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Amino Acid Profile and Functional Properties of Roasted Groundnut (*Arachis hypogaea*) and Cashew Nut (*Anacardium occidentale*) From Southeast Nigeria

Perpetua O. Ndubuisi[1]*, Rosemary Obi – Joachim[2], Charity U. Obi[3], and Olufemi G. Abimbola[4]

[1]Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike, Nigeria.
[2] China Pharmaceutical University, Nanjing Jiangsu, China.
[3]Odumegwu Ojukwu Teaching Hospital, Awka, Anambra, Nigeria.
[4] Department of Nutrition and Health, Universidade Federal de Viçosa, Brazil.

*Corresponding author email: nduperp2011@gmail.com

Abstract

Background: Nuts are valued for their nutrient density, functional food properties, and potential in addressing protein-energy malnutrition. Groundnut (*Arachis hypogaea*) and cashew (*Anacardium occidentale*) are widely consumed in Nigeria but remain underutilized in food formulation research.
Objective: This study evaluated the amino acid profile and functional properties of roasted groundnut and cashew nut seeds to assess their nutritional potential and suitability for food applications.
Methods: Seeds were purchased from markets in Abia State, Nigeria, roasted using the traditional sand-roasting method, defatted, and analyzed for amino acid composition using an Applied Biosystems PTH Amino Acid Analyzer. Functional properties including bulk density, water and oil absorption capacity, solubility index, foaming properties, and emulsion capacity were determined using standard procedures.
Results: Both seeds contained all essential amino acids, with glutamic acid being the most abundant (14.84 g/100 g protein in groundnut; 12.64 g/100 g in cashew). Groundnut showed higher water absorption capacity (1.35 g/g) and oil absorption capacity (2.44 g/g), while cashew exhibited greater foaming capacity (13.5%). Bulk density values were comparable (~0.55 g/ml), and both samples displayed low foam stability.
Conclusion: Roasted groundnuts and cashew nuts are rich in amino acids and exhibit desirable functional properties, supporting their use as affordable plant-based ingredients in complementary foods, baked goods, and meat substitutes. Their incorporation into food systems could help mitigate protein-energy malnutrition in resource-limited populations.

Keywords: *Amino acid profile, Cashew nut, Functional properties, Food formulation, Groundnut, Protein-energy malnutrition.*

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1. Introduction

Malnutrition remains a major public health challenge in sub-Saharan Africa, largely due to inadequate dietary diversity, low purchasing power, and poor feeding practices. This challenge is further compounded by the global threat to food security, which has become increasingly urgent as population growth continues to rise at an accelerated rate (Anyaiwe et al., 2024). Diets in many low- and middle-income countries are deficient in essential macro- and micronutrients, contributing significantly to child morbidity and mortality (Ijarotimi, 2013; Brabin *et al.*, 2003). Plant-based foods, particularly legumes and nuts, have gained attention as affordable sources of high-quality protein that can mitigate protein-energy malnutrition.

In recent years, the focus of nutrition research has expanded beyond meeting basic dietary needs to exploring functional foods those that not only supply nutrients but also contribute to disease prevention (WHO/FAO, 2003). Nuts such as groundnut (*Arachis hypogaea*) and cashew (*Anacardium occidentale*) are nutrient-dense foods rich in proteins, fats, vitamins, and minerals, with growing recognition of their role in cardiovascular health, weight management, and overall metabolic function (Alasalvar *et al.*, 2009; Kubala, 2020). They contain appreciable amounts of essential amino acids including leucine, lysine, methionine, and tryptophan, which are critical for protein synthesis, tissue repair, and growth (Du *et al.*, 2017).

Groundnut is one of the most widely consumed legumes in Nigeria, valued for its high protein content and palatability (Ogungbenle *et al.*, 2015). Cashew nut, equally popular, is consumed as a snack and contributes significantly to Nigeria's agricultural economy, while also being recognized for its well-balanced amino acid composition and heart-healthy unsaturated fatty acids (Cheng-mei *et al.*, 2018; Akinhanmi *et al.*, 2008). Processing methods, particularly roasting, have been reported to influence both the nutritional and functional properties of nuts, including solubility, foaming, and gelation behavior (Enwere *et al.*, 1986).

Despite their nutritional potential, limited studies have simultaneously examined the amino acid composition and functional properties of roasted groundnut and cashew nuts commonly consumed in Nigeria. Establishing such information is important not only for evaluating their role in combating protein-energy malnutrition but also for identifying their suitability in food formulations such as infant foods, baked products, and meat substitutes.

Therefore, this study aimed to profile the amino acid composition and functional properties of roasted groundnut and cashew nut seeds, with a view to highlighting their nutritional value and potential applications in food product development.

2. Materials and Methods

2.1 Sample collection and preparation

Raw cashew nuts (*Anacardium occidentale*) and groundnut (*Arachis hypogaea*) sampleswere purchased from major markets in Abia State, Nigeria. The seeds were sorted to remove debris and damaged ones, soaked in hot water for 24 h, drained, and roasted using the traditional sand-roasting method at 180 °C for 15 min. Roasted seeds were dehulled, ground into flour, and stored in airtight containers until analysis.

2.2 Amino acid analysis

Two grams of each roasted seed sample were defatted with chloroform/methanol (2:1 v/v) using a Soxhlet apparatus as described by AOAC (2019). From the defatted flour, 30 mg was hydrolyzed with 7 ml of 6 M HCl under nitrogen sealed, and incubated at 105 ± 5 °C for 22 h. The hydrolysates were then cooled, filtered, evaporated under vacuum at 40 °C, reconstituted in 5 ml of acetate buffer (pH 2.0), and stored at −20 °C until analysis. Amino acid composition was subsequently determined according to AOAC (2019) using an Applied Biosystems PTH Amino Acid Analyzer, and the results were expressed as g/100 g protein. In addition, total nitrogen content was determined using the Micro Kjeldahl method (AOAC, 2019), and crude protein was estimated by multiplying the nitrogen value by a conversion factor of 6.25.

2.3 Functional properties

Functional properties were determined in triplicate using standard procedures. Bulk density (BD) was measured according to Adeleke and Odedeji (2010), where 5 g of each sample were placed in a graduated cylinder, tapped to a constant volume, and bulk density calculated as weight per unit volume (g/ml). Wettability was assessed following Nwosu et al. (2010) by releasing 5 g of sample from a height of 10 cm into 500 ml of distilled water and recording the time taken for complete wetting. Dispersibility was determined as described by Kulkarni *et al.* (1991); 5 g of flour were suspended in 100 ml of distilled water, stirred, and allowed to settle for 3 h, after which dispersibility (%) was calculated from the settled volume. Swelling power and solubility index were evaluated according to Leach (1959) by suspending 1 g of flour in 50 ml of water, heating at 90 °C for 15 min, centrifuging at 3000 rpm for 10 min, and calculating the indices from the supernatant and sediment weights. Water absorption capacity (WAC) was measured as described by Ruales *et al.* (1993) using 1.25 g of flour mixed with 15 ml of distilled water, centrifuged at 2500 rpm for 30 min, and recording the sediment weight. Finally, least gelation concentration (LGC) was determined following Adeleke and Odedeji (2010) by preparing dispersions (2–20% w/v), heating them at 95 °C for 1 h, cooling at 4 °C for 2 h, and recording the lowest concentration at which the sample did not fall from an inverted test tube.

2.4 Statistical analysis

All data were expressed as means ± standard deviation (SD). Differences between samples were analyzed using one-way analysis of variance (ANOVA). Differences were considered significant at $p < 0.05$. Statistical analyses were performed using SPSS version 20 IBM, Armonk, NY, USA).

3. Results

3.1 Amino acid composition

The amino acid profiles of roasted groundnut and cashew nuts are presented in Figures 1–3. Both seeds contained all 18 amino acids, comprising nine essential and nine non-essential types. Glutamic acid was the most abundant in both nuts, with concentrations of 14.84 g/100 g protein in groundnut and 12.64 g/100 g protein in cashew. Aspartic acid and arginine also contributed significantly, accounting for 10.33 and 9.55 g/100 g protein in groundnut, and 9.24 and 10.32 g/100 g protein in cashew, respectively.

Comparative analysis (Figure 3) revealed that groundnut contained slightly higher levels of glutamic acid and aspartic acid (by approximately 1–2 g/100 g protein) compared to cashew. Conversely, cashew showed marginally higher levels of arginine and threonine. Methionine and tryptophan were the least abundant amino acids in both samples (<1.5 g/100 g protein). Overall, the amino acid distribution patterns of both nuts were broadly similar, suggesting comparable protein quality.

3.2 Functional Properties

The functional properties of roasted groundnut and cashew flours are summarized in Table 1. Bulk density values were comparable between the two seeds (0.55–0.56 g/ml). Groundnut exhibited higher water absorption (1.35 g/g) and oil absorption capacity (2.44 g/g) than cashew (1.27 and 2.39 g/g, respectively). In contrast, cashew showed superior foaming capacity (13.53%) compared with groundnut

(12.78%), although both had similar foam stability (~9%). The solubility index values were low in both samples (<1.5%), indicating limited water solubility. Emulsion capacity was slightly higher in groundnut (25.79%) compared to cashew (24.27%).

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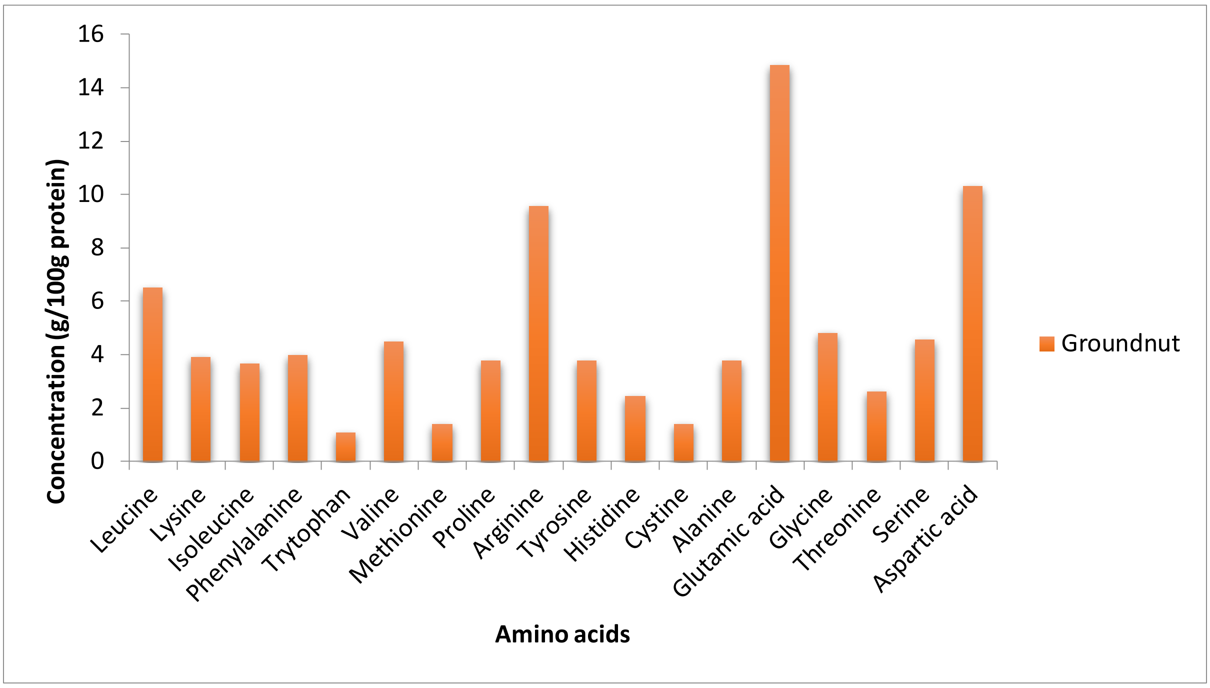

Figure 1. Amino acid composition of roasted groundnut (*Arachis hypogaea*) expressed as g/100 g protein.

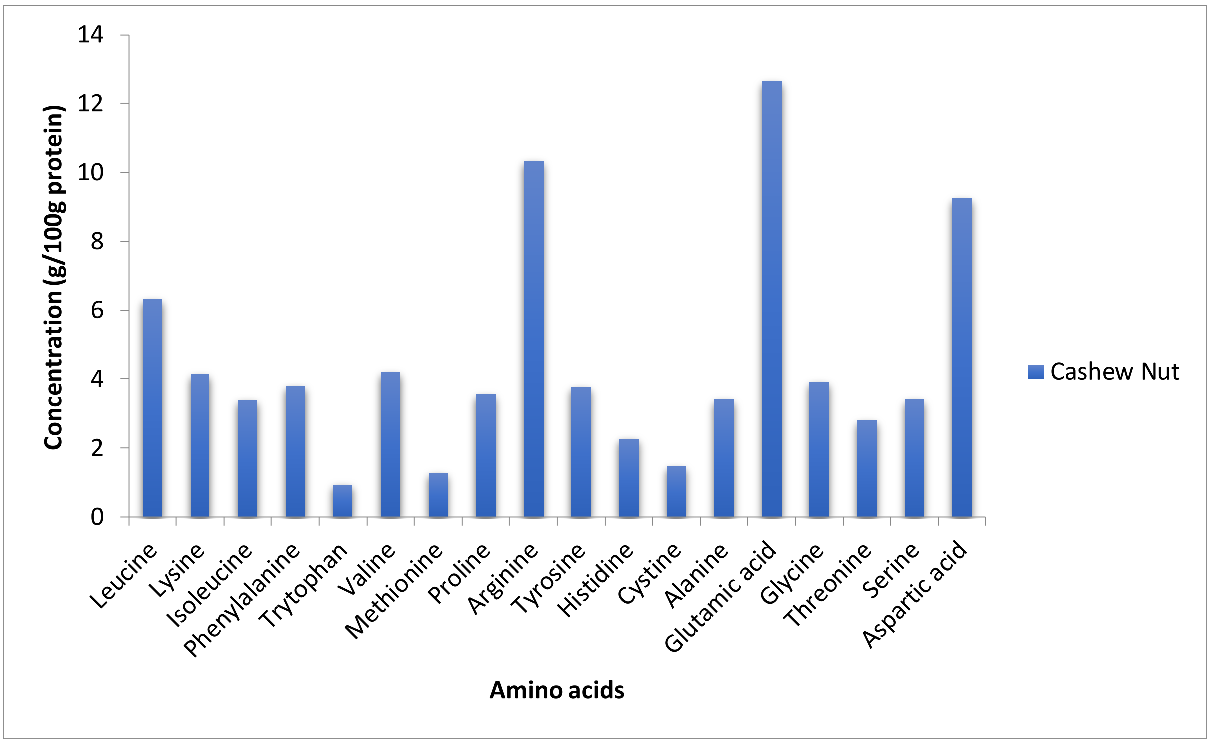

Figure 2. Amino acid composition of roasted cashew nut (*Anacardium occidentale*) expressed as g/100 g protein.

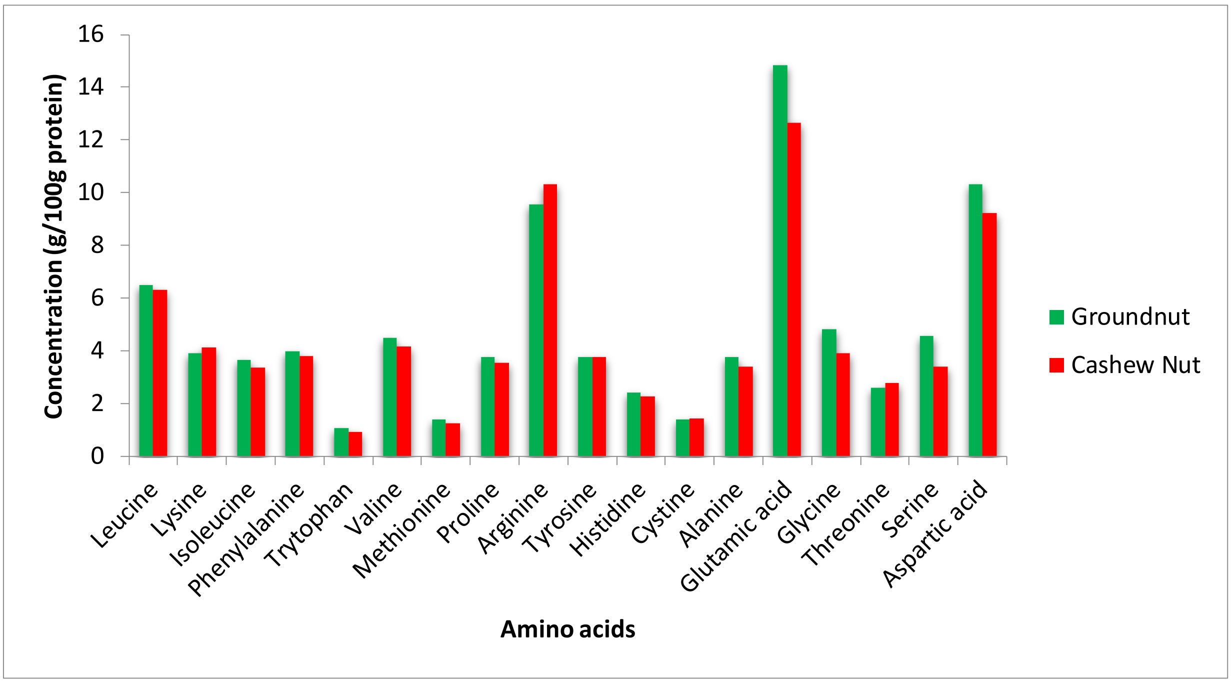

Figure 3. Comparative amino acid composition of roasted groundnut (*Arachis hypogaea*) and cashew nut (*Anacardium occidentale*).

Table 1: Functional properties of roasted groundnut (*Arachis hypogaea*) and cashew nut (*Anacardium occidentale*) flours (mean ± SD, n = 3).

Sample	Bulk Density (g/ml)	WAC (g/g)	OAC (g/g)	Solubility Index (%)	Foaming Capacity (%)	Foaming Stability (%)	Emulsion Capacity (%)
Groundnut	0.55 ± 0.001[a]	1.35 ± 0.01[a]	2.44 ± 0.02[a]	1.44 ± 0.02[a]	12.78 ± 0.03[a]	9.53 ± 0.08[a]	25.79 ± 0.01[a]
Cashew	0.56 ± 0.001[b]	1.27 ± 0.01[b]	2.39 ± 0.01[b]	1.37 ± 0.01[b]	13.53 ± 0.08[b]	9.29 ± 0.01[b]	24.27 ± 0.47[b]

Values represent mean ± standard deviation (n = 3). Means in the same column with different superscripts differ significantly ($p < 0.05$). WAC = Water Absorption Capacity; OAC = Oil Absorption Capacity.

4. Discussion

4.1 Amino acid profile

The amino acid analysis revealed that both groundnut and cashew nut contained all nine essential amino acids, alongside nine non-essential ones. Glutamic acid, aspartic acid, and arginine were the dominant amino acids, consistent with previous findings on leguminous seeds (Aremu *et al.*, 2017; Venkatachalam *et al.*, 2006). The predominance of glutamic acid is typical of legumes and plays an important role in protein metabolism and flavor enhancement in food applications.

Methionine and tryptophan were the least abundant, a trend also reported in other nut species (Du *et al.*, 2017). This limitation is important to consider in diet formulation, as supplementation with sulfur-containing amino acids may be necessary when these nuts are used as the primary protein source. Cashew exhibited a slightly higher arginine content than groundnut, which is noteworthy since arginine is a precursor for nitric oxide, a vasodilator linked to cardiovascular health (Shi *et al.*, 2013). This supports earlier evidence that cashew consumption may contribute to reduced cardiovascular risk, alongside the beneficial effects of unsaturated fatty acids and phytosterols (Kris-Etherton *et al.*, 2008).

4.2 Functional Properties

Significant differences were observed in the functional properties of groundnut and cashew flours. Bulk density values were comparable and relatively low, which is desirable for infant and weaning foods because it enhances digestibility and nutrient density (Osundahunsi *et al.*, 2002; Tufa *et al.*, 2016).

Groundnut demonstrated superior water and oil absorption capacities compared to cashew. High oil absorption is advantageous for food systems where flavor retention and improved mouthfeel are important, such as in bakery and meat analogue products (Aremu *et al.*, 2006; Ubbor *et al.*, 2009). Water absorption capacity, although moderate in both samples, suggests structural compactness of proteins, which may influence product texture and microbial stability (Giami *et al.*, 1992).

Cashew exhibited slightly higher foaming capacity than groundnut, in line with previous reports on nut protein isolates (Kaur *et al.*, 2005). However, both nuts displayed low foam stability (~9%), indicating limited potential in highly aerated foods such as whipped toppings, compared to proteins like hemp isolates which show superior stability (Malomo *et al.*, 2014). The poor stability likely reflects slower film formation and weaker interfacial elasticity (Wani *et al.*, 2015).

14.3 Implications for food applications

The amino acid composition and functional attributes of these nuts highlight their potential in diverse food systems. Groundnut's higher oil and water absorption capacities suggest suitability in baked goods, sausages, and meat substitutes, where fat retention and texture are critical. Cashew's superior foaming ability indicates possible applications in confectioneries and beverages requiring aeration. Both nuts, due to their low bulk density, may also serve as valuable ingredients in the formulation of complementary and weaning foods, particularly in regions where protein-energy malnutrition is prevalent.

4.4 Limitations and future directions

While this study provides valuable insights into the nutritional and functional potential of roasted groundnut and cashew, certain limitations remain. The study did not evaluate the effect of different processing methods beyond sand roasting, which may alter amino acid profiles and functionality. In addition, antinutritional factors were not assessed, yet they can influence protein digestibility and nutrient bioavailability. Future work should investigate protein digestibility-corrected amino acid scores (PDCAAS), the influence of alternative processing methods, and incorporation into model food systems to confirm their functional performance.

5. Conclusion

Roasted groundnut (*Arachis hypogaea*) and cashew nut (*Anacardium occidentale*) are rich in essential and non-essential amino acids, with glutamic acid, aspartic acid, and arginine as the most abundant. Groundnut contained higher glutamic and aspartic acids, while cashew had more arginine. Functional properties also differed: groundnut showed higher water and oil absorption capacities, favoring use in bakery and meat analogue products, while cashew demonstrated superior foaming capacity, making it suitable for confectioneries and beverages. Both nuts exhibited low bulk density, supporting their use in weaning and infant foods.

Overall, these results underscore their value as affordable plant-based protein sources with potential to enhance food quality and alleviate protein-energy malnutrition. Further studies should assess processing effects, digestibility, and applications in formulated products to maximize their nutritional and functional benefits.

Conflict of interests

The authors declare no conflicts of interest.

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