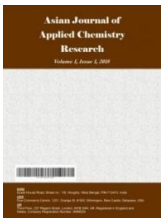

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Amino Acid Profile and Mineral Content of *Balanites aegyptiaca* Kernel

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Authors' contributions

This work was carried out in collaboration between all authors. Authors IUM, AJA, AM and YR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AN, AIY and IA managed the analyses of the study. Authors YU and MDE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Study on the evaluation of the nutritional quality of poorly utilized plant products is of immense importance. This research work, therefore, evaluates the amino acid profile and mineral content of *Balanites aegyptiaca* kernel using standard analytical methods. The amino acid profile analysis revealed the presence of essential and the non-essential amino acids of which Total sulphur and

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Total aromatic amino acids content were 2.86 g/100 g protein and 7.21 g/100 g protein respectively. Analysis of the mineral content showed the presence of the following minerals in the order; Magnesium > Sodium > Calcium > Potassium > Iron > Zinc > Manganese > Lead > Copper > Nickel > Chromium > Cadmium. The kernel could, therefore, be used as a good source of protein and minerals in supplementing other sources in order to reduce food insecurity and hence malnutrition from lack of protein diets.

Keywords: Amino acid profile; mineral content; Balanites aegyptiaca, Kernel.

1. INTRODUCTION

Balanite aegyptiaca (Linn.) is a genus of flowering plants in the caltrop family, commonly known as desert date. *Banalites aegyptiaca* is an important multipurpose tree found in most African countries [1]. It is a woody evergreen xylophylic tree with a height of 10m grown in various ecological conditions mainly distributed in semi-arid zones in tropical Africa especially in Senegal, Sudan and also Asian countries such as India [2]. In Arabic, it is known as lalob, hidjihi, inteishit and heglig. In Hausa, it is called Aduwa and in Swahili and Amharic, it is respectively called mchunju and bedena [3].

Balanite aegyptiaca is used in treatment of various ailments such as jaundice, intestinal worm infection, malaria, syphilis, epilepsy, dysentery, constipation, haemorroid among others [4]. The seed is about 1.5-3cm long, light brown, fibrous and hard, making up to 50-60% of the fruit with about 500-1500 dry clean seeds/kg. These seeds were reported to contain a cytostatic saponins "balanitins" [5], deltonin and isodeltonin which are used as molluscicidal agents [6]. In addition, various reports on the nutritional and anti-nutritional profile of *Balanites aegyptiaca* seeds powder has shown that the seed powder contains a relatively high amount of protein and lipids [7] and some amount of anti-nutritional factors such as tannins, oxalate and phytic acid as compared to other plant products [8]. Antinutritional factors such as phytic acid, tannins, saponins, oxalic acid, have an adverse effect on health through inhibition of protein digestion, growth, iron and zinc absorption [9, 10]. Due to the presence of high protein content in *Balanites aegyptiaca* seed kernel as mentioned by [11], there is a need for determination of the amino-acid profile and mineral content of this kernel.

This study could go a long way in proving the nutritional content of kernel obtained in Kano sate, northwest Nigeria. Thus, providing a scientific basis of the use of this seed as source of food in drought areas, war zones as well as commercialization of *Balanites aegyptiaca* which could bring about boosting the economy, encouraging its cultivation and hence solving the problem of malnutrition and food insecurity.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Balanites aegyptiaca fruits were obtained from Gwammaja market, Dala Local Government Area, Kano state Nigeria. It was authenticated at the department of plant biology Bayero University Kano, with an accession number BUKHAN0359. The fruit was processed by soaking in water for 48 hours, de-pulped. The seed obtained were hard cracked using a hammer to obtain its kernel. The kernels were air-dried for 12 hours and pulverized using a mortar and pestle. The pulverized sample was stored in plastic containers.

2.2 Analysis of Amino Acid Profile of *Balanites aegyptiaca* Kernel

Amino Acid profile in the sample was determined using the methods of [12]. The sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM).

2.3 Analysis of Mineral Content of *Balanites aegyptiaca* Kernel

Elemental analysis of *Balanites aegyptiaca* kernel involves ashing of the solid sample, digestion, dilution and quantitative analysis with atomic absorption spectrophotometer [13]. Into a previously weighed (W_1) proclein crucible, approximately 10.0 g of finely pulverized dried sample of *Balanites aegyptiaca* kernel was placed. The crucible and the sample was ignited in a muffle furnace for 6-8 hours at 500ºC

and then cooled in a desiccator and re-weighed (W_2). The difference between the weight of the crucible and ash and the weight of the crucible alone was used to calculate the percentage ash content of the *Balanites aegyptiaca* kernel sample.

To the left-over ash, 5.0 cm^3 of 1M HNO_3 solution was added and evaporated to dryness on a hot plate of a heating mountain for 5 minutes and returned to the furnace and heated again at 400ºC for 15-20 minutes until perfectly grayish-white ash was obtained. The sample was cooled in a desiccators followed by addition of 15 cm^3 1:1 (vol:vol) HCl to dissolve the ash and the solution was filtered into a 100 cm^3 volumetric flask. The volume was made to the mark with distilled water.

3. RESULTS

Table 1 shows the amino acid profile of *Balanites aegyptiaca* kernel. The result showed the presence of both essential and non-essential amino acids.

Table 2 shows the amino acid score for the *Balanites aegyptiaca* kernel compared with WHO ideal protein value in both children and adults.

Table 3 showed the calculated total amino acids (TAA), total non-essential amino acids (TNEAA), total essential amino acids (TEAA), their respective percentages, the predicted protein fficiency ratio (P-PER), Leu/Ile ratio value for *Balanites aegyptiaca* kernel.

Table 4 showed the mineral content of *Balanites aegyptiaca* kernel. The result showed a very high quantity of Sodium and Magnesium. The micronutrients (Cu, Cd, Cr, Mn, Ni, Pb, Zn) were quite low except for Fe which is a bit high.

Table 1. Amino acid profile of *Balanites aegyptiaca* kernel

Amino acid	Abbreviation	g/100g protein
Lysine*	Lys	3.52
Histidine*	His	2.19
Arginine	Arg	6.38
Aspartic acid	Asp	8.71
Threonine*	Thr	2.98
Serine	Ser	3.58
Glutamic acid	Glu	13.57
Proline	Pro	2.90
Glycine	Gly	4.40
Alanine	Ala	3.94
Cystine	Cys	1.52
Valine*	Val	4.02
Methionine*	Met	1.34
Isoleucine*	Ile	3.29
Leucine*	Leu	6.69
Tyrosine	Tyr	2.98
Phenylalanine*	Phe	4.23

**Essential amino acids and their corresponding percentages when compared to the total amino acids analyzed*

4. DISSCUSSION

The amino acids profile of *Balanites aegyptiaca* revealed the presence of only seventeen amino acids out of the common twenty amino acids found in proteins. This may be due to the complete destruction of tryptophan during acid hydrolysis and the conversion of the amide glutamine and asparagine to their corresponding amino acids [14]. i.e glutamate and aspartate respectively [15]. The result showed that the percentage of non-essential amino acid is higher than that of essential amino acids which were 50.17% and 26.07% respectively, this may be due to the fact that proteins from plant sources tend to have a relatively lower concentration of protein by mass in comparison to protein from animal sources. They are nevertheless

Table 2. Amino acid score for *Balanites aegyptiaca* kernel

Amino acid	Amino acid (g/100 g protein)	WHO ideal protein (g/100 g protein)		[(%Aminoacid/ideal)×100]	
		Children	Adult	Children	Adult
Isoleucine	3.29	2.8	1.3	117.50	253.08
Leucine	6.69	8.3	6.6	80.60	101.36
Lysine	3.52	4.2	5.8	83.81	60.69
Histidine	2.19	1.9	1.6	115.26	136.88
Valine	4.02	4.4	3.5	91.36	114.86
Threonine	2.98	3.0	3.4	99.33	87.65
Total Sulphur amino acid	2.86	1.6	2.5	178.75	114.40
Total Aromatic amino acid	7.21	7.4	6.3	97.43	114.44

Table 3. Various Amino acids parameters of *Balanites* aegyptiaca kernel

Amino acid	Abbreviation	g/100 g protein
Total amino acid	TAA	76.24
Total non-essential amino acid	TNEAA	50.17
Total essential amino acid	TEAA	26.07
-With His		28.26
-No His		26.07
%TNEAA		65.80
%TEAA		34.19
-With His		37.07
-No His		34.19
Total neutral amino acid	TNAA	41.87
%TNAA		54.92
Total acidic amino acid	TAAA	22.28
%TAAA		29.22
Total basic amino acid	TBAA	12.09
%TBAA		15.86
Total sulphur amino acid	TSAA	2.86
%TSAA		3.75
% Cys in TSAA		53.15
Total aromatic amino acid	TArAA	7.21
% TArAA		9.56
Predicted protein efficiency ratio	P-PER	2.26
Leu/Ile ratio		2.03
Leu-Ile (difference)		3.40
% Leu-Ile		4.46

Table 4. Mineral content of *Balanites aegyptiaca* kernel

Mineral	Concentration (mg/g)
Zinc	2.18 ± 0.81
Copper	1.06 ± 0.21
Iron	7.80 ±3.57
Lead	1.32 ±0.81
Cadmium	0.05 ± 0.04
Chromium	0.26 ±0.03
Sodium	111.48 ±15.45
Potassium	10.79 ± 3.31
Calcium	21.94 ± 6.23
Magnesium	152.57± 7.82
Manganese	1.49±0.05
Nickel	0.61±0.04

"complete" in that they contain trace amounts of all of the amino acids that are essential in human nutrition in adequate quantities [16]. The non-essential amino acids which are higher than essential amino acids in *Balanites aegyptiaca* kernel play several important roles in human body along with these essential amino acids. They are incorporated into new proteins needed by cells and can undergo chemical conversion to ultimately create glucose, for use as a fuel source, or fatty acids, for storage of excess calories. Therefore, *Balanites aegyptiaca* kernel is a good source of both non-essential and essential amino acids used as building blocks of protein that boost tissue growth and repair, immunity, red blood cell formation, hormone synthesis among others.

To evaluate the nutritional quality of the kernel, the respective percentages of the essential, total aromatic (TArAA) and total sulphur (TSAA) containing amino acids in the sample were compared with the reference standard amino acids profile established for both adults and preschool children by [17]. The results showed that the TArAA and TSAA of the kernel were all slightly higher than that of the reference standard amino acids profile established for both adults and preschool children by [18] indicating its high nutritional quality. Sulphur containing amino acids, aromatic amino acids and arginine are always required by infants and growing children in order to enhance brain function, growth and boost their immunity against infections. The amino acid score for the kernel was calculated from the WHO ideal protein value in both children and adults. From the calculations done, TSAA and TArAA were found to be 114.40 and 114.44 in adults and 178.75 and 97.43 in children respectively showing that it is a good source of TSAA and TArAA since the TSAA and TArAA are

above 100% except for TArAA in children which is slightly below the ideal value. Hence, with proper processing the kernel could meet up with the WHO ideal protein value for both children and adults.

Threonine, Leucine, Valine were found to be close to the WHO ideal protein value in both adults and children of which Isoleucine and lysine with calculated value of 3.29 and 3.52 g/100 g of protein were only closer to the value of that of children. However, Histidine with calculated value of 2.19 g/100 g of protein was found to be higher than the WHO ideal protein value in both adults and children. It could therefore be deduced that *Balanites aegyptiaca* kernel could be used in weaning and general food formula for infants and children after adequate processing. In addition, adults especially the elderly could be given the food products of *Balanites aegyptiaca* kernel.

From the various parameters presented, total amino acids (TAA) in the kernels is 76.24 g/100 g as compared with the TAA in its leaves (71.67 g/100 g of protein) [19]. The total non-essential amino acids (TNEAA) for the kernel, 50.17 g/100 g was found to be higher than that of its leaves, 44.95 g/100 g of protein and their respective percentages are 65.80% and 62.71%. However, the TEAA in *Balanites aegyptiaca* kernel which was 26.07 g/100 g of protein and its percentage TEAA with His 37.07% was found to be lower than that of soybean (44.4 g/100 g protein) [20], melon (53.4 g/100 g protein) and gourd oilseeds (53.6 g/100 g protein) [21]. Therefore, as expected that for a food substance to be acceptable for consumption its non-essential amino acids has to be higher than that of the essential amino acids as some of these essential amino acids could be harmful when in excess, *Balanites aegyptiaca* kernel could be used as a good source of essential amino acids.

In addition, the predicted protein efficiency ratio (P-PER) for the kernel was 2.27 which is comparable in value with reported values for true digestible protein of whole dried honey bees (*Apis mellifera L.*), 2.47 and 2.50 for casein [22]. Due to the fact that the experimentally determined P-PER usually ranged from 0.0 for a very poor protein to a maximum possible value of just over 4 [23], the protein from the kernel could be efficiently utilized in the human body.

Furthermore, the Leu/Ile ratio value of the kernel was found to be 2.03 of which Ile was less than half that of Leu. It has been suggested that an amino acid imbalance from excess leucine might be a factor in the development of pellagra due to sorghum consumption [24]. High Leu in the diet impairs tryptophan and niacin metabolism and is responsible for niacin deficiency in sorghum eaters [25]. This leads to the hypothesis that excess Leu in sorghum is etiologically related to pellagra in sorghum-eating populations [26]. In addition, a study was carried out showing that Leu/Ile balance is more important than the dietary excess of Leu alone in regulating the metabolism of Tryptophan and niacin and hence the disease process [27]. However, in dogs, experiments have shown that animals fed with sorghum proteins having Leu value to be less than 11.0g/100g protein did not suffer from nicotinic acid deficiency. From some of the above findings, *Balanites aegyptiaca* kernel could therefore be recommended as a good source of protein in supplementing other sources in order to reduce food insecurity and hence malnutrition from lack of protein diets [28]. Mineral content of *Balanites aegyptiaca* kernel with Magnesium and Sodium having higher values than other mineral content. Sodium content was also found to be higher than those in the flower and the recommended daily allowance for Sodium in adults [29]. Otori and Mann [30] show that *Balanites aegyptiaca* kernel is a good source of Sodium. Magnesium which is important in connection with circulatory diseases and calcium metabolism in bone [31], has a higher content than that of the flower [32]. However, the Calcium content of *Balanites aegyptiaca* kernel was found to be lower than those in the flower as reported by [33]. The kernel is therefore not a good source of calcium and could be made up to the recommended daily allowance of calcium though, enough to increase the shelf-life of the kernel. In addition, most of the micronutrients (trace elements) Zinc, Copper, Lead, Cadmium, Chromium, Manganese and Nickel were found to be of low quantities. This indicates that the kernel is a good source of essential nutrients in moderate quantities needed by animals for various activities especially in metabolic processes acting as cofactors.

5. CONCLUSION

The study revealed that *Balanites aegyptiaca* kernel is of high nutritional value due to its high content of minerals, essential and non-essential amino acids. Therefore, its nutritional information could be of great use to nutritionists, industrialists and researchers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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