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Nutritional, Elemental and Amino Acid Profile Analyses of the Seeds of *Aspilia africana*: A Neglected and Underutilized Species (NUS)

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Authors' contributions

This work was carried in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was designed to investigate the nutritional, anti-nutritional, amino acid profile and elemental constituents of the seeds of Aspilia Africana; a neglected and underutilized species (NUS). The nutritional and anti-nutritional contents of *A. africana* was determined using standard methods. The nutritional analysis showed the presence of carbohydrate (39.40±0.17%), crude protein (21.78±0.24%), fat (20.80±0.25%), ash (6.95±0.44%), crude fiber (9.70±0.25%) and moisture (1.31±0.02%). Anti-nutrients present include; oxalate (0 33±0.02%), saponins (2.96±0.04%), alkaloids (3,99±0.02%), phytate (0.13±0.00%), tannins (155.09±0.78 mg/100 g) and cyanogenic glycosides (4.30±0.06 mg/100 g). Amino acid profile was determined using the model 120a PTH amino acid analyzer. All essential and non-essential amino acids were detected. The seeds were found to be rich in amino acids (12.26 g/100 g-2.19 g/100 g), except for tryptophan (1.02 g/100 g) and cysteine (1.15 g/100 g). Macro and micro minerals found include: Calcium (Ca),

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potassium (K), Sulphur (S), Phosphurus (P), Iron (Fe), Copper (Cu), Rubidium (Rb), Manganese (Mn), Rhenium (Re), Gold (Au), Chromium (Cr), Nickel (Ni), Zinc (Zn) and Strontium (Sr). This shows that *A. africana* seeds are rich in nutrients and capable of ameliorating the acute food shortage being experienced the world over.

Keywords: Aspilia africana; seeds; amino acid profile; amino acid analyzer.

1. INTRODUCTION

There are indications that world hunger is sadly on the rise and reports show that in 2016, 38 million people suffered from hunger than in 2015. On daily basis, over 800 million people struggle to get any food at all, and risk starvation [3,4]. Most of these people live in developing countries like Nigeria. Despite Nigeria's significant natural resources, poverty remains widespread especially in rural areas where 80 percent of the population lives below the poverty line [1]. An estimated 70 percent of Nigerians live on less than US$1.25 per day. It was ranked 103rd out of 119 countries on the 2018 Global Hunger Index [2].To stem this trend, the identification of promising neglected and underutilized species (NUS)- sometimes called " orphan crops" – that are nutrition dense, climate resilient, economically viable and locally available or adoptable as " Future Smart Food" (FSF) should be vigorously and aggressively pursued. Also their multidimensional benefits and potential contribution to achieving zero hunger is extensively harnessed. Currently, NUS such as *A. africana* are being overlooked even though they have a central role to play in the fight against hunger and malnutrition [5].

A. africana is a plant that falls under the group of Neglected and Underutilized Species (NUS). It is a perennial herb belonging to the family Asteraceae which is native to Africa and Latin America. It can grow up to 1.5m high. Its leaves are opposite and hairy [6]. In English, it is referred to as hemorrhage plant or wild Sunflower, Kissinyana in Sierra Leone. In Nigeria, the Efik call it Edeme edon and in Hausa Jamajina; meaning to draw mucus [7].

A. africana is commonly used in African folk medicine to arrest hemorrhage, induce delivery, remove corneal opacities and treat anemia [8,6,9]. Its leaves have been reported to have antiulcer effects [10,11]. Phytochemical studies of its leaves revealed the presence of saponins, alkaloids, tannins, sesquiterpenes and monoterpenes [12-14]. Acute and sub-acute toxicity of its leave extract has been reported [15,16].

A. africana is believed to have nutritive values. It was reported to be a source of protein although the quantity was too low for human and livestock demands [17]. However, reports indicate high carbohydrate content in the leaves of *A. africana* [18]. Investigation and reports also revealed the presence of kaurenoic and grandiflorenic acids in the leaves of *A. africana* [19].

Despite the seemingly extensive researches on the leaves of *A. africana*, no nutritional study of its seeds, as far as our literature search is concerned, have been reported. The present study was undertaken to determine the nutritional composition of the seeds of *A. africana*. Locals in Plateau State – Central Nigeria use the seeds of *A. africana* as a condiment in the preparation of a local delicacy known as 'bebal' (local bean garnished with powdered *A. africana* seeds).

It is hoped that the results of this research would restore the knowledge of traditional and local crops, provide adequate awareness of the nutritional value of this local variety and eradicate the perceived low status of this local and traditional food.

2. MATERIALS AND METHODS

2.1 Collection Identification and Preparation of Seed Samples

Fresh plant of *A. africana* was collected in November from Dong village- Jos North, Plateau State. It was identified at the Federal College of forestry, Jos Nigeria by Mr. Azila.

Healthy dried seeds samples of *A. Africana* were pulverized and stored in air tight polythene bags for subsequent use.

2.2 Proximate Analysis

The determination of crude protein, crude tat, ash, carbohydrate and crude fiber was carried out using the methods of AOAC [20].

2.3 Determination of Anti-nutrients

Anti-nutrients including saponin, phytic acid, tannin, oxalate, cyanogenic glycosides and alkaloids were determined using standard methods [21-24].

2.4 Determination of Amino Acid Profile

Amino acid in the known sample was determined using standard method [25]. The known sample was dried to a constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino acid Analyzer. An integrator attached to the Analyzer calculated the peak area proportional to the concentration of each of the amino acids.

2.5 Elemental Analysis

The determination of macro-mineral and micro-mineral content of *A. africana* seeds was carried out using the Energy Dispersive x-Ray fluorescence spectrometer, minipal4 model © 2005 pw4025/145B type with Rh tube.

2.6 Statistical Analysis

The data obtained were reported as duplicate observations. The data were subjected to one way analysis of variance (ANOVA) using Statistical Package (SPSS) 20 software. The values are mean ± standard deviation of two replicate determinations.

3. RESULTS

The proximate composition of the seeds of *A. africana* are shown in Table 1. They were found to contain high concentration of protein, fat and carbohydrate; moderate concentration of crude fiber and ash while the moisture content was very low.

Table 1. Proximate composition of seeds of *A. africana*

Parameter (%)	Concentration
Moisture	1.31±0.02
Crude protein	21.78±0.24
Fat	20.80±0.25
Ash	6.95±0.44
Crude fiber	9.70±0.25
Carbohydrate	39.41±0.22

Results are presented as mean ± SD of two replicate determinations

3.1 Mineral Content of Seeds of *A. africana*

The levels of macro-minerals; Calcium (Ca), Potassium (K), Phosphorus (P) and Sulphur(S) are shown in Fig. 1. The results indicate that calcium has a very high concentration in the seeds of *A. africana*, followed by potassium, phosphorus and Sulphur in that order.

The micro-mineral composition of seeds of *A. africana* showed that iron (Fe) was the most abundant mineral in the seeds of the plant. Other elements of relatively high content are copper (Cu), manganese (Mn), Rubidium (Rb), Rhenium (Re) and Gold (Au). Others include Strontium (Sr), nickel (Ni) and Chromium (Cr). It was interesting that the seeds of *A. africana* did not contain toxic elements such as Cobalt, Cadmiun, lead and Arsenic.

Table 2. Anti-nutrient composition of seeds of *A. africana*

Parameter	Concentration (%)
Oxalate	0 33±0.02
Saponins	2.96±0.04
Alkaloids	3,99±0.02
Phytate	0.13±0.00
Tannins	155.09±0.78 mg/100 g
Cyanogenic glycocides	4.30±0.06 mg/100 g

Results are presented as mean ± SD of two replicate determinations

Result of the amino acid profile of *A. africana* seeds is presented in Table 3. This showed that the seeds contain all amino acids in good quantities except norlecine which was not detected. The concentration of amino acids was found to range from 1.02-12.26 g/100 g protein.

4. DISCUSSION

Proximate analysis of plant products consumed by man are carried out to ascertain their nutrient level. Table1 gives the proximate analysis for the seeds of *A. africana*. It revealed 1.31% moisture, 21.78% protein, 20.80% fat, 6.95%, ash, 9.70% crude fibre and 39.48% carbohydrate. This result is in agreement with the other research findings [26,27]. The low moisture content of 1.31% suggests its non-susceptibility to microbial degradation, hence longer shelf life.

The protein value shown in Table 1 is 21.78% was higher than the leaves 3.31% and those

obtained for calyx of *Bombax costatum* and *Hibiscus esculentus* [26,28]. It was also found to be more than adequate to meet the FAO/WHO Recommended Daily Allowance of protein of 0.59 g/kg body weight for an average healthy individual and 0.88 g/kg body weight for children age 1-10 years [29]. This result indicates that *A. africana* seed possesses the relevant nutritive value of protein which is vital for the synthesis of body tissues and regulatory substances such as enzymes and hormones [30]. Crude fat value of 20.80% in this study is in conformity with most legumes; groundnut (45.30%), Soybeans (17.70) and winged bean (17.0%) [31]. This high value of fat in *A. africana* seeds could be explored as a cheap source of vegetable oil and also for medicinal purposes.

The total ash content of 6.95% is higher than for most legumes; 2.00% in peas and 5.00% in soybean. It reflects the findings which showed that the flowers of *A. africana* contains 9.17% ash. This indicates that the seeds of *A. africana* is a good source of minerals required by humans [27].

Table 3. Amino acid profile of *A. africana* seeds

Amino acid g/100 g Protein	Concentration
Essential amino acid(EAA)	
Leucine	8.11
Lysine	4.24
Isoleucine	3.93
Phenylalanine	4.00
Tryptophan	1.02
Valine	3.16
Methionine	2.19
Arginine	2.20*
Tyrosine	3.10*
Histidine	2.23
Cystine	1.15*
Non-essential amino acid(NEAA)	
Norleucine	
Proline	4.06
Alanine	4.32
Glutamic acid	12.26
Glycine	3.90
Threonine	3.61
Serine	4.10
Aspartic acid	7.63

** Conditionally Essential Amino Acids (CEAA)*

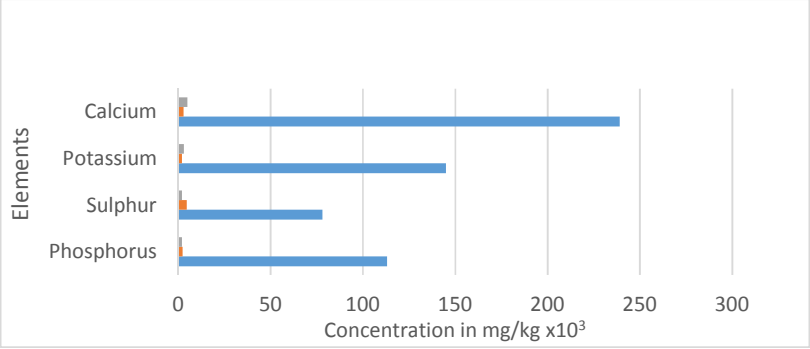

Fig. 1. Macro-mineral composition of *A. africana* seeds

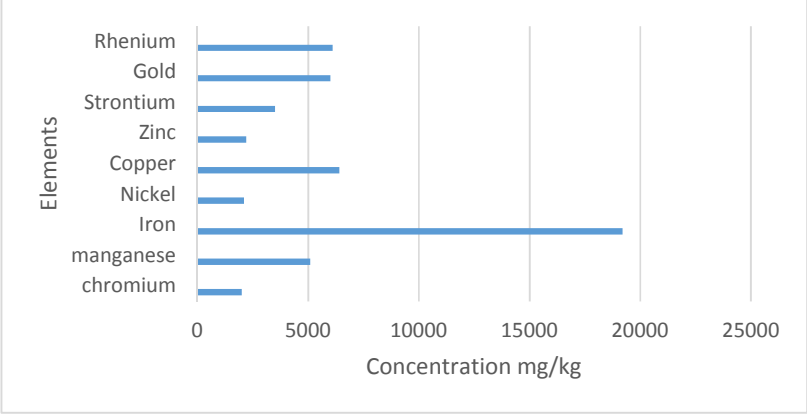

Fig. 2. Micro-mineral composition of *A. africana* seeds

The crude fibre was found to be 9.70% which is in consonance with the findings that recorded a total ash of 9.10% for the flowers of *A. africana* [27]. This value of 9.17% is high and compares favorably with the fruit pulp of locust bean (11.75%) [32]. Although crude fibre is not a nutrient, it is a source of dietary fibre which is required for good bowel movement and prevention of obesity, colon cancer, diabetes and other gastro intestinal problems. The total carbohydrate content of *A. africana* seeds was found to be 39.44%. Total carbohydrate content of 53.43% for dry flower of *A. africana* and 67.30% for fruit pulp of locust bean respectively have been reported [27,32]. With this content of carbohydrate, *A. africana* seeds are a good source of energy.

The results of anti-nutritional factors presented in Table 2 showed that the phytate content was 130 mg/100 g. This is far above what was reported for locust bean fruit pulp and locust bean seed [32,33]. Although the minimum lethal dose for phytate has not been established, it is apparent that high doses are required to elicit any effect in man as no effect was found with 2,000 mg of phytate [34].

Tannin content was found to be 155.09 mg/100 g. This is comparable to some commonly consumed seeds like the locust bean seed (81.00 mg/100 g), lima beans (140.00 mg/100 g) and pigeon pea (100.00 mg/100 g) [32,33]. The content of tannin in *A. africana* seed can be considered to be safe as it is within the limit of most consumable seeds. The relatively high tannin content might be good for ulcer patients as they have been reported to have astringent activities which help to hasten the healing of wounds and treat inflammations [35,11].

Saponin content was found to be 2.96% (2,960 mg/100 g). This is relatively high compared to most commonly consumed crops like millet, 19.47 mg/100 g, lime beans, 24.50 mg/100 g and locust bean seed, 17.80 mg/100 g. [32,33]. Although the high content of saponin in *A. africana* seeds raises concern about its potential toxicity, fermentation of the seeds using various yeasts might reduce their concentration [36]. Cynanogenic glycocides content of 4.30 mg/100 g is considered to be too low compared to 17.30 in locust bean seed [32]. An LD_{50} of 50-60 mg/100 g body weight/day for men has been reported [37].

Alkaloids concentration of 3.98% (39,800 mg/kg) would be said to be high as against the current Maximum Permitted Concentration of 200 mg/kg body weight [38]. It is comparable to values obtained by Australia New Zealand Food Authority (ANZFA) for bitter Lupin > 10,000 mg/kg [39]. *A. africana* seeds can be debitterred to be safe for human consumption.

Oxalate is produced and accumulates in many crop plants and pasture weeds. When taken into the body, oxalates do not only combine with calcium but also with magnesium to form insoluble salts which are not available to the body [40]. In the present work, oxalate content of 0.33% (3,300 mg/100 g) was found to be higher than other findings [41-43]. The availability of nutrients has been found to be affected by oxalate in that it causes nutrients to be unavailable by forming complex with bivalent ions like Ca^{2+}, Zn^{2+}, Mg^{2+} and Fe^{2+} [33].

Figs. 1 and 2 give the mineral composition of the seeds of *A. africana*. The seeds have the potential of being a good source of both micro and macro minerals. The result of this work agreed with the works of other researchers who reported the presence of such elements in the leaves of *A. africana*, with the most predominant being Calcium, Potassium, Phosphorus and Iron [44,27]. The high concentration of minerals in the seeds of *A. africana* corroborates the findings that revealed similar concentration in the floral parts of the plant [27].

The elemental content of plant parts plays a significant role in enhancing the activities of such parts against diseases owing to appropriate correlation between such minerals in human body with a number of ailments [45]. Calcium has being known to play an important role in blood coagulation and other metabolic functions [46,47]. Since the deficiency of calcium and phosphorus elicit medical conditions such as knock knees, bow leggedness, bone loss, curved spine and thoracic deformities, consumption of seeds of *A. africana*, which is known to contain high concentrations of both elements, may tend to prevent them.

Iron plays a pivotal role in almost all metabolic processes in living organisms. It is implicated as the main element that forms an integral part of most enzymes and protein, serving as a catalytic centre in most enzymatic activities as well as playing significant role in the process of oxygen binding in haemoglobin [46]. Thus, consumption of seeds of *A. Africana* may avail both humans and animals the benefits listed above as well as for cases of anaemia.

Results of the run of sample hydrolysates showed that eighteen (18) amino acids are present in the seed of *A. africana* (Table 3). It is found to contain all the Essential Amino Acids (EAA): Leucine, Lysine, Isoleucine, Phenylalanine, Tryptophan, Valine, Methionine, Histidine and Threonine in concentration range of 1.02 g/100 g (tryptophan) – 8.11 g/100 g (Leucine). The conditionally Essential Amino Acids (CEAA): Arginine Tyrosine and Cystine were also present in concentration range of 1.15g/100g (Cystine) – 6.20 g/100 g (Arginine). The Non Essential Amino Acids (NEAA) present were: Proline (4.06 g/100 g), Alanine (4.32 g/100 g), Glutamic Acid (12.26 g/100 g), Glycine (3.90 g/100 g), Serine (4.10 g/100 g) and Aspartic Acid (7.63g/100g). *A. africana* can be classified as complete protein alongside Soy, quinoa and buckwheat because it contains all nine EAA [48]. Populations with diets high in Soy protein and low in animal protein have lower risks of prostate and breast cancers than others without [49]. It is hoped that the same propensity as Soy can be replicated in populations with diets high in *A. africana*.

Although Nigeria has no established Recommended Daily Allowances for EAA, comparison with the United States (US) RDA per 1Kg body weight showed that all EAA in *A. africana* meet this requirement and even surpass in most instances [50].

5. CONCLUSION

The results of this work revealed that the seed of *A. africana* has good proximate content. Levels of both essential and non-essential amino acids as well as minerals were high. These suggest that the seed could be a rich source of proteins, oil and minerals nutrients to both man and animals as well as an excellent contributor to alleviating the global food shortage.

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COMPETING INTEREST

Authors wish to declare that no competing interests exist.

REFERENCES

1. FAO. Food and Agriculture Organization of the United Nations. The State of Food Security and Nutrition in the World: Building Resilience for Peace and Food Security; 2017
2. Al-Riffai P, Breisinger C, Mondal Md. AH, Ringler C, Wiebelt M, Zhu T. Linking the economics of water, energy, and food: A nexus modeling approach; 2017.
DOI: 10.13140/RG.2.2.14026.16321
3. Food Security Portal; Facilitated by IFPRI, 2033 K St, NW, Washington, DC 20006-1002, USA; 2012.
Available:https://www.globalhungerindex.org/results/
4. The global food security index: Measuring food security and the impact of resource risks. A report from. The Economist Intelligence Unit. 6th edition, Commissioned by DuPont. 2017;10.
5. FAO. Food and Agriculture Organization of the United Nations. Eds. Li X, Siddique KHM. Future smart food – redis-covering hidden treasures of neglected and underutilized species for Zero Hunger in Asia, Bangkok. 2018;242.
6. Adjanohoun JE, Aboubakar N, Dramane K, Ebot ME, Ekpere JA, Enow-Orock EG, Focho D, Gbile ZO, Kamanyi A, Kamsu kom J, Keita A, Mbenkum T, Mbi CN, Mbielle AL, Mbome LL, Mubiri NK, Nancy WL, Nkongmeneck B, Satabie B, Sofowa A, Tamze V, Wirmum CK. Traditional medicine and pharmacopeia-contribution to ethnobotanical and floristic studies in Cameroun (CNPMS), Porto-Novo, Benin. 1996;227.
7. Adams CD. Acute effects of aqueous leaf extract of *Aspilia africana* on some haematological parameters in rats. African Journal of Traditional, Complementary and Alternative Medicine. 2010;10:236-243.
8. Iwu MM. Handbook of African medicinal plants. CRP Press. Boca Raton Florida; 1993.
9. Okoli CO, Akah PA, Okoli AS. Potentials of leaves of *A. Africana* (Composite) in wound care: An experimental evaluation. Biomedical Centre Complementary and Alternative Medicine. 2007;7(24):101-109.
10. Tèlesphore BN, Pierre W, Sylvie LW, Ngetla MM, Dieudonne N, Pierre T, Albert K. The antiulcer effects of the methanolic extract of the leaves of *Aspilia africana (Asteraceae)* in rats. African Journal of

Traditional, Complementary and Alternative Medicines. 2005;2(3):233-237.
11. Charles O, Peter A, Arinze SO. Potentials of the leaves of *Aspilia africana* (compositae) in wound care: An experimental evaluation. Biomed Central Complementary and Alternative Medicine. 2007;7:20.
DOI: 10.1186/1472-6882-7-24
12. Obadoni BO, Ochuka PO. Phytochemical studies and comparative efficacy of the crude extracts of some haemostatic plants in Edo and Delta states of Nigeria; 1998.
Available:http:/www.LIFE.UIUC.EDU:bio324/VERT plant.html
13. Kuiate JR, Zollo RHA, Kamaty G, Menut C, Bessiere JM. Composition of the essential oils from the leaves of two varieties of *Aspilia africana.* Flavour Fragrance Journal. 1999;14(3):167-169.
14. Adeniyi BA, Odufowora RO. *In-vitro* antimicrobial properties of *Aspilia africana*. African Journal of Boimedical Research. 2000;3(3):167-170
15. Taziebou LC, Etoa FX, Nkegoum B, Pieme CA, Dzeufiet DPD. Acute and subacute toxicity of *Aspilia africana* leaves. African Journal of Traditional, Complementary and Alternative Medicines. 2007;4(2):127-134.
16. Oluyemi KA, Omotuyi IO, Jimoh OR, ADesanya OA, Salau CL, Josiah SJ. Erythropoeitic and anti-obesity effects of *Gercinia cambogia* in Winster rats. Journal of Biotechnology and Applied Biochemistry. 2007;47:69-72.
17. Umoh IB, Oke OL. Nutritive of some lesser known oil seeds. Food Chemistry. 1974;2: 315-321.
18. Agbor RB, Ekpo LA, Ekanem BE. Antimicrobial properties and nutritional composition of *Aspilia fricana* C.D. International Journal of Applied Science and Technology. 2012;2(7):94-102.
19. Page JE, Balza FF, Nishida T, Towers GHN. Biochemically active diterpenes from *Aspilia mossambicensis*, a chimpanzee medicinal plant. Phytochemistry. 1992; 31(10):3437-3439
20. AOAC. Official Method of Analysis. Association of official analytical chemists (W. Horwitz Editor). Washington D.C., USA.18th Edn; 2005.
21. Harborne JB. Phytochemical methods: A guide to modern technology of plant analysis, 2nd edn, New York, Chapman and Hall. 1973;88-185.
22. Lucas GM, Markaka P. Phytic acid and other phosphorus compounds of bean (*phaseolus vulgaris*). Journal of Agricultural Education and Chemistry. 1975;23: 13-15.
23. AOAC. Official Method of Analysis. Association of official analytical chemists (W. Horwitz Editor). Washington D.C., USA.13th Edn; 1980.
24. Abeza RH, Blake TT, Fisher EJ. Oxalate determination: Analytical problems encountered with certain plant species. Journal of the Association of Official Agricultural Chemists. 1968;51:963-965.
25. Benitez LV. Amino acid and fatty acid profiles in aquaculture nutrition studies. In De Silva SS (ed.). Fish Nutrition Research in Asia. Proceedings of the third Asian Fish Nutrition Network Meeting. Asian Fish. Society Special Publication. 4, Asian Fisheries Society, Philippines. 1989;23-35, 166.
26. Chindo IY, Wufem BM, Agho MO, Gushit J, Gambo N, Shibdawa MA. Nutritional potential of the calyx of the Kapok tree. Agriculture, Business and Technology Journal. 2008;6:1-5.
27. Okwuonu UC, Dorothea B, Njoya H, Iyemene PT. Phytochemical, proximate and Elemental constituents of *Aspilia africana* (Wild flower) flowers. Journal of Medicinal Plants Studies. 2017;5(4):22-27.
28. Vickery ML, Brain V. Plant products of tropical Africa, 3539, MacMillan Press Ltd.; 1979.
29. Shakuntala SFM, Shadakihavaswamy A. Foods: Facts and principle. Willey Eastern Ltd; New Delhi; 1987.
30. Vaughan JG, Judd PA. The oxford book of health foods: A comprehensive guide to natural remedies. 1st edition, Oxford University Press, New York USA. 2003;17.
31. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. Macmillan Publishers Ltd. 1985; 65-193,283-294.
32. Gernah DI, Atolagbe MO, Echegwo CC. Nutritional composition of the African locust bean (*Perkia biglobosa*) fruit pulp. Nigerian food Journal. 2007;25(1): 190-196.
33. Osagie AU, Eka OU. Nutritional quality of plant foods. Postharvest Research Unit, University of Benin, Benin City, Nigeria. 1998;ISBN-13: 9782120022:279.

34. McCance RA, Widdowson EM. Phytin in human nutrition. Biochemistry Journal. 1953;29:2694-2699.
35. Dimo T, Tan PV, Dongo E, Kaintchouing P, Raktoniria SV. *In vitro* vascular smooth muscle contractile activity of *Aspilia africana* extracts on rat aortic preparation. Pharmazie. 2002;57(6):421-423.
36. Essien AI, Ebana RU, Udo BH. Chemical evaluation of the pod and pulp of the fluted pumpkin (*Telfaria occidentalis*) fruit. Food Chemistry. 1992;45:35-40.
37. Balagopalan C, Padmosa G, Nanda SK, Moorthy SN. Cassava in food, feed and industry. C.R.C. Press Inc. Boca Raton, Florida;1988.
38. Cheeke PR. (Ed.), Toxicants of plant origin. CRC Press; 1989.
39. ANZFA. Lupin alkaloids in food: A toxicological review and risk assessment. Australia New Zealand Food Authority. Technical Report Series. 2001;3.
40. Shimelis, Yogesh. Role of anti-nutritional factors in food industry; 2013. Available:https://www.researchgate.net/publication/280722236_Role_of_Antinutritional_Factors_in_Food_Industry [Accessed Nov 13 2018]
41. Amata IA, Iwelu EE. Changes in the proximate composition and anti-nutritional content of the fruits of *Gmelina arborea* tree during growth and development. International Journal of Innovative Bio-sciences. 2012;2:126-129.
42. Owolabi AO, Ndidi US, James BD, Amune FA. Proximate, antinutrient and mineral composition of five varieties (improved and local) of Cowpea, *Vigna unguiculata*, commonly consumed in samaru community, Zaria-Nigeria. Asian Journal of Food Science Technology. 2001;2(4):70-72.
43. Zafar Iqbal Khan, Kafeel Ahmad, Asma Zafar, Humayun Bashir, Abrar Hussain, Zile Huma, Hazoor Ahmad Shad, Muhammad Sher, Ghulam Hussain, Ijaz Rasool Noorka, Nudrat Aisha Akram, Muhammad Ashraf, Fahim Arshad, Irfan Mustafa, Vincenzo Tufarelli, Mariano Fracchiolla and Eugenio Cazzato. Assessment of poisonous and anti-nutritional compounds in wild edible forages consumed by ruminant species. Journal of Environmental Science and Technology. 2015;8:91-101.
44. Okwu DE, Josiah. Evaluation of the chemical composition of two Nigerian medicinal plants. African Journal of Bio-technology. 2006;5(4):357-361.
45. Ceyik U, Ergen E, Budak G, Karabulut A, Tiraolu E, Apaydin G, Kopya AI. Elemental analysis of akçaabat tobacco and its ash by EDXRF spectrometry. J. Quant. Spectrosc. Ra. Transf., 2003;78:409-415.
46. Okaka JC, Okaka ANO. Food composition, Spoilage and Shelf life extension. Ocjarco Academic Publishers, Enugu, Nigeria. 2001;54-56.
47. Kazeem OA, Seyi SE, Dayo RO. Acute effects of aqueous leaf extract of Aspilia africana C.D. African Journal of Traditional, Complementary and Alternative Medicine. 2003;10(5):236-243.
48. Julian K. Essential amino acids: Definition, benefits and food sources. Healthline Newsletter; 2008.
49. Aaron M. Soy. A complete source of protein. Pub Med. 2009;79(1):43-47.
50. NASEM. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. The National Academies of Sciences, Engineering and Medicine. The National Academies Press. 2005;589-600.

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