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Short Communication

Phytochemicals and Chemical Compositions of Raw Cashew (*Anarcardium occidantale*) Nuts Sourced from Enugu State, South Eastern Nigeria

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ABSTRACT

Cashew nut is one of the most beneficial nuts in the international trade. This study evaluated the chemical and phytochemical properties of fresh cashew nuts. The determination of proximate, fatty acid, free fatty acid, trans fat, total sugar, amino acid, phytochemicals, minerals and vitamin composition of cashew nut was done using GCMS, HPLC and other standard analytical methods. The result showed carbohydrate (52.30 ± 0.89%), protein (12.60 ± 1.75%) crude fat (7.14 ± 0.35%), moisture (22.49 ± 0.35%), ash (3.53 ± 0.49%), fibre (1.94 ± 0.29%), free fatty acid (1.67 ± 0.08%), total sugar (1.67±0.03%). Oleic acid (31.36 ± 0.00%), alpha linoleic acid (12.43 ± 0.00%), linoleic acid (16.80 ± 0.00), eicosapentanoic acid (1.96 ± 0.00%), docosatetraenoic (4.89 ± 0.00), docohexanoic acid (1.73 ± 0.00). Saturated fatty acid includes palmitic acid (16.08 ± 0.00%), Myristic (11.09 ± 0.00), lauric acid (3.63 ± 0.00%) and an insignificant amount of trans fat. Phytochemical in highest amount was cardiac glycosides (33.840 ± 0.020%). Essential amino acid, leucine (7.079 ± 0.095 µg/100g) was the highest while methionine (1.298 ± 0.051 µg/100 g) was the least. Non-essential amino acid, glutamate (7.568 ± 0.213 µg/100 g) was the highest, while cysteine (1.079 ± 0.043 µg/100 g) was the least. Most of these nutritional qualities are in line with the RDA intended to be used as a goal for daily intake by individuals, therefore, consumption of cashew nuts may serve as a dietary source of essential elements and should be encouraged.

Keywords: Amino acids, Cashew nuts, Fatty acids, GCMS, HPLC.

Introduction

Nutrition is a key environmental exposure from conception to death that impacts on wellbeing and the way genes are expressed.[1] Nutrients such as minerals, protein, fat, vitamin, carbohydrates are basic substances the body definitely requires to perform its functions notably, create vitality, identify and react to natural environment, move, excrete wastes, breathe, develop and replicate. Mineral, fiber, and water are sources of nourishment to the body. Nuts are among the nutritiously and healthfully endowed human foods and are vital edible source for rural inhabitants and forest settlers. A number of them can be readily consumed and used by mankind for food, spices, beverages etc whereas others are not. Nuts are nutrient dense foods that have complete structure which is high in fatty acids (unsaturated), some biologically active components, vegetable proteins (high quality), tocopherols, fiber, minerals, phenolic acids and polysterols.[2] Hard shell of nut provides protection for the main nutritional store house which is the nut or seed. Nuts are most times consumed raw, unsalted and on empty stomach to ensure proper absorption of nutrients that are endowed in them.[2] Cashew nuts belong to the Anacardiaceae family[3] and were presented in Nigeria within the 15th century by the Portuguese as a sort of afforestation plot in a bid to control the enormous rate of erosion in the eastern part of the country.[4] In the international trade, one of the most beneficial nuts is the cashew nut.[5] It is all inclusively eaten for their alluring dietary and tangible properties which are due to its good source of protein, carbohydrates, fats etc.[6] Cashew nuts are attached to a cashew fruit or apple produced by cashew trees beneath the fruit enclosed in a strong shell.[7] It also contains a permeable honeycomb like structure containing caustic liquid which is made up of anarcadic acid that serves as protection to the cashew nut during growth by its poisonous property [7]. Cashew nuts symbolizes a rich source of amino acids, unsaturated fatty acids, sterols, fiber, vitamins which proposes that their consumption may play beneficial roles in wellbeing such as providing energy, repairing worn out tissues and provide the body with needed nutrients.[8]

In 2010, Nigeria was positioned one of the biggest makers of cashew within the world besides Philippines, Cote d'Ivore, Tanzania, Vietnam, Indonesia, Brazil, India, Guinea-Bissau and Benin with an add up to yield of around 2,757,598 metric tonnes.[9]Nutritional composition such as amino acid composition among others has been documented.[10]Cashew trees are widely spread across Nigeria and other tropical regions near to the equator, hence the nutritional properties may variegate based on source and geographical location. The purpose of this research was to resolve the nutritional components of raw cashew (*Anarcardium occidantale*) nuts sourced from Enugu State, South Eastern Nigeria.

Materials and Methods

Sample collection

Cashew nuts were brought in neat bags from Obukpa in Nsukka, Enugu state.

Sample identification

The cashew nuts used for this study were collected on 2nd April, 2019. The cashew nut was identified and authenticated by Professor A.O. Nwadinigwe, a Botanist at the Botany Department, University of Nigeria, Nsukka. Voucher number is UNH No: 240c.

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Sample preparation

The cashew nuts were fried using 1 L of vegetable oil for 10 min and allowed to cool. The pods were broken after cooling using a mechanical machine. It was then placed in an oven for three days (3) at 40-70^{o}C. After oven drying, dried cashew nuts were ground using a clean domestic engine to a semi powdered form and then taken for analysis.

Reagents and chemicals

All thereagents and chemicals used for the following analysis were obtained from Numex, India and were of analytical grade.

Instruments and equipment

The equipment and instrument were sourced from the laboratory units of the Springboard Research Laboratories, Awka, Anambra state, Nigeria. They include: atomic absorption spectrophotometer (South Africa), agilent atomic absorption spectra standard (USA), Oven (precision electrothermal model BNP 9052 England), Water bath (Memmert), Vaccum filter (Whatman 541,Maidstone,England), HP 88 capillary column (100m x 0.25micrometer,film thickness), USA, Muffle furnace, Gas chromatography-Mass spectrometer and High performance liquid chromatography.

Proximate content

Proximate content was done to ascertain the level of moisture, ash, protein, raw fiber, raw fat and carbohydrate in the cashew nut powder using the Association of Official and Analytical Chemists (AOAC)[11] method.

The Carbohydrate content of the cashew nut powder was ascertained using differential method.

100-(%Protein+ %Moisture+%Ash+% Fibre+%Fat)

Reducing sugar

The sugar content of the cashew nut powder was obtained using AOAC[11] method.

Approximately 2.6 g of cashew nut powder was weighed and transferred to a 500 mL flask. A volume, 5 mL of standardized Fehlings solutions A and B were transferred to a 250 mLErlenmeyer flask containing 7 mL of water and 15 mL of cashew nut solution. The Erlenmeyer flask was heated and 1 ml of methylene blue (0.2%) was added. Titration was carried out by adding the diluted cashew nut solution until the indicator decolorized.

Free fatty acid (FFA) determination

Free fatty acid content of cashew nut powder was determined using AOAC[11]method.

A quantity, 25 mLdiethyl ether was added to 25 mL alcohol, 1 mL phenolphthalein solution (1%) was neutralized with 0.1 M NaOH. A volume, 10 mL of the oil was dissolved in the mixed neutral solvent and titrated with aqueous 0.1 M NaOH, shaking constantly until a pink colour was obtained which persisted for 15 sec.

Determination of trans fat

The trans-fat content of the cashew nut powder was determined using GC-MS.

Cashew nut powder (500 mg) was added 2 mL water. It was mixed properly to dissolve and let to stand for 15 minutes at room temperature. About 5 mL of internal standard (C11:0 FAME+ C13:0 TAG, each at 2 mg/mL in methyl tertbutyl ether) and 5 mL of 5% (w/v) methanolic sodium methoxide solution were added to the mixture. The tubes were closed and vortexed for 10 sec. Hexane (2 mL) and 10 mL of neutralization solution (10 % disodium hydrogen citrate/ 15% sodium chloride) in water were added. The mixture was centrifuged at 1750 rpm for 5 min. Supernatant (200 uL) was transferred into 10 mL flask and diluted to the mark.

Fatty acid profile determination

Fatty acid profile of cashew nut powder was determined using Gas chromatography-Mass spectrometry (GCMS).

Filtered cashew residue (1 mL) was dissolved in 50 mL chloroform. The mixture was transferred to a 100 mL volumetric flask, diluted to mark and 1 mL of the reagent (20% benzene and 50% methanol) added. It was heated in 40^{o}C water bath for 30 min. After heating, the organic sample was extracted with water and hexane. About half of the top hexane phase was transferred into a small test tube for injection.

Quantitative phytochemical analysis of cashew nuts

Quantitative phytochemical analysis was carried out using the methods of Harborne;[12] Obadoni and Ochuka;[13] Bohm and Kocipai;[14] Pearson;[15] Okeke and Elekwa;[16] Wang and Filled.[17]

Determination of vitamin A, B2, B1, B6, B3, B12, E, C

This was carried out using Kirk and Sawyer[18] method.

Determination of vitamin D

Vitamin D was carried out using Brockman *et al*.[19] method.

Determination of vitamin K and beta carotene

This was carried out using Zakaria*et al*.[20] method.

Determination of minerals

This was done by the wet digestion method using the atomic absorption spectrophotometer.

Amino acids analysis

This was done by Elkin and Griffith [21] method using the high performance liquid chromatography (HPLC).

Statistical analysis

The result gotten was studied using Statistical Products for Service Solutions version 23. Results were exhibited as mean ± standard deviation of all parameters determined in tables.

Results and Discussion

This research work focused on some dietary component of fresh raw cashew *(Anarcadium occidentale)* nuts from Enugu state, Nigeria. Table 1 presents the proximate composition of cashew nuts: ash (3.53%), moisture (22.49%), fat (7.14 %,), fibre (1.94%), protein (12.60%) and carbohydrate (52.30%).

Table 1: *Proximate composition of cashew nut*

Proximate components	Concentration (%)
Ash	3.53 ± 0.49
Moisture content	22.49 ± 0.35
Fat	7.14 ± 2.08
Fibre	1.94 ± 0.29
Protein	12.60 ± 1.75
Carbohydrate	52.30 ± 0.89

Data are mean ± standard deviation of triplicate determination.

In this study, moisture and carbohydrate content are higher than values documented by Griffin and Dean.[7] However, fat and protein content in this study is lower than those reported by Griffin and Dean.[7] These differences may be attributed to environmental factors, location and method of analysis.

Fatty acid composition as seen in Table 2 shows the following average % : Oleic acid (31.36%), palmitic acid (16.08%), linoleic acid (16.80%), alpha linoleic acid (12.43%), lauric acid(3.63%), myristic acid (11.09%), eicosapentanoic acid (1.86%), docohexanoic acid (1.73%).This result differed with work done by Ogungbenle and Afolayan[22] who reported myristic acid (0.07%), palmitic acid (12.1%), palmitoleic acid (0.29%), Stearic acid (9.05%), Oleic acid

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(58.7%), linoleic acid (18.9%), arachidic acid (0.28%), Lignoceric acid (0.40%) and Behenic acid (0.14%). These differences could be attributed to geographical location of the sample, soil type and methods used. The total saturated fatty acids are lower than unsaturated fatty acid in cashew nut oil in this study.

The trans-fat content was not detected during the analysis and this observation is consistent with findings by Griffin and Dean [7]; Ogungbenle and Afolayan.[22] Trans fats are made by hydrogenating liquid fat to solid to make it more stable, increase its shelf life and also increase the quality of the oil. Trans fats are bad for the heart, causes plaque in the artery and this leads to arterioscerosis. Increased dietary intake of trans fat is bad for the health and is not recommended.

The total sugar content present in *Anacardium occidentale* below is 1.67%. This is lower than 6.02% for raw cashew nut, 6.3% for dry - roasted cashew nut and 5.9% for wrapped Cashew nut reported by Griffin and Dean.[7] Increased intake of sugar leads tooth decay, increased body weight, insulin resistance. The recommended dietary intake should not be more than 5 calories in a day.

Table 3 below shows the quantitative phytochemical analysis of cashew nut. The result shows that it contains flavonoids (2.980 ± 0.560 %), alkaloids (0.440 ± 0.080 %), phenol (26.513 ± 1.996 mg/kg), terpenoids (5.220 ± 0.319 mg/kg), steroids (0.670 ± 0.051 mg/kg), cardiac glycosides (33.840 ± 0.020 %), saponins (1.540 ± 0.360 %), tannins (0.765 ± 0.000 %). From Table 3 below, cashew nut contains cardiac glycosides in highest concentration while alkaloid has the lowest concentration.

The flavonoid, tannin, saponin and alkaloid concentrations (2.98 ± 0.56%, 0.765 ± 0.0%, 1.54 ± 0.36% and 0.44 ± 0.08%), respectively of the cashew nut powder were in conformity with values published by Onuh *et al*.[23] Flavonoid lowers oxidative stress and also act as anti-allergen, 'nature's biological modifiers, anti-inflammatory, and motivates phase two enzymes which eradicates carcinogens and mutagens [24]. Tannins play essential roles such as forming complexes with alkaloids, carbohydrates, proteins, gelatin and due to presence of the phenolic group, function as antiseptic. Saponins play biological roles notably activity against cough and enhancing respiratory system. Saponins possess anti-inflammatory and anti-protozoaproperties whereby they act by combining withcholesterol in cell membranes (protozoal)leading to cell lysis.[24] Alkaloids are important because they are known to posses' anti-arrhythmic effects, anti-hypertensive effects, anticancer and anti-malarial including anti-diabetic activities.[25]

Phenols observed in this analysis were slightly higher than the work reported by Akujiobi *et al*.[26] The derivatives of phenols notably ferulic acid is reported to possess a wide range of pharmacological role against neurodegenerative, diabetes, cardiovascular, cancer and inflammatory diseases.[27] Terpenoids as seen in Table 3 (5.220 ± 0.319 mg/kg); enhance the skin tone and replenish inflammed tissues by increasing supply of blood.[28] Steroids as seen in Table 3 (0.670 ± 0.051 mg/kg) promote nitrogen retention in osteoporosis.[29]

Table 4 below shows that cashew nuts contains Vitamin A (8.621 ± 0.524 mg/kg), Vitamin D (128.160 ± 11.040 mg/kg), Vitamin C (15.664 ± 0.528 mg/100g), Vitamin B_1 (1.366 ± 0.008 mg/kg), Vitamin B_3 (0.561 ± 0.037 mg/kg), Vitamin B_2 (1.484 ± 0.112 mg/kg),Vitamin B_{12} (0.725 ± 0.125 mg/kg), Vitamin E (35.233 ± 3.869 mg/kg), Vitamin B_6 (100.000 ± 17.500 mg/kg), Beta Carotene (15.216 ± 0.432 mg/100g), Vitamin K (4.530 ± 0.524 mg/kg), Ascorbic acid (20.323 ± 4.947 mg/100g). From Table 4 below, Vitamin D has the highest concentration while Vitamin B_3 has the lowest concentration in cashew nut.

The high content of vitamin E, 35.233 ± 3.869 mg/kg is in line with the values obtained in the analysis of cashew nut varieties by Akujiobi *et al.*[26] and relatively higher than the RDA values for vitamin E, 15 mg/dL.[30] The RDA (Recommended Dietary Allowance) is supposed to be utilized as an objective for day to day intake by persons, as its value estimates an intake level that is adequate to meet the requirement of 97 to 98% of sound persons. Alpha tocopherol is recognized as the primary active form of vitamin E in humans. Vitamin E is an important antioxidant which acts as a radical scavenger to protect other components of cell membranes, PUFAs and low-density lipoprotein (LDL) free radicals leading to oxidation.[31] Vitamin C is vital for bone remodeling due to the availability of collagen within the natural framework of bones and its deficiency causes scurvy.[32] Beta carotene is a form of carotenoids which assist in photosynthetic processes in plants.[33] They reduce the risk for diseases such as cardiovascular diseases and cancer by scavenging free radicals and protecting LDL cholesterol from oxidation.[34] Vitamin D is needed to preserve typical blood levels of calcium and phosphate, which are in turn required for typical mineralization of bone, nerve conduction, muscle contraction, and general cellular processes in cells of the body [32]. Vitamin K plays a basic part in arrangement and control of blood clotting proteins and enhances the function of calcium in bone/teeth development.[35] Ascorbic acid which is also a form of vitamin C functions as an antioxidant; shields cells from damage and subsequently may diminish the danger of some cancers and cardiovascular disease.[35] Vitamin B_6functions as coenzyme, plays a role in the metabolism of sphingoid bases, amino acids and glycogen.[32]

Table 4 below also shows that cashew nut contains zinc (6.707 ± 0.248ppm), iron (33.983 ± 3.914 ppm), selenium (0.204 ± 0.008 ppm), potassium (8.563 ± 0.998 ppm), magnesium (21.257 ± 3.637 ppm), sodium (117.922 ± 7.233 ppm), phosphorus (90.696 ± 0.380 mg/kg) and calcium (18.312 ± 1.528 ppm).

Among these minerals, sodium is the most abundant mineral with concentration of (117.922 ± 7.233 ppm). This was in reverse with the data documented by Akujiobi *et al.*[26]; Ricard*et al*.;[8] Ogungbenle and Afolayan.[22] The quantity of sodium in a diet affects the wellbeing of the persons. Despite the fact that sodium is vital to enhance stability in physical fluid systems by assisting in the absorption of glucose and also needed for the functioning of muscles and nerves, it is also associated with a number of health issues ranging from damage of the kidneys and increment within the conceivable outcomes of hypertension when present in high amounts.[36] The concentration of phosphorus (90.696 ± 0.380 mg/kg) and iron (33.983 ± 3.914 ppm) were higher than that reported by Emelike *et al*.[37] Phosphorous is important to health as it performs basic structural needs such as in bones and teeth formation , phospholipids, plays active role in acid-base balance and protein activation through phosphorylation.[26] Iron on the other hand is a trace mineral necessary for diminishing the incidence of anemia and maintain good health and well-being.[38] Magnesium and zinc with (21.257 ± 3.637 ppm) and (6.707 ± 0.248ppm) respectively agree with mineral composition of cashew nuts documented by Akujiobi *et al*.[26] Dietary Mg allowance of 300 mg/day for women and 350 mg/day for men is recommended by the Food and Nutrition Board and a daily reference value of 15 mg for Zn by FDA. Magnesium is important as it plays a role in skeleton, soft tissues and muscle such as, a co-factor of many enzymes involved in protein synthesis, energy metabolism, DNA and RNA synthesis, and maintenance of the electrical potential of cell membranes and nerve tissues.[36] Zinc plays an essential role as metalloenzymes, zinc fingers during transcription and as cofactor of so many enzymes.[39] Values obtained in this study as seen in Table 4 are calcium (18.312 ± 1.528 ppm) and potassium (8.563 ± 0.998 ppm) are slightly lower than the values reported by Ricard*et al*.[8] Calcium ion is known to be included in and controls the porousness and electrical functions of biological membranes. It plays basic parts in numerous enzyme-assisted processes, neuromuscular work, providing strength to the skeleton through phosphate salts and blood clotting,while potassium functions as an electrolyte for stabilizing normal fluid balance in cells and a balance of this element helps to maintain normal cardiac rhythm and prevent an increase in blood pressure.[40] Selenium is the least abundant in this study with a value of 0.204 ± 0.008 ppm. Selenium acts as an antioxidant thus reducing carcinogenicity.[41] These differences observed in mineral composition could be as a result of variations in mineral composition of the soil to which the cashew grew on and method of analysis.

The result observed in salt content is 2.146 ± 0.131ppt. The WHO recommended levels of 2 g of sodium to be equivalent to 5 g of salt. Therefore, the amount of salt in cashew nut is moderate and should be consumed by various age ranges.

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Table 2: Fatty acid profile

Sytematic name	Components	Concentration (%)
cis-9-octadenoic acid(oleic acid)	C18:1	31.36 ± 0.00
Dodecanoic acid (lauric acid)	C12:0	3.63 ± 0.00
Tetradecanoic acid (myristic acid)	C14:0	11.09 ± 0.00
Hexadenoic acid (palmitic acid)	C16:0	16.08 ± 0.00
Alpha Linoleic acid	C18:3	12.43 ± 0.00
Eicosapentanoic acid	C20:5	1.96 ± 0.00
Docosatetraenoic acid	C22:4	4.89 ± 0.00
Linoleic acid	C18:2	16.80 ± 0.00
Docohexanoic acid(cervonic acid)	C22:6	1.73 ± 0.00

Data are mean ± standard deviation of triplicate findings

Table 3: Quantitative phytochemical concentration of cashew nut powder

Phytochemicals	Concentration
Flavonoids (%)	2.980 ± 0.560
Alkaloids (%)	0.440 ± 0.080
Phenols (mg/kg)	26.513 ± 1.996
Terpenoids (mg/kg)	5.220 ± 0.319
Steroids (mg/kg)	0.670 ± 0.051
Cardiac Glycosides (%)	33.840 ± 0.020
Saponins (%)	1.540 ± 0.360
Tannins (%)	0.765 ± 0.000

Values are presented in mean ± standard deviation

Table 4a: Micronutrient concentration of cashew nut powder

Vitamins	Concentration
Vitamin A(mg/kg)	8.621 ± 0.524
Vitamin D (mg/kg)	128.160 ± 11.040
Vitamin C (mg/100 g)	15.664 ± 0.528
Vitamin B_1 (mg/kg)	1.366 ± 0.008
Vitamin B_2 (mg/kg)	1.484 ± 0.112
Vitamin B_3 (mg/kg)	0.561 ± 0.037
Vitamin B_6 (mg/kg)	100.000 ± 17.500
Vitamin B_{12} (mg/kg)	0.725 ± 0.125
Vitamin K (mg/kg)	4.530 ± 0.524
Vitamin E (mg/kg)	35.233 ± 3.869
Beta –Carotene (mg/100 g)	15.216 ± 0.432
Ascorbic acid (mg/100 g)	20.323 ± 4.947

Values are presented in mean ± standard deviation

Table 4b: Micronutrient concentration of cashew nut powder

Minerals	Concentration (ppm)
Zinc	6.707 ± 0.248
Iron	33.983 ± 3.914
Selenium	0.204 ± 0.008
Potassium	8.563 ± 0.998
Magnesium	21.257 ± 3.637
Sodium	117.922 ± 7.233
Phosphorus	90.696 ± 0.380
Calcium	18.312 ± 1.528

Table 5: Amino acid composition of cashew nut powder

Amino acids	Values (µg/100 g)
Glycine	2.675 ± 0.099
Alanine	2.484 ± 0.038
Serine	3.984 ± 0.230
Proline	4.285 ± 0.249
Valine	5.665 ± 0.667
Threonine	3.691 ± 0.000
Isoleucine	4.136 ± 0.251
Leucine	7.079 ± 0.095
Aspartate	4.568 ± 0.443
Lysine	1.346 ± 0.870
Methionine	1.298 ± 0.051
Glutamate	7.568 ± 0.213
Phenylalanine	3.459 ± 0.577
Histidine	2.319 ± 0.465
Arginine	4.658 ± 0.592
Tyrosine	3.390 ± 0.012
Tryptophan	1.154 ± 0.134
Cysteine	1.079 ± 0.043

Values are presented in mean ± standard deviation

The amino acids analysis yielded results ranging from 1.079 µg/100 g to 7.568 µg/100 g as seen in Table 5 below. Cashew nut contains the following essential amino acids; leucine (7.079 ± 0.095 µg/100 g), valine (5.665 ± 0.667 µg/100 g), threonine (3.691 ± 0.000 µg/100 g), isoleucine (4.136 ± 0.251 µg/100 g), lysine (1.346 ± 0.870 µg/100 g), methionine (1.298 ± 0.051 µg/100 g), phenylalanine (3.459 ± 0.577 µg/100 g), histidine (2.319 ± 0.465 µg/100 g), arginine (4.658 ± 0.592 µg/100 g), tryptophan (1.154 ± 0.134 µg/100g), and the following non-essential amino acids; glycine (2.675 ± 0.099 µg/100 g), alanine (2.484 ± 0.038 µg/100 g), serine (3.984 ± 0.230 µg/100 g), aspartate (4.568 ± 0.443 µg/100 g), glutamate (7.568 ± 0.213 µg/100g), proline (4.285 ± 0.249 µg/100 g), cysteine (1.079 ± 0.043 µg/100 g), tyrosine (3.390 ± 0.012 µg/100 g). Table 5 below shows that glutamate has the highest concentration while cysteine has the lowest concentration in cashew nut.

The amino acids analysis as seen in table5 shows that leucine and glutamate were the major abundant amino acids with values of (7.079 ± 0.095 µg/100 g) and (7.568 ± 0.213 µg/100 g) respectively. This is in accordance with findings documented by Ogunwolu *et al*.[10] Leucine is an essential amino acid which contributes to development and repairs of bone tissue and muscle, control of blood-sugar levels, wound healing, growth hormone production, prevents breakdown of muscle proteins after severe stress or trauma and may be beneficial for individuals with phenylketonuria. Since leucine is accessible in many foods, the deficiency is rare.[42]Non-essential amino acid, glutamate, helps in synthesis of glutathione and following transamination reactions is converted to alpha ketoglutaric acid.[43] Other essential amino acids whose values are in accordance with those reported by Ogunwolu *et al*;[10] Ricard*et al.*,[8] include valine (5.665 ± 0.667 µg/100g), threonine (3.691 ± 0.000 µg/100 g), isoleucine (4.136 ± 0.251 µg/100g), methionine (1.298 ± 0.051 µg/100g), phenylalanine (3.459 ± 0.577µg/100 g), histidine (2.319 ± 0.465 µg/100 g) and tryptophan (1.154 ± 0.134 µg/100 g).Arginine 4.65778 ± 0.5919 µg/100 g agree with the value documented by Aremu *et al*.[44] Valine activates muscle development and regeneration. It participates in energy production and is involved in the synthesis of substrates for ketogenesis and gluconeogenesis [45]. Threonine is the vital portion of structural proteins such as elastin and collagen which are significant components of the connective tissues and skin.[45] Methionine plays a major role in detoxification and metabolism. It is also necessary for absorption of selenium, zinc and other essential elements and tissue growth.[45] Phenylalanine is needed for the synthesis of the epinephrine, catecholamine, norepinephrine, dopamine which is chemicals that transmits signals between the brain and nerve cells.[45]Trytophan is a natural relaxant that helps reduces anxiety and depression , alleviate insomnia by inducing normal sleep, , stimulates the immune system, helps in the treatment of migraine headaches, reduces the risk of artery and heart spasms; works with Lysine in reducing cholesterol levels.[46] Histidine is the precursor molecule to histamine, the compound that causes many allergic responses and which may be inhibited by the use of anti-histamines which has histamine antagonistic properties and anxiolytic properties that combats health problem.[47]Arginine acts as a carrier and storage form of nitrogen in plants and functions in vasodilation of blood vessels in the human body.[48] The values observed as seen in Table 5 are higher than data recorded by Ogungbenle and Afolayan.[22] This could be as a result of the nature of the soil and agricultural practices such as fertilizer application, environmental effects and genetic variation in crops.Cysteine (1.07885 ± 0.04343 µg/100 g), the least non-essential amino acid present agrees with the value documented by Aremu *et al.*[44] Proline is an amino acid that is hydroxylated to hydroxyproline in presence of vitamin C.[43] Tyrosine is a precursor to thyroxin and growth hormone, effective antidepressant for norepinephrine deficient depressions. It improves mental clarity, concentration and increases energy.[49] Cysteine is essential for the growth, repair of skin and also a natural detoxifier.[49]Serine is generated by the body when inadequate quantities are consumed. It is metabolized from glycine and ketones, and retroconversion with glycine moreover happens.[50] Glycine is helpful in formation of bile acids by combining with colic acid to form glycocholate. It is also a component of glutathione.[43]Alanine is the basic amino acid in sugar metabolism and improves immune system by producing antibodies; also a key component of connective tissue. The deficiencies in alanine are generally characterized by hypoglycemia, fatigue and muscle breakdown.[49]

Conclusion

The level of essential amino acids and protein content in the nuts make them possible protein sources for fortification in a number of food products to eradicate protein deficiency especially in developing and under developed countries. Its oil is also economically and industrially useful. The results obtained also show that cashew nuts (*Anarcadium occidentale*) are rich in nutrients; therefore its consumption incorporated in a healthy diet may not only reduce cardiovascular diseases but mortality.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

References

1. Tiffon C. The impact of nutrition and environmental epigenetics on human health and disease. Int J Mol Sci. 2018; 19:325-328.
2. Emilio R. Health benefits of nut consumption. Nutrients 2010; 2:652-682.
3. Asogwa EU, Hammed LA, Ndubuaku TCN. Integrated production and protection practices of cashew, *Anacardium occidentale* in Nigeria. Afr J Biotechnol. 2008; 7(25)*:*4868-4873.
4. Ohler JG. Cashew growing. Department of Agricultural Resources.Tropical Institute. 1979; **7**(4)*:*260-271.
5. Pinto AMB, Santos TMP, Caceres CA, Lima JR, Ito EN, Azeredo H MC. Starch-cashew tree gum nano-composite films and their application for coating cashew nuts.LWT - Food Sci Technol (Campinas).2015; 62:549-554.
6. Das I, Shah NG, Kumar G. Cashew nut quality as influenced by microwave heating used for stored grain insect control. Int J Food Sci. 2014; 5:1-7.
7. Griffin LE and Dean LL. Nutrient composition of raw, dry and roasted cashewnut. J Food Res. 2017; 6(6):13-23.
8. Ricard R, Mònica B, Jordi S. Nutritional composition of raw fresh cashew (*Anacardium occidentale* L.) kernels from different origin. J Food Sci Nutr.2016; 4(2):329-338.
9. Food and Administration Organisation . *Fruit-bearing forest trees*. Forestry Paper. 1982; No. 34. FAO, Rome
10. Ogunwolu SO, Henshaw FO, Oguntona BE, Afolabi OO. Nutritional evaluation of cashew nut (*Anacardium occidentale*) Protein Concentrate and Isolate. Afri J Food Sci.2015;9(1):23-30.
11. Association of Official and Analytical Chemists. Official method of analysis of the Association of Official Analytical Chemist, Washington DC. 1990.1250-1255p.
12. Harborne JB. Phytochemistry. Academic Press, London. 1993; 89-131pp.
13. Obadoni BO and Ochuko PO. Phytochemical studies and comparative efficacy of the crude extracts of some homostatic plants in Edo and Delta states ofNigeria. Global J Pure Allied Sci. 2001; 8:203-208.
14. Bohm BA and Kocipai- Abyazan R. Flavonoid and condensed tannins fromthe leaves of *Vaccinum raticulation* and *Vaccinum calcyimium.* J Pac Sci. 1994; 48:458-463.
15. Pearson D. The chemical analysis of food, 17th ed. Churchill Livingstone, London. 1976.3-4p.
16. Okeke CU and Elekwa I. Phytochemical study of the extract of *Gongronema latifolium.* J Health Visual Sci. 2003; *5*(1):47-55.
17. Wang Z and Filled Y.Antimutagenic activity of green tea polyphenols. Mutat Res Genet Toxicol. 1989; 223(3):273-285.
18. Kirk RS and Sawyer R. Pearson's Composition and Analysis of Foods, 9th edition.(student edition), England: Addision Wesley Longman Ltd. 1991.33-36p.
19. Brockmann UH, Eberlein K, Junge HD, Trageser H, Trahms KJ. Einfache folientanks zur planktonuntersuchungm situ. Mar Biol. 1974; 24:163-166.
20. Zakaria M, Simpson K, Brown P, Krstulovic A. Use of reverse phase HPLC analysis for the determination of

provitamin A carotenes in tomatoes. J Chromatogr. 1979;176:109-117.
21. Elkin RG and Griffith JE. Amino acids analysis of feedstuff hydrolysates by cation exchange high performance liquid chromatography. J Assoc Anal Chem. 1985; 68(5):28-32.
22. Ogungbenle HN andAfolayan MF. Physical and Chemical Characterization of Roasted Cashew Nut (*Anacardium occidentale*) Flour and Oil. Int JFood Sci Nutr Eng. 2015; 5(1):1-7.
23. OnuhJO, Idoko G, Yusufu P, Onuh F.Comparative studies of the phytochemical, antioxidant and antimicrobial properties of cashew leaf, bark and fruits extracts. Am J Food Nutr. 2017; 5(4)*:*115-120.
24. Ngoci SN, Josphat CM, Mwaniki G, Mwendia CM, George KK. A review of some phytochemicals commonly found in medicinal plants. Int J Med Plants. 2013; 105**:**135-140.
25. Nyamai DW, Arika W, Ogola PE, Njagi EN, Ngugi, M P. Medicinally important phytochemicals. J Pharmacogn Phytochem.2016; 4:35-44.
26. Akujobi IC, Afam-Anene OC, Nnoka K, Amadi JAC, Duruaku BC. Nutrient composition, phytochemical and sensory properties of nuts from red and yellow varieties of cashew fruit. Int J Innov Food Nutr Sustain Agric. 2018;6(3):40-47.
27. Joshi SS, Kuszynski CA, Bagchi D. The cellular and molecular basis of health benefits of grape seed proanthocyanidin extract. Curr Pharm Biotechnol. 2001;2:187-200.
28. Aggarwal BB, Ichikawa H, Garodia P, Weerasinghe P, Sethi G. Identification of therapeutic targets for suppression of inflammation and cancer. Expert OpinTher Targets. 2006;10:87-118.
29. Maurya R, Singh G, Yadav PP. Antiosteoporotic agents from natural sources. Stud Nat Prod Chem.2008; 35:517-545.
30. USDA. United States Department of Agriculture. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. 2015b; Retrieved from https://fnic.nal.usda.gov/dietary-guidance/dri-nutrient-reports/vitamin-c-vitamin -e. Retrieved 14th January, 2019
31. Kraisid T and Graeme C.Dietary reference intakes for vitamin C, vitamin E, selenium and carotenoids. A report of the Panel on Dietary Antioxidants and Related Compounds. J Food Nutr Board. 2000;4:33-49.
32. Aleksandrova KV, Rudko NP, Zaporizhzhya. Biochemistry of vitamins. Textbook for students of International Faculty Speciality:7.120 10001 <<General medicine>> K.V. Aleksandrova, N.P.Rudko.-zaporizhzhya: ZSMU. 2016; 73pp.
33. Raven P, Johnson G, Mason K, Losos J, Singer S. Biology. New York: McGraw-Hill. 2011.
34. Voutilainen S, Nurmi T, Murso J, Rissanen TH. Carotenoids and cardiovascular health. Am J Clin Nutr. 2006; 83(6):1265-1271.
35. Duyff RL. Complete food and nutrition guide. 4th ed. American Dietetic Association. Hoboken, NJ: John Wiley & sons. 2012. 470-501 p.
36. Mir-Marqués A, Cervera ML, Guardia M. A preliminary approach to mineral intake in the spanish diet established from analysis of the composition of university canteen menus. J Food Comp Anal. 2012;27:160-168.
37. Emelike NJT, Barber LI, Ebere CO.Proximate, mineral and functional properties of defatted and undefatted cashew (*Anacardium Occidentale Linn.*) kernel flour**.** Eur J Food SciTechnol. 2015; 4(3):11-19.
38. Ashraf W and Mian AA. Levels of selected heavy metals in black tea varieties consumed in Saudi Arabia. Bull Environ Contamin Toxicol. 2008;81:101-104.
39. Food and Drug Administration. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum,nickel, silicon, vanadium, and zinc. Report of the panel on micronutrients.National academy press, Washington,DC. 2001.
40. Desideria D, Melia MAC, Cantaluib F, Ceccottob C, Rosellia, Feduzi L. Essential and toxic elements in meat of wild and bred animals. Toxicol Environ Chem. 2005; 94(10):1995–2005.
41. Osamu W. What are trace elements, their deficiency and excess states?J Japan Med Assoc. 2004; 47(8):351-358.
42. Food and Nutrition Board. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (Macronutrients). National Academy Press, Washington DC 2009.593-594p.
43. Akram M, Naveed A, Asif HM, Pervaiz AS, Tariq S, Arshad M, Nadia SM.Amino acids: A review article.J Med Plants Res. 2011;5(17):3977-4000.
44. Aremu MO, Ogunlade I, Olonisakin A. Fatty acid and amino acid composition of protein concentrate from cashew nut (*Anarcadium occidentale*) grown in Nasarawa State, Nigeria. Pak J Nutr. 2007; 6(5):419-423.
45. Petkova V, Obreshkova LD, Vodenicharov E, Hadjieva B, Koleva N, Petkova E,Dimitrov M.Essential amino acids - review of some of the contemporary analytical methods for detection.World J Pharm Pharm Sci. 2013; 2(2):658-666.
46. Ringdahl E, Pereira S,Delzell J.Treatment of primary insomnia. J American Board Family Pract. 2004; 17:212-219.
47. Harris DC. Exploring chemical analysis, Second edition, New York: W.H.Freeman; Basingstoke: Macmillian. 2001.
48. Shi HT and Chan ZL. *In vivo* role of *Arabidopsis* arginase in arginine metabolism and abiotic stress response. Plant Signal Behav. 2013; 8:138-245.
49. Khanifar JI, Ghoorchian H, Ahmadi AR, Hajihosaini R. Comparison of Essential and non-essential amino acids in the single cell protein (scp) of white rot fungi fromwheat straw. Afr J Agric Res. 2011; 6(17):3994-3999.
50. Kapalka MG. Nutritional and herbal therapies for children and adolescents; a handbook for mental health clinicians. A volume in practical resources for the mental health professional. Elsevier Science Publishing Inc, US. 2010. 141-187 p.