
Dry Matter %	92.8	92.75	93.25	92.7	92.14
Calculated Gross Energy (Kcal/g)	396.07	398.03	375.14	397.59	399.9
Ca(g/100g)	0.234±0.01	0.185±0.01	0.291±0.01	0.238±0.01	0.261±0.01
Fe (g/100g)	0.012±0.01	0.01±0.01	0.016±0.01	0.013±0.01	0.0158±0.01
Mg(g/100g)	0.102±0.01	0.122±0.01	0.174±0.01	0.116±0.01	0.143±0.00
Na(g/100g)	0.240±0.02	0.177±0.01	0.349±0.02	0.251±0.01	0.317±0.02
K (g/100g)	1.457±0.02	1.044±0.01	1.836±0.02	1.539±0.01	1.677±0.01
P (g/100g)	0.206±0.01	0.231±0.01	0.275±0.01	0.224±0.01	0.241±0.01

Cal. Gross energy after (NRC, 1993) as 5.64, 9.44 and 4.11 Kcal/g for Protein, lipid and Nitrogen free extract respectively.

Table 2: Effect of processing methods on Essential Amino Acid Compositions of *Detarium microcarpum* seed (g/16N dry weight basis)

Essential amino acids	Raw	Boiled	Toasted	Soaked	Fermented
Arginine	4.23±0.01	4.24±0.01	5.12±0.01	4.05±0.00	4.96±0.01
Histidine	1.85±0.00	1.87±0.01	2.67±0.01	1.79±0.01	2.45±0.00
Isoleucine	2.65±0.01	2.85±0.01	3.30±0.00	2.56±0.01	2.97±0.01
Leucine	6.84±0.01	7.34±0.01	8.23±0.01	6.94±0.01	8.13±0.01
Lysine	2.46±0.01	2.62±0.01	3.25±0.01	2.38±0.01	3.16±0.01
Methionine	0.87±0.01	1.13±0.01	1.66±0.01	0.93±0.01	1.53±0.01
Phenylalanine	3.72±0.01	3.85±0.01	4.76±0.01	3.68±0.01	4.34±0.01
Threonine	2.13±0.01	2.25±0.00	3.52±0.01	2.07±0.01	3.41±0.01
Tryptophan	3.53±0.01	3.78±0.01	4.32±0.01	3.65±0.01	4.11±0.01
Valine	4.04±0.02	4.01±0.01	5.04±0.01	3.93±0.01	4.87±0.01

Table 3: Effect of processing methods on Vitamin Compositions of *Detarium microcarpum* seeds

Vitamins	Raw	Boiled	Toasted	Soaked	Fermented
A (IU/100g)	4157.30±0.02	2645.83±0.01	986.32±0.01	4571.44±0.01	5364.13±0.01
B1(mg/100g)	0.32±0.01	0.26±0.01	0.18±0.01	0.34±0.01	0.36±0.00
B3(mg/100g)	0.23±0.01	0.18±0.00	0.09±0.00	0.25±0.01	0.29±0.01
B6(mg/100g)	0.16±0.00	0.12±0.00	0.04±0.00	0.17±0.01	0.21±0.00
C(mg/100g)	21.46±0.01	18.63±0.01	9.32±0.01	23.45±0.00	28.05±0.01
D(mg/100g)	0.26±0.01	0.28±0.01	0.34±0.01	0.25±0.00	0.42±0.01

Table 4: Effect of processing methods on Fatty acids Compositions of *Detarium microcarpum* seed (g/100g dry weight basis)

Fatty acids	Raw	Boiled	Toasted	Soaked	Fermented
C10:0 (Capric)	0.006±0.01	0.006±0.01	0.004±0.01	0.005±0.01	0.005±0.00
C12:0 (Lauric)	0.007±0.01	0.0078±0.02	0.004±0.01	0.006±0.01	0.006±0.01
C14:0 (Myristic)	0.006±0.01	0.0067±0.01	0.003±0.01	0.005±0.00	0.005±0.00
C16:0 (Palmitic)	0.018±0.01	0.019±0.01	0.012±0.01	0.019±0.01	0.014±0.01
C18:0 (Stearic)	0.017±0.02	0.018±0.01	0.012±0.01	0.017±0.00	0.014±0.01
C18:1 (Oleic)	0.022±0.02	0.022±0.01	0.014±0.01	0.023±0.01	0.016±0.01
C18:2 (Linoleic)	0.042±0.01	0.044±0.01	0.028±0.02	0.043±0.01	0.032±0.01
C20:0 (Arachidic)	0.007±0.01	0.007±0.01	0.003±0.01	0.007±0.01	0.005±0.01

Table 5: Effect of processing methods on Anti–nutrients Compositions of *Detarium microcarpum* seed

Antinutrients	Raw	Boiled	Toasted	Soaked	Fermented
Tannins	0.08±0.02	0.068±0.01	0.021±0.01	0.071±0.01	0.074±0.01
Phytic acids	0.0025±0.01	0.020±0.01	0.005±0.01	0.021±0.01	0.023±0.01
Saponins	0.021±0.01	0.018±0.01	0.004±0.01	0.019±0.00	0.020±0.01
Oxalates	0.018±0.02	0.015±0.01	0.004±0.00	0.016±0.01	0.017±0.01
Terpenoids	0.015±0.01	0.012±0.01	0.004±0.01	0.014±0.01	0.015±0.02
Trypsin inhibitor	0.338±0.02	0.136±0.01	0.046±0.02	0.204±0.01	0.261±0.01
Glycosides	0.046±0.01	0.032±0.00	0.012±0.01	0.035±0.01	0.038±0.01
Flavonoids	0.047±0.01	0.036±0.01	0.013±0.01	0.039±0.02	0.041±0.01
Alkaloids	0.059±0.01	0.035±0.01	0.020±0.01	0.037±0.01	0.040±0.01

4. Discussion

The crude protein content of raw *D. microcarpum* seeds 12.54% reported in this study was found to be higher when compared to an earlier report of [11] (3.82%) of *D. microcarpum* edible fruit seed and [12] (7.23%). However, a significant higher protein content of (29.4% - 30%) was recorded by [3] from *D. microcarpum fruit pulp* [7]; (35.96%) [6]; (37.1%) and [1] (26.54%). Processing affect the protein content of the seed meal and is in agreement with the result of [13], but cannot still be used as sole protein source in the diet of fish because it recorded low protein value of 16.83% from fermentation, which is less than 20% as recommended by [14]. Protein requirement is given high priority in any nutritional study because it is the single nutrient that is required in the largest quantity for growth and development and also the most expensive ingredient in diet formulation. The fat content of raw and processed *D. microcarpum* seed in this study was lower than (14.64%) from *D. microcarpum* as reported by [10]; 15.18% by [1]; 15.2% by [15]. 1.5%, 1.41% and 1.7% were reported by [3] from Ghibaish, Abu-Gibaiha and Omdurman localities and are lower than the ones from this study. The significance of fat in food may not be over-emphasized as it contributes greatly to the energy value of foods. It could also slow down the rate of utilization of carbohydrates. During starvation, fat could be metabolized by the process of beta oxidation to provide energy for the body, it also provides more energy when compared with carbohydrates [12]. Fat is an important vehicle for fat soluble vitamins and also acts as lubricants in the intestine as reported by [12]. Crude fibre (CF) content in raw *D. microcarpum* 5.26% was obtained in this study, toasted method increase the (CF) to 7.13%. The CF 11.11% reported by [16]; 11.1% by [14]; 19.05%, 18.15% and 20.39% by [3]; 31.16% by [11] were higher than that obtained in this study. CF of 1.4% in undehulled and 1.1% dehulled *D. microcarpum* seed was reported by [12]; 2.9% by [6] are lower than the one from this study. This finding is in agreement with that of Ene-Obong and Carnovale [17] who reported high dietary fibre content of 5.13g per 100g dry matter for *B. eurycoma*. Crude Fibre is the sum total of all those organic compounds of the plant cell membranes and supporting structures which in chemical analysis of plant foodstuff remain after removal of the crude protein, fat, and nitrogen-free extract [18]. Thus the crude fibre in diet consists mostly of plant polysaccharides that cannot be digested by human and monogastric dietary enzymes such as cellulose, hemicellulose and some materials that encrust the cell walls [18]. Fibre in diet plays very significant roles. Certain physiological responses have been associated with the consumption of dietary fibre, for example, increase in faecal bulk, lowering of plasma cholesterol, blunting of the post-ranal increase in plasma glucose and lowering of nutrient bioavailability [16]. The ash content (4.50%) was obtained in the raw *D. microcarpum* seed while the processed ranged from 4.63% - 7.22% (soaked and toasted). The value was higher than 1.93% [11]; 3.5% [14]; 3.49% [15]; 2.7% [7]; 2.6%, 2.49% and 2.69% [3]; 2.2% - 2.5% [19] while 5.12% by [10] was reported higher than the raw seed from this study. The low value of ash in the raw seed may be as a result of the effect of anti-nutrients on the mineral contents of sample, previous work had reported that anti-nutrients could interfere with the bioavailability of minerals [20]. However, since anti-nutrients are heat liable, processing can reduce the levels of the anti-nutrient, thereby improving the bio-

availability of the minerals as seen in the resultant increase in the ash values of flour from processed kidney bean seeds [21] and correspond with my findings. The Nitrogen free extract (NFE) content of 62.89% was obtained from raw seed meal, while there was reduction in NFE values from the processed [11]. Reported 28.43% and [12] 52.2% and 57.0% that were lower than the value recorded in this study [10]. reported 69.22% which is higher than the value from this study. The very high carbohydrate content of these seeds as well as their ability to form viscous gums at such low concentrations of 0.1-1.0% in sauce showed that they belong to the class of food ingredients known as hydrocolloids [12]; [22]. Apart from the supply of energy, studies have shown that viscous polysaccharides can slow the rate of gastric emptying [23]. Within the small intestine, viscous polysaccharides which can form gel matrix may slow absorption by trapping nutrients, digestive enzymes, or bile acids in the gel matrix and by slowing mixing and diffusion in the intestine [24]. Have shown through animal experiments, that viscosity is necessary for gum to blunt the rise in plasma glucose load. Thus the high carbohydrate content of these seeds is quite significant to health. The dry matter (DM) content of 92.8% was obtained in this study and is higher than 87.34% by [10]. The high DM content of detarium seeds is an indication that they can be stored for a long time without the development of molds [15]. For the mineral elements, Potassium (K) had the largest value (1457.24mg/100g) but processed method (boiled) had reduced value of (1044.53mg/100mg) and this is in agreement with the report of [11] and [15]. Magnesium recorded least value. These macro-elements play vital roles in the metabolism of living organisms. Potassium and Sodium maintain the water balance in cells and are important for the transmissions of the nerve impulse, as well as the stimulation of the normal movement of the intestinal tract [11]. Magnesium maintains, repairs cells, provides energy and increases the body's resistance to infection. It also plays a role in the metabolism of calcium [11]. Its deficiency may result in nervousness, convulsions, anemia, insomnia and vertigo [25]. Calcium provides rigidity to the skeleton and calcium ion plays a role in many metabolic processes [26]. Iron helps in oxygen transport and oxidative metabolism in the body and assist in blood formation. Iron deficiency can lead to the impairment of immunologic responses as well as phagocytic action of neutrophil leucocytes Scrimshaw [27].

The essential amino acid content of *D. microcarpum* seed are generally higher than the values reported by [7]. Among the essential amino acid, Leucine was highest and processing increased the content. Leucine is responsible for regulating the blood sugar concentrations, growth and repairs of muscles/tissues, hormone production, wound healing and energy production. Its deficiency causes dizziness, headaches, fatigue, depression, confusion, irritability and hypoglycemia in infants as reported in [27, 7] observed that Phenylalanine is another essential amino acid that is used by the brain to produce norepinephrine (a chemical that transmits signals between the nerve cells and the brain). It keeps the body alert and reduces hunger pains. It is an antidepressant and helps in improving memory and its deficiency could result in slow growth, liver damage, and skin lesions. Isoleucine amino acid helps in development and repair of muscles, development of hemoglobin and acts as energy regulator. Its deficiency results in ailments similar to leucine deficiency [28]. stated that Lysine insures the adequate absorption of calcium, help the formation of collagen, in addition it aids the production of antibodies, hormones and enzymes. Lysine deficiency may result in tiredness, inability to concentrate, irritability, bloodshot eyes, retarded growth, hair loss, anemia and reproductive problems. These values are considered to be high when compared to the World Health Organization protein standard [7]. Threonine is necessary in the body because, it produces antibodies, prevent fat buildup in liver and assist metabolism and assimilation [28]. It is an important constituent of collagen, elastin and enamel protein. Its deficiency has been associated with skin disorders and weakness [7]. Valine promotes mental vigor, muscle coordination and calm emotions as reported by [29]. Methionine is a sulphur containing amino acid, it functions as a supplier of sulphur, which prevents disorders of hair, skin and nails. It prevents arterial fat buildup, regulates ammonia formation and creates ammonia free urine which reduces bladder irritations; its deficiency results in similar symptom like phenylalanine [7]. Histidine is essential especially in children; it is used for growth, tissue repairs and histamine development [28]. Cystine is a sulphur containing amino acid which acts as an antioxidant and protects the body from radiation and pollution. It also aids protein synthesis and prevents cellular changes. In addition, it deactivates free radicals and neutralizes it. The fatty acids particularly Palmitic acid, Linoleic acid and Oleic acid of *D. microcarpum* seeds in this study did not agree with the report of [11] whom identified Linoleic (44.1%), Oleic acids (30.8%) and Palmitic acid (4.2%). The anti-nutrients in *Detarium microcarpum* seed meal in this study are higher than those reported by [14, 15] and [12]; but the value of phytic acid reported by [15] was higher than the one from this study and the variations observed could be as a result of method of processing, geographical and edaphic factors.

In conclusion, toasted and fermented methods were found to be more effective in reducing the anti-nutrients in Detarium seeds without affecting the nutritional quality. The low levels of these anti-nutrients most of which are lost during processing indicate an overall good quality of the seeds nutritionally. This study therefore has provided some biochemical basis for the use of these seeds as a rich source of nutrients, minerals, vitamins, fatty acids and anti-nutrients, they could be playing a major role in the nutritional status of feed industries.

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