CHEMICAL ANALYSIS AND ANTINUTRITIONAL VALUE OF SELECTED INBRED LINES OF GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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Abstract

This study assesses the proximate composition and anti-nutritional profiles of three groundnut (*Arachis hypogaea* L.) breeding lines: (SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328). Seed samples of these hybrid lines were obtained from the Seed Centre at the College of Agronomy, Joseph Sarwuan Tarka University, Makurdi, Nigeria. Standard analytical methods were employed to determine moisture, ash, crude fibre, lipid, protein, carbohydrate contents, and selected anti-nutritional parameters, including phytic acid, oxalate, and cyanide levels. Moisture content varied from 6.29% in SAMNUT-23×ICGV-91324 to 7.05% in SAMNUT-26×ICGV-91328. Ash content ranged between 3.26% and 4.50%, with SAMNUT-23×ICGV-91324 exhibiting the highest value. Fibre content was relatively stable, with a narrow range of 2.91%–3.14%. Lipid concentration was highest in SAMNUT-26×ICGV-91328 (47.00%) and lowest in SAMNUT-23×ICGV-91324 (46.12%). The highest protein content (22.85%) was recorded in SAMNUT-24×ICGV-91328, while carbohydrate content peaked at 18.37% in SAMNUT-23×ICGV-91324. Regarding anti-nutritional factors, SAMNUT-23×ICGV-91324 had significantly higher cyanide levels (5.10 mg/100g) compared to the other two lines ($P < 0.05$), followed by SAMNUT-24×ICGV-91328 (4.63 mg/100g) and SAMNUT-26×ICGV-91328 (2.56 mg/100g). Similarly, the highest oxalate concentration was observed in SAMNUT-23×ICGV-91324. Overall, the results reveal notable compositional differences among the groundnut hybrid lines, with SAMNUT-24×ICGV-91328 emerging as the most nutritionally advantageous candidate based on its superior protein and balanced nutrient profile.
Keywords: Peanut, fibre content, Cyanide, Phytic acid, oxalate, proximate, Proteinous Proteins food

Introduction

Groundnut (*Arachis hypogaea*), also known as peanut, is a globally important oilseed crop cultivated across a wide range of agroecological zones, from tropical to temperate regions. Africa produces an average groundnut yield of 1,007 kg/ha, with Nigeria presently contributing

Received 01 January 2026; Reviewed 24 May 2026; Accepted 04 June 2026;
Published Online 4 June 2026; Published 15 July 2026

about 3.3 t/ha, a part of the 55% West African Groundnut production in the continent (Fukah et al. 2024, Njoki et al. 2024). Globally, though Nigeria's groundnut production ranks high, it is less than the 60 % combined contributions by China and India (Gelaye and Luo 2024). Its agricultural versatility and high economic value have made it an essential part of food systems in many nations of the world, particularly in Asia, Africa, and South America. Groundnut cultivation has been naturally driven by its high oil yield to supply domestic consumption and industrial processing (Abady et al. 2019). However, a recent study highlights a broader nutritional and functional profile, positioning groundnut as a promising crop for improving dietary quality and combating micronutrient deficiencies, particularly in low- and middle-income countries (Njoki et al. 2024).

In addition to its oil content, groundnut is a rich source of high-quality protein, polyphenols, flavonoids, dietary fibre, and essential micronutrients such as magnesium, phosphorus, potassium, calcium, and vitamins E, K, and the B-complex group (Musalima et al. 2019, Lakhlifi El Idrissi et al. 2024). Compounds such as resveratrol, phytosterols, and other antioxidants found in groundnuts have demonstrated potential cardiovascular benefits by inhibiting cholesterol absorption and improving lipid profiles (Ortiz and Martirosyan 2025). In food-insecure areas, where plant-based diets predominate, and animal protein is often costly, groundnut offers an affordable and nutrient-dense dietary alternative.

Beyond these mentioned nutritional values, groundnut seeds can be consumed raw, roasted, processed into oil and butter, or incorporated into a variety of conventional edibles and animal feed (Onyeike and Oguike 2016). However, processing methods can significantly influence nutrient availability. For example, roasting enhances flavour and mineral bioavailability but may degrade heat-sensitive amino acids and reduce protein digestibility, depending on temperature and exposure time (Adeyeye 2010, Eltom et al. 2023). Selecting and improving new groundnut breeding lines is essential to increase crop production, diversify products, and better match the needs of farming and the production value chain down to the consumers. Farmers' concern is getting high-yielding, disease and stress-tolerant, early-maturing, high-price, and specific-grain-colour varieties (Abady et al. 2019, Regassa et al. 2023), while others, including consumer desire for big, clean grains, oil content, storability, good price, Color, protein/nutrition, texture, flavour, healthiness (high oleic, low aflatoxin), nutritious products (Pandey et al. 2020). Studies conducted on Pakistani groundnut hybrid lines support these findings, reinforcing the crop's potential as a rich protein source with a favourable proximate composition (Atasie et al. 2009). Additionally, roasting has been linked to the generation of aromatic pyrazines, which enhance flavour but may also alter oil quality and shelf stability (Hu et al. 2021).

While groundnuts offer significant nutritional advantages, their consumption is not without concern. Like many legumes, groundnut contains several anti-nutritional factors (ANFs) that can impair nutrient absorption and utilisation. Notably, phytic acid can chelate divalent cations such as calcium, iron, and zinc, reducing their bioavailability (Gupta et al. 2015). Tannins—whose levels vary by seed colour—can inhibit digestive enzymes but may also provide antioxidant benefits when present in moderate amounts (Singh et al. 2023). Additionally, trypsin inhibitors—although present in relatively low quantities—can also reduce protein digestibility (Tibe and Amarteifio 2010).

Cyanogenic glycosides are another class of ANFs found in trace amounts in some groundnut hybrid lines. Upon hydrolysis, these compounds release hydrogen cyanide (HCN), a potent respiratory toxin. Improper post-harvest handling or storage may exacerbate cyanide volatilisation, posing a significant food safety concern (Adejoh et al. 2020). Similarly, oxalates present in groundnuts can form insoluble salts with calcium and other minerals, potentially contributing to kidney stone formation if consumed excessively (Ritter and Savage 2007). Despite these concerns, some ANFs, such as phytic acid, have demonstrated protective effects against oxidative stress and inflammation, further complicating their classification as purely detrimental (Midorikawa et al. 2001).

Comparative data on the proximate and anti-nutritional composition of improved groundnut hybrid lines remain limited, particularly within the Nigerian context. Such insights are essential for guiding breeding efforts, dietary planning, and food processing practices that enhance nutritional benefits while reducing potential health risks. Although previous studies have explored some groundnut hybrid lines, further evaluation of newly improved hybrid lines is warranted (Olasan et al. 2024). This study aims to analyze and compare the nutritional and anti-nutritional profiles of three improved groundnut hybrid lines (SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328) to support evidence-based selection and utilization.

Materials and Methods

Study Area and Sample Collection

This study was conducted in the Biochemistry Laboratory of the College of Biological Sciences, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria (≈7.4–7.7° N, 8.4–8.5° E, ~100–113 m above sea level). This place has a low-elevation tropical wet-and-dry climate with mean temperatures of about 26–31 °C across cool-dry, hot-dry, and hot-wet seasons, relative humidity around 44–86%, and annual rainfall of roughly 1,000–1,250 mm concentrated between April and October (Tyubee et al. 2021). Three improved hybrid lines of groundnut seeds (SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328) were obtained from the Seed Centre at the College of Agronomy, Joseph Sarwuan Tarka University, Makurdi. These hybrid lines were selected for evaluation based on their availability and relevance to ongoing local breeding programs. Identification of the hybrid lines followed standard descriptors as outlined by Yenikalayci (2021).

Sample Preparation

Collected groundnut seeds were cleaned and air-dried at room temperature for 24 hours to reduce surface moisture and remove impurities that could cause analytical error. The dried seeds were then pulverised into fine flour using a laboratory grinder and stored at room temperature in airtight containers until analysis.

Proximate Composition Analysis

Moisture Content

Moisture content was determined using the standard oven-drying method. Clean crucibles were dried, cooled in a desiccator, and weighed. Five grams of each groundnut hybrid line were placed in the crucibles and dried in a hot-air oven at 103–105°C for two hours. Samples were cooled in a desiccator and reweighed. Drying continued until a constant weight was obtained. Moisture content was calculated as:

% Moisture $\frac{w_2 - w_3}{w_2 - w_1} \; x \; \frac{100}{1}$

$$w_1 = weight\ of\ the\ empty\ moisture\ can$$
$$w_2 = weight\ of can\ and\ sample\ before\ drying$$
$$w_3 = weight\ of\ can\ and\ sample\ after\ drying$$

Crude Protein

Protein content was determined using the micro-Kjeldahl method. Two grams of each groundnut hybrid line was digested with concentrated sulfuric acid and a selenium catalyst. The digest was diluted to 100 mL with distilled water. A 10 mL aliquot was mixed with 45% sodium hydroxide and distilled. The distillate was collected in 4% boric acid containing a mixed indicator (methyl red and bromocresol green), and then titrated with 0.02N sulfuric acid.

Titration was done from the initial green colour to a deep red or pink endpoint. The total nitrogen was calculated and multiplied by the factor 6.25 to obtain the crude protein content (Sáez-Plaza et al. 2013).

$$\%\ Crude\ protein = \%N6.25$$
$$\%\ N_2 = \frac{(100x)Nx14xV_f xT}{w\ x\ 100\ x\ V_A}$$
$$W = weight\ of\ the\ sample$$

N = Normality of filtrate ((H_2SO_4) = 0.02N
V_f = Total volume of the digest = 100mL
V_A = Volume of the digest distilled

Crude Fat
Fat content was extracted using a Soxhlet apparatus with petroleum ether as the solvent. Five grams of each groundnut sample were wrapped in filter paper, placed in the extractor, and subjected to reflux for approximately 4 hours. After extraction, the solvent was recovered, and the flask containing the oil was dried, cooled, and weighed. Fat content was calculated as:
Formula for the Calculation:

$$\%\ of\ fat = \frac{w_2 - w_1}{Ww_1} x \frac{100}{1}$$

Where: *W = weight of the sample*
W_1 weight of empty extraction flask
W_2 = weight of flask and oil extract

Ash Content
Ash content was determined by weighing 5 grams of dried groundnut sample of each breeding line into pre-dried crucibles and igniting in a muffle furnace at 550–600 °C for 2 hours until all organic matter burns off, leaving inorganic residue (ash). The crucibles were cooled in a desiccator and re-weighed; ash % = (ash residue ÷ original sample) × 100 (Quirino et al. 2023). Ash content was determined by incinerating 5 grams of each groundnut sample in a muffle furnace at 700°C for 2 hours. Pre-weighed crucibles were used, and after cooling in a desiccator, the residual ash was weighed. The percentage ash content was calculated as:

$$\%\ Ash = \frac{w_2 - w_3}{w_2 - w_1} x\ \frac{100}{1}$$

W_1 = weight of the crucible
W_2 = weight of sample crucible
W_3 = weight of crucible + ash

Crude Fiber
Crude fiber was determined using the Weende method. Defatted Groundnut samples (from fat analysis) were boiled in 1.2% sulfuric acid for 30 minutes, filtered, washed, and then boiled in 1.25% sodium hydroxide for another 30 minutes. The residue was washed, dried in an oven at 150°C, cooled, and weighed. It was then incinerated at 550°C in a muffle furnace, cooled, and reweighed (Medina-Saavedra Tarsicio et al. 2018). Crude fiber was calculated using:

$$\%\ Crude\ fibre = \frac{loss\ in\ weight\ incinertion}{weight\ of\ sample} x\ \frac{100}{1} = \frac{w_2 - w_3}{weight\ of\ sample}$$

W_2 = weight of crucible sample after washing and drying in oven

W_3 = weight of crucible + sample ash

Carbohydrate Content
Carbohydrates were estimated by difference, using the nitrogen-free extract method:

$$\% \text{ NFE} = 100 - \% (a+b+c+d+e)$$

where: *a= protein*, *b= fat*, *c= fibre*, *d= ash*, *e= moisture*

Anti-Nutritional Factor Analysis
Oxalate Content
Approximately 0.5g of each sample was extracted with 15 mL of 3M sulfuric acid for one hour. The mixture was filtered, and 5 mL of the filtrate was titrated hot with 0.05M potassium permanganate until a faint pink color persisted for at least 30 seconds. Oxalate content was calculated using the factor that 1 mL of 0.05M $KMnO_4$ equals 2.2 mg oxalate (Ijarotimi and Keshinro 2013).
Phytic Acid
Two grams of the finely ground sample were extracted with 25 mL of 0.1 mol L^{-1} HCl (≈2% v/v) for 3 h and filtered to obtain a clear chloride-containing filtrate. A 25 mL aliquot of this extract was then treated with 0.1 mol L^{-1} ammonium thiocyanate (NH_4SCN) indicator and titrated with 0.014 mol L^{-1} $FeCl_3$ solution until a stable brownish-yellow ferric thiocyanate colour persisted for 5 min, following a Volhard-type argentometric/thiocyanate titration principle for chloride determination (Cai et al. 2020). Two grams of the sample were soaked in 2% HCl for three hours and filtered. A 25 mL aliquot of the filtrate was reacted with ammonium thiocyanate (NH_4SCN) as an indicator and titrated with iron (III) chloride solution until a stable brownish-yellow colour persisted for 5 minutes (Yahaya et al. 2022a). The phytic acid content was calculated using:

$$\text{Phytic Acid} = \text{Titre Value} \times 1.15 \times 1.19 \times 3.55$$

The **titre value** from the titration of phytic acid-P and $FeCl_3$.
The factor **3.55** is the classical chemical conversion from phytic acid-P to phytic acid ($C_6H_{18}O_{24}P_6$).
The **1.15** and **1.19** are constants to account for extraction dilution, sample aliquot, or moisture basis (Romero-Aguilera et al., 2017).

Cyanide Content
A 2.5 g portion of the ground sample was soaked in 50 mL of distilled water overnight. After filtration, 1 mL of the extract was mixed with 4 mL of alkaline picrate and incubated at 100°C for 5 minutes. The absorbance was read at 450 nm against a blank, and cyanide content was determined from a standard curve.
Statistical Analysis
Data The data collected were subjected to one-way analysis of variance (ANOVA) using SPSS version 2016. Mean differences were separated using Duncan's Multiple Range Test at a 95% confidence level ($p < 0.05$).

Results

Proximate Composition in three Groundnut Breeding lines
Table 1 presents the proximate composition of three groundnut breeding lines: SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328. Moisture

content ranged from 6.29% to 7.05%, with SAMNUT-26×ICGV-91328 showing the highest value and SAMNUT-23×ICGV-91324 the lowest (6.29 ± 0.13%), giving a mean of 6.62%. Ash content varied between 3.26% and 4.50%, highest in SAMNUT-23×ICGV-91324 and lowest in SAMNUT-26×ICGV-91328, with an overall mean of 3.84%.
Fiber content ranged from 2.91% in SAMNUT-24×ICGV-91328 to 3.14% in SAMNUT-23×ICGV-91324, averaging 3.05%. Lipid content was highest in SAMNUT-26×ICGV-91328 (47.00%) and lowest in SAMNUT-23×ICGV-91324 (46.12%), with a mean of 46.70%. Protein content was highest in SAMNUT-24×ICGV-91328 (22.85 ± 0.07%) and lowest in SAMNUT-23×ICGV-91324 (21.59 ± 0.07%), yielding a mean of 22.32%. Carbohydrate content ranged from 16.99% to 18.37%, with the highest in SAMNUT-23×ICGV-91324 and the lowest in SAMNUT-24×ICGV-91328, averaging 17.47%. The grand means are presented in Figure 1.

Table 1. Proximate composition in three groundnut breeding lines

Varieties	Moisture (%)	Ash (%)	Fiber (%)	Lipid (%)	Protein (%)	Carbohydrate (%)
SAMNUT-26x1CGV-91328	7.05±0.04[a]	3.26±0.03[a]	3.11±0.03[a]	47.00±0.28[a]	22.52±0.52[a]	17.06±0.83[a]
SAMNUT-23x1CGV-91324	6.29±0.13[a]	4.50±0.01[a]	3.14±0.06[a]	46.12±1.31[a]	21.59±0.07[a]	18.37±1.46[a]
SAMNUT-24xICGV-91328	6.52±0.02[a]	3.76±0.28[a]	2.91±0.07[a]	46.97±0.64[a]	22.85±0.07[a]	16.99±0.58[a]
Grand mean	6.62±0.23	3.84±0.36	3.05±0.07	46.70±0.29	22.32±0.38	17.47±0.45

Moisture: χ^2 (Variety Vs Moisture content) = 0.046, P=0.977 (P>0.05)
Ash: χ^2(Variety Vs Ash content) = 0.203, P=0.904 (P>0.05)
Fiber: χ^2 (Variety Vs Fiber content) = 0.01, P=0.995 (P>0.05)
Lipid: χ^2 (Variety Vs Lipid content) = 0.011, P=0.995 (P>0.05)
Protein: χ^2 (Variety Vs Protein content) = 0.038, P=0.981 (P>0.05)
Carbohydrate: χ^2 (Variety Vs Carbohydrate content) = 0.069, P=0.966 (P>0.05)
Carbohydrate: χ^2 (Variety Vs Carbohydrate content) = 0.069, P=0.966 (P>0.05)

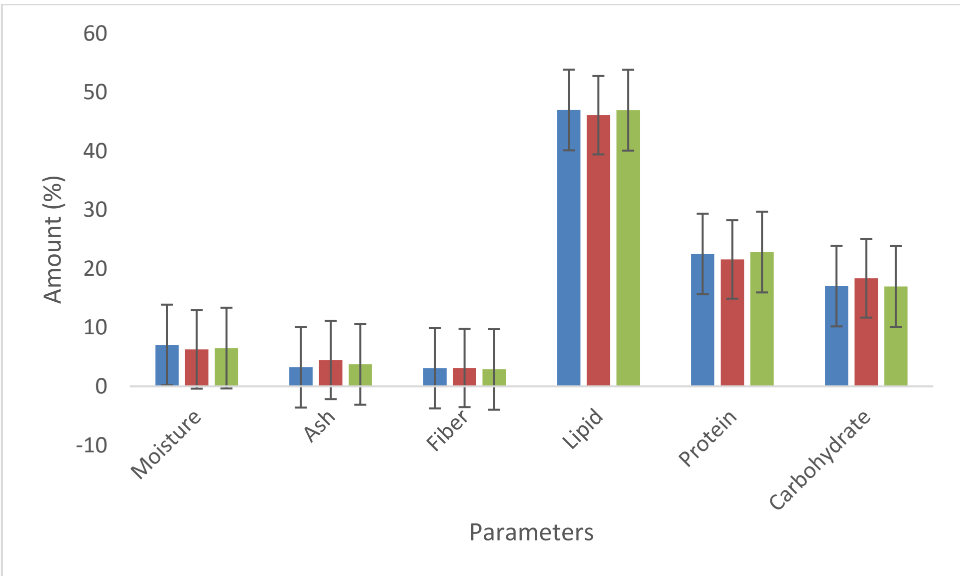

Figure 1. Grand mean of proximate composition in groundnut breeding lines

Anti-nutritional factors in three groundnut breeding lines

Table 2 with figures 2-4 presents the levels of three anti-nutritional factors—cyanide, oxalate, and phytic acid—in the groundnut breeding lines SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328. Figure 5 shows the Comparative analysis of anti-nutritional factors in the groundnut hybrid lines. Cyanide content was highest in SAMNUT-23×ICGV-91324 (5.10 ± 0.10 mg/100g), followed by SAMNUT-24×ICGV-91328 (4.63 ± 0.08 mg/100g), and lowest in SAMNUT-26×ICGV-91328 (2.56 ± 0.02 mg/100g). These differences were statistically significant ($F = 322.37$, $p < 0.05$).

Oxalate levels ranged from 0.51 ± 0.07 mg/100g in SAMNUT-24×ICGV-91328 to 1.32 ± 0.55 mg/100g in SAMNUT-23×ICGV-91324. However, the variation was not statistically significant ($F = 1.83$, $p > 0.05$). For phytic acid, SAMNUT-24×ICGV-91328 showed the highest concentration (85.10 ± 0.30 mg/100g), followed by SAMNUT-23×ICGV-91324 (74.66 ± 0.27 mg/100g) and SAMNUT-26×ICGV-91328 (71.98 ± 0.55 mg/100g), with statistically significant differences across the hybrid lines ($F = 313.85$, $p < 0.05$).

Table 2. Anti-nutritional factors in three groundnut varieties

Varieties	**Cyanide (µg/100g d.w)**	**Oxalate (mg/100g)**	**Phytic acid (mg/100g)**
SAMNUT-26x1CGV-91328	2.56±0.02[c]	1.21±0.05[a]	71.98±0.55[c]
SAMNUT-23x1CGV-91324	5.10±0.10[a]	1.32±0.55[a]	74.66±0.27[b]
SAMNUT-24xICGV-91328	4.63±0.08[b]	0.51±0.07[a]	85.10±0.30[a]
FAO/WHO limit			

F (Cyanide content) = 322.37, P= 0.000 (P<0.05)

F (Oxalate content) = 1.83, P=0.24 (P>0.05)

F (Phytic acid content) = 313.85, P=0.000 (P<0.05)

Means that do not share a letter are significantly different.

F (Cyanide content) = 322.37, P= 0.000 (P<0.05)

F (Oxalate content) = 1.83, P=0.24 (P>0.05)

F (Phytic acid content) = 313.85, P=0.000 (P<0.05)

Means that do not share a letter are significantly different.

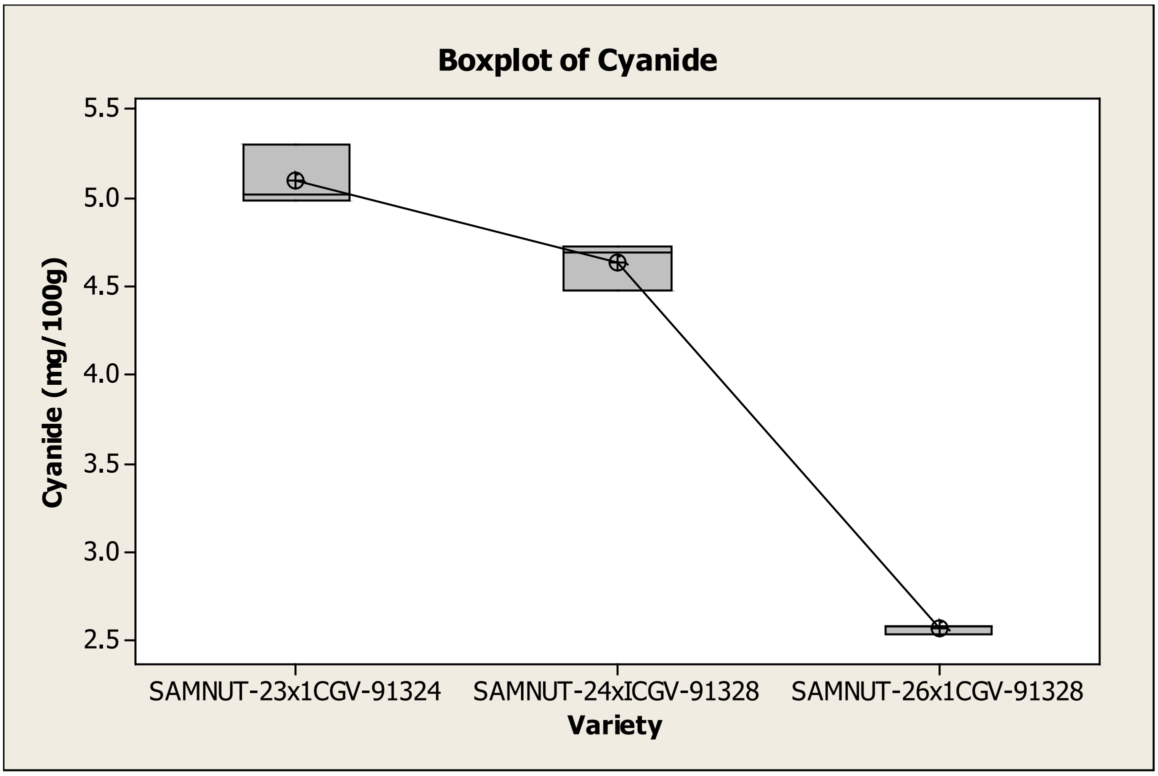

Figure 2. Boxplot of cyanide content in three groundnut breeding lines

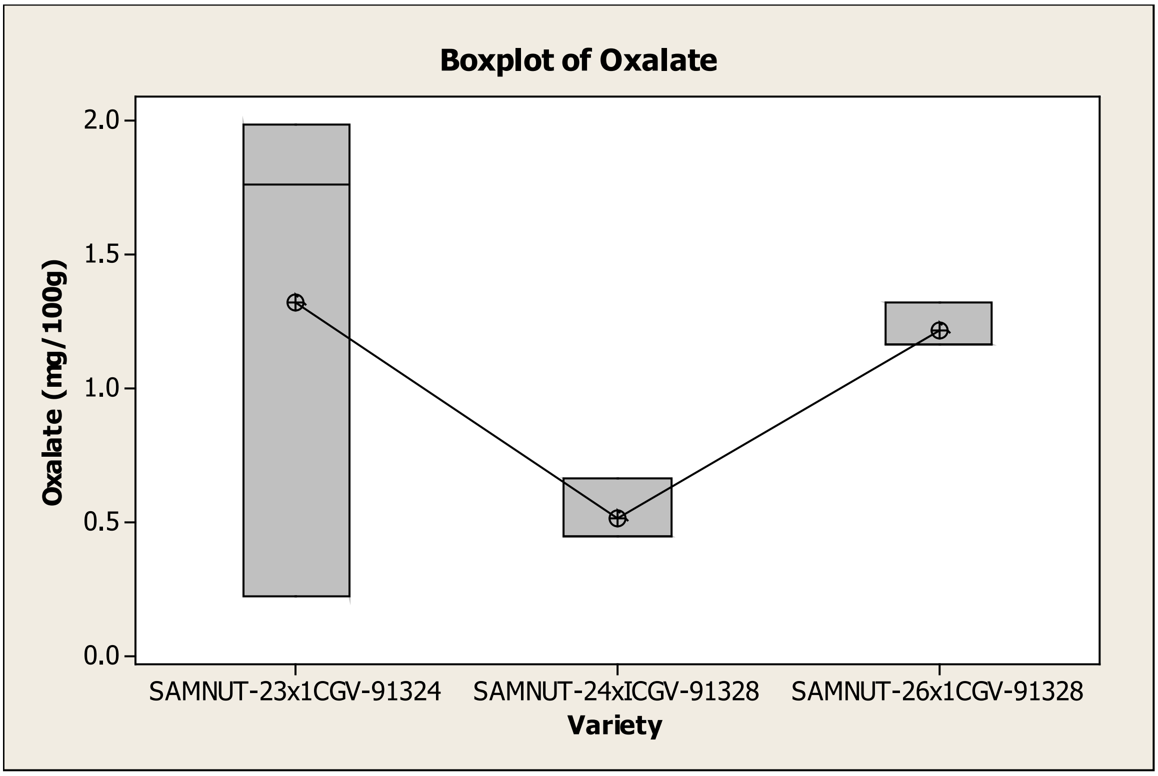

Figure 3. Boxplot of oxalate content in three groundnut breeding lines

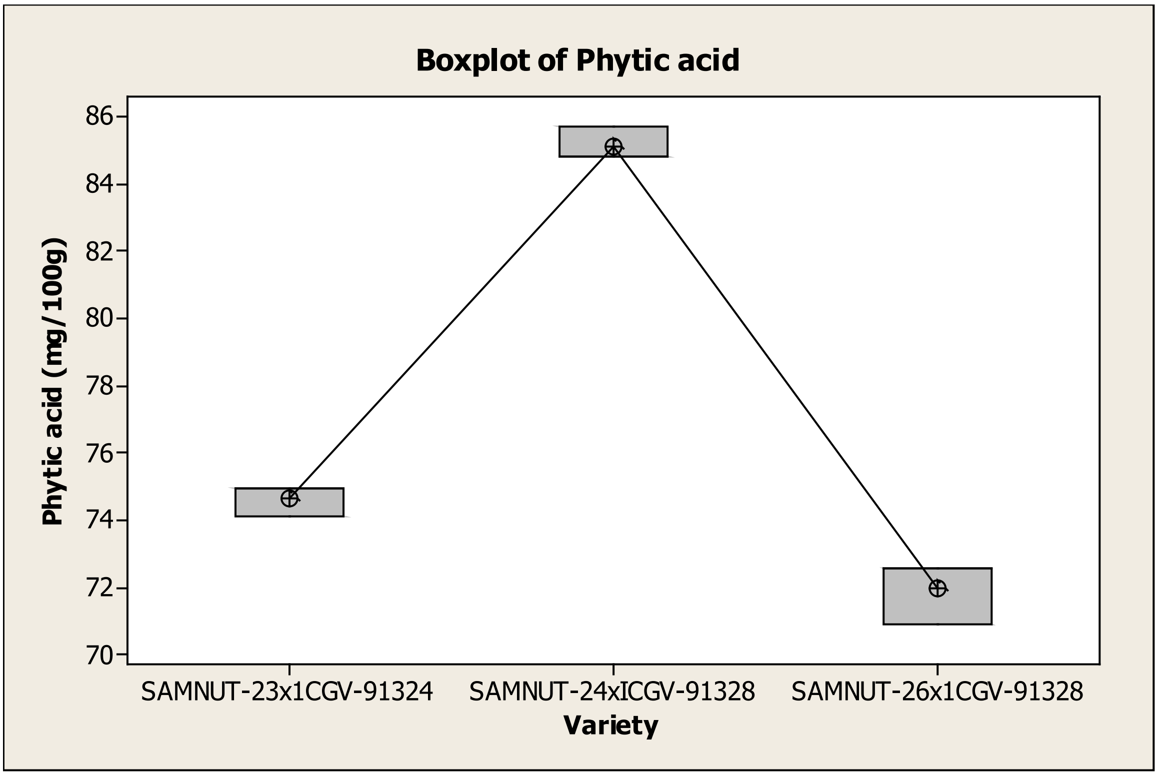

Figure 4. Boxplot of phytic acid content in three groundnut breeding lines

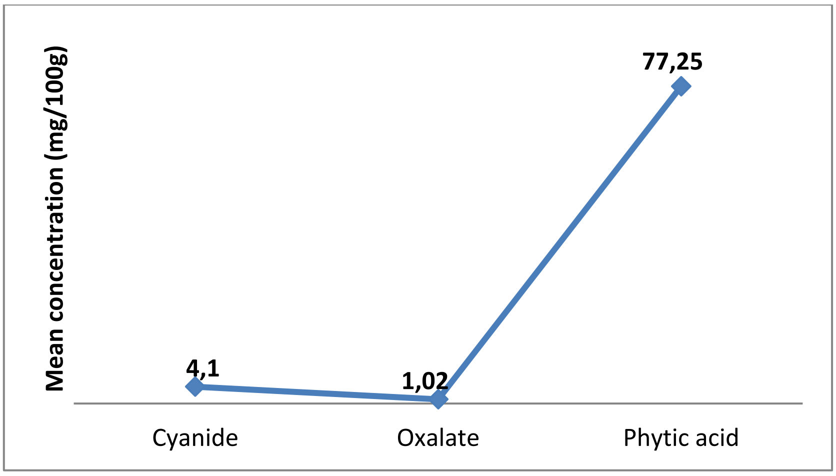

Figure 5. Comparative analysis of anti-nutritional factors in groundnut breeding lines

Correlation among Nutritional and Anti-Nutritional Components

Table 3 summarises the Pearson correlation coefficients among the nutritional and anti-nutritional parameters of the groundnut hybrid lines. Moisture content showed no significant correlation with any other component. Ash content was negatively correlated with moisture (r = -0.810) and moderately correlated with carbohydrate (r = 0.345), but showed weak or no meaningful relationships with other components.

Fiber content displayed weak, non-significant correlations across the board. Lipid content had a moderate negative correlation with ash (r = -0.345) and a weak positive correlation with fibre (r = 0.099). Protein content correlated moderately with lipid (r = 0.410) and negatively with ash (r = -0.583).

Carbohydrate content showed strong negative correlations with lipid (r = -0.944) and protein (r = -0.624), and a moderate positive correlation with ash (r = 0.345). Cyanide content was strongly negatively correlated with moisture (r = -0.938) and positively with ash (r = 0.797). Oxalate showed a weak positive correlation with fiber (r = 0.805) and a weak negative correlation with lipid (r = -0.567). Phytic acid was moderately positively correlated with protein (r = 0.472), and negatively correlated with moisture (r = -0.370), ash (r = -0.552), and carbohydrate (r = -0.191).

Table 3. Pearson's Correlation Matrix

	Moisture	Ash	Fiber	Lipid	Protein	Carbohydrate	Cyanide	Oxalate	Phytic acid
Moisture	1								
Ash	-0.810	1							
Fiber	0.083	0.073	1						
Lipid	0.330	-0.345	0.099	1					
Protein	0.480	-0.583	-0.462	0.410	1				
Carbohydrate	-0.408	0.345	-0.007	-0.944	-0.624	1			
Cyanide	-0.938	0.797	-0.237	-0.253	-0.334	0.287	1		
Oxalate	0.143	0.099	0.805	0.567	-0.298	-0.461	-0.192	1	
Phytic acid	-0.370	0.083	-0.720	0.118	0.472	-0.191	0.506	-0.552	1

Strength of correlation:
0.00-0.39 = Weak correlation
0.40-0.69 = moderate correlation
0.7-0.9 = High correlation
>0.90 = Very high correlation

Discussion

Proximate Composition in three Groundnut Breeding lines

Groundnut seeds are valued for their dense energy and nutrient content, but composition varies with cultivar, environment, and processing methods. In this study, the moisture content of 6.29%–7.05% aligns closely with ranges reported in Nigeria (6.0%–7.9%) and elsewhere (6.5%–8.6%) (Shokunbi et al. 2012). Recent analyses of improved SAMNUT lines—23, 24, 26—also showed moisture around 8.6%, supporting the consistency of these findings (Olasan et al. 2024).

The lipid content observed (46.1%–47.0%) is higher than the 40.9%–43.2% seen in Chinese hybrid lines (Huang et al. 2022) but closely matches the 44%–50% range reported in Nigerian hybrid lines, including SAMNUT-23 with about 49.7% oil (Huang et al. 2022). Similarly, protein levels (21.6%–22.8%) are comparable to the 20%–26% commonly observed in Nigerian groundnuts, though slightly lower than the 24%–28% range noted in other studies (Mshelmbula et al. 2017).

Fibre content (2.91%–3.14%) remains within expected norms (2.6%–3.8%), reflecting typical groundnut roughage levels (Pardeshi 2019). Ash content (3.26%–4.50%) also falls within standard soil mineral ranges (2.6%–5.0%) (Abdulbaki et al. 2022), indicating consistent mineral composition suited for both nutrition and soil quality implications.

Anti-nutritional factors in three groundnut breeding lines

Anti-nutritional factors (ANFs) are naturally occurring compounds that can impair nutrient absorption or exert toxic effects when consumed in excess (Gemede and Ratta 2014). In groundnuts, their presence and concentration are influenced by genetic variation, environmental factors, and processing techniques (Okereke et al. 2025). This study assessed the levels of three common ANFs—cyanide, oxalate, and phytic acid—in three improved groundnut breeding lines: SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328.

Cyanide, a known metabolic toxin, interferes with cellular respiration and can pose serious health risks when ingested at high concentrations (Park et al. 2024). Among the hybrid lines studied, cyanide levels ranged from 2.56 mg/100 g in SAMNUT-26×ICGV-91328 to 5.10 mg/100 g in SAMNUT-23×ICGV-91324—the highest among the three. These values are comparable to those previously reported in groundnut and similar legume studies (Adejoh et al. 2020). While the observed levels are not immediately alarming, monitoring and minimising cyanide content in breeding selections is important for food safety.

Oxalate levels also varied across the genotypes, ranging from 0.51 mg/100 g to 1.32 mg/100 g, with the highest again recorded in SAMNUT-23×ICGV-91324. Oxalates reduce calcium bioavailability by forming insoluble calcium oxalate complexes, which may contribute to kidney stone formation in sensitive individuals (Mitchell et al. 2019). These results align with previous findings in groundnut hybrid lines (Dele et al. 2020), suggesting that while levels are within expected ranges, reducing oxalate content through breeding or processing could improve nutritional safety.

Phytic acid, another prominent ANF in legumes, was detected in amounts ranging from 71.98 mg/100 g to 85.10 mg/100 g, with SAMNUT-24×ICGV-91328 exhibiting the highest level. Phytates are known to chelate essential minerals such as iron, zinc, and calcium, limiting their intestinal absorption. Although phytic acid can also exert antioxidant and anticancer properties at moderate levels, its high concentration in certain hybrid lines may warrant nutritional balancing in breeding targets (Pires et al. 2023). These findings are in line with those from earlier studies on Nigerian groundnut lines (Solanki et al. 2021).

The variation in ANF content across the three groundnut breeding lines suggests opportunities for genetic selection. SAMNUT-23×ICGV-91324 showed the highest levels of cyanide and oxalate, while SAMNUT-24×ICGV-91328 contained the most phytic acid. These results can inform breeding strategies aimed at reducing ANF concentrations while maintaining or enhancing nutritional quality. Furthermore, applying traditional processing methods—such as soaking, roasting, and boiling—has been shown to significantly reduce ANF levels and improve mineral bioavailability in groundnut products (Yahaya et al. 2022b).

Pearson's correlation matrix

The Pearson correlation matrix presented in Table 3 offers insights into how various nutritional and anti-nutritional components in the groundnut samples relate to one another. Understanding these relationships is important for improving both the nutritional quality of groundnut and its suitability for food processing and breeding programs.

Moisture content did not show any significant relationship with other components, except for a perfect correlation with itself. However, a strong negative correlation was observed between ash and moisture contents. This suggests that as moisture decreases, the concentration of minerals (represented by ash) increases—likely due to the concentration effect during drying. Ash also showed a weak positive relationship with fibre, indicating that samples with slightly higher fibre content may also carry more mineral matter.

Fibre content, on the other hand, showed no notable correlation with most other nutrients, implying it remains relatively unaffected by the changes in other components. A weak positive relationship between fibre and lipid content was noted, suggesting a slight tendency for higher-fat samples to also contain more fibre. Lipid content also had a moderate negative correlation with ash, possibly due to the inverse relationship between dense mineral matter and the lighter lipid fraction during sample processing.

Protein content was moderately correlated with lipid levels, indicating that hybrid lines richer in fat might also be higher in protein. However, protein showed a strong negative relationship

with ash, implying that as mineral content increases, protein levels tend to decrease. This might reflect the lower inorganic content of protein-rich tissues.
Carbohydrates showed a strong inverse relationship with lipids, and a moderate negative correlation with protein. These patterns may reflect a natural nutrient trade-off in seed composition—where higher fat and protein content come at the expense of carbohydrate reserves. A weak positive correlation between carbohydrates and ash was also observed.
Among the anti-nutritional factors, cyanide content had a strong negative correlation with moisture, suggesting that drier samples tend to concentrate more cyanide. It also had a weak positive correlation with ash, possibly reflecting a co-accumulation of certain compounds in mineral-rich tissues.
Oxalate levels were weakly correlated with fiber (positive) and lipids (negative), indicating that oxalate presence may be slightly higher in fibrous samples but lower in those with high fat content. Phytic acid levels showed several associations: a weak negative correlation with moisture, a moderate positive correlation with protein, and negative correlations with ash and carbohydrate content. This suggests that phytate may accumulate more in protein-rich samples but decrease in carbohydrate- or mineral-rich ones.
Together, these correlations reveal how nutrient and anti-nutrient profiles in groundnut interact. This information is valuable for selecting hybrid lines with balanced compositions and for optimizing processing techniques to enhance nutritional value while minimising potential health risks. It also provides a useful foundation for breeding programs focused on developing groundnut lines with improved health benefits and functionality in food products.

Conclusions

This study has demonstrated that the nutritional and anti-nutritional profiles of the three evaluated groundnut breeding lines—SAMNUT-26×ICGV-91328, SAMNUT-23×ICGV-91324, and SAMNUT-24×ICGV-91328—vary notably across key components. Among the hybrid lines, SAMNUT-24×ICGV-91328 stood out with the most favourable nutritional composition, including higher levels of protein and lipid. In contrast, SAMNUT-23×ICGV-91324 recorded the highest levels of cyanide and oxalate, while SAMNUT-24×ICGV-91328 also showed the highest phytic acid content.
These findings highlight the importance of selecting groundnut hybrid lines not only for their nutrient density but also for their lower levels of anti-nutritional factors. The results can guide breeders, nutritionists, and food processors in identifying and developing hybrid lines that offer improved health benefits and food safety. Further research on processing methods to reduce anti-nutrients in high-performing hybrid lines like SAMNUT-24×ICGV-91328 is recommended to fully harness their nutritional potential.

Acknowledgement
The authors appreciate the assistance rendered by the laboratory technologists in the course of this work.
Disclosure statement
There is no potential conflict of interest regarding this work by the authors.
Funding: NIL

References

Abady S, Shimelis H, Janila P. 2019. Farmers' perceived constraints to groundnut production, their variety choice and preferred traits in eastern Ethiopia: implications for drought-tolerance

breeding. Journal of Crop Improvement. 33(4): 505–521. https://doi.org/10.1080/15427528.2019.1625836.
Abdulbaki AS, Olayinka BU, Abdulkareem KA, Ibuowo MB., Kareem I, Sagaya A, Adigun ARBA, Olaniyi BT, Mustapha OT. 2022. Physicochemical and proximate composition of MK 373, Abujachi and Makowchi groundnut varieties grown in Kwara State, Nigeria. Sri Lankan Journal of Biology. 7(2): 26–30.
Adejoh J, Idoko FE, Ujah EA, Okoh MP. 2020. Cyanide Content Analysis in Selected Food Crops (Soya Beans, Maize, White Beans), Nuts (Ground Nut, Tiger Nut) Cultivated and Consumed in Nigeria and, Espouse of Environmental Toxicants as Epigene (s) Modifier. Chemical Science and Engineering Research. 2(4). https://doi.org/10.36686/ariviyal.cser.2020.02.04.017.
Adeyeye EI. 2010. Effect of cooking and roasting on the amino acid composition of raw groundnut (*Arachis hypogaea*) seeds. Acta Sci. Pol., Technol. Aliment. 9(2): 201–216.
Atasie VN, Akinhanmi TF, Ojiodu C.C. 2009. Proximate Analysis and Physico-Chemical Properties of Groundnut (*Arachis hypogaea* L.). Pakistan Journal of Nutrition. 8(2): 194–197.
Cai L, Ouyang Z, Song J, Yang L. 2020. Indicator-Free Argentometric Titration for Distance-Based Detection of Chloride Using Microfluidic Paper-Based Analytical Devices. ACS Omega. 5(30): 18935–18940. https://doi.org/10.1021/acsomega.0c02143.
Dele PA, Kasim OB, Akinyemi BT, Kenneth-Obosi O, Salawu FE, Anotaenwere CC, Jolaosho AO, Arigbede OM. 2020. Forage Yield and Nutritive Quality of Two Groundnut (*Arachis Hypogaea* L) Varieties As Influenced By Fertilizer Types. Journal of Agricultural Science and Environment. 19(1): 1–16. https://doi.org/10.51406/jagse.v19i1.2011.
Eltom HAE., Sulieman MA, Hassan AB. 2023. Effect of boiling and roasting processing on nutritional quality of two Sudanese peanuts (*Arachis hypogaea*) cultivars. Legume Science. 5(1): 1–9. https://doi.org/10.1002/leg3.159.
Fukah FK, Magubika AJ, Tryphone GM, Nassary EK. 2024. Meta-analysis of legumes and groundnut production trends and variability in the Global South. Journal of Agriculture and Food Research. 18. https://doi.org/10.1016/j.jafr.2024.101501.
Gelaye Y, Luo H. 2024. Optimizing Peanut (*Arachis hypogaea* L.) Production: Genetic Insights, Climate Adaptation, and Efficient Management Practices: Systematic Review. In Plants. 13(21):2988. https://doi.org/10.3390/plants13212988.
Gemede FH, Ratta N. 2014. Antinutritional Factors in Plant Foods: Potential Health Benefits and Adverse Effects. International Journal of Nutrition and Food Sciences. 3(4): 284. https://doi.org/10.11648/j.ijnfs.20140304.18.
Gupta RK, Gangoliya SS, Singh NK. 2015. Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains. Journal of Food Science and Technology. 52(2): 676–684. https://doi.org/10.1007/s13197-013-0978-y.
Hu H, Shi A, Liu H, Liu L, Fauconnier ML, Wang Q. 2021. Study on key aroma compounds and its precursors of peanut oil prepared with normal-and high-oleic peanuts. Foods., 10(12). https://doi.org/10.3390/foods10123036.
Huang Y, Ma R, Xu Y, Zhong K, Bu Q, Gao H. 2022. A comparison of lipid contents in different types of peanut cultivars using uplc-q-tof-ms-based lipidomic study. Foods. 11(1): 10–21. https://doi.org/10.3390/foods11010004.
Ijarotimi SO, Keshinro OO. 2013. Determination of nutrient composition and protein quality of potential complementary foods formulated from the combination of fermented popcorn, african locust and bambara groundnut seed flour. Polish Journal of Food and Nutrition Sciences. 63(3): 155–166. https://doi.org/10.2478/v10222-012-0079-z.
Lakhlifi El Idrissi Z, Oubihi A, Ibourki M, El Youssfi M, Gharby S, El Guezzane C, Ullah R, Iqbal Z, Goh KW, Gallo M, Bouyahya A, Harhar H, Tabyaoui M. 2024. Peanut (*Arachis hypogaea* L.) flour and oilcake flour: Exploring the influence of roasting and varietal

differences on proximal composition, elemental profiling, antimicrobial and antioxidant properties. Food Chemistry: X. 24(July), 101791. https://doi.org/10.1016/j.fochx.2024.101791.

Medina-Saavedra T., Arroyo-Figueroa G., Herrera-Méndez C., Gantes-Alcantar M., Mexicano-Santoyo L., Mexicano-Santoyo A. 2018. Análisis químico proximal en residuos sólidos de cerveza artesanal y su aceptación en cerdas. Abanico Veterinario. 8(3): 86–93. https://doi.org/10.21929/abavet2018.83.6.

Midorikawa K, Murata M, Oikawa S, Hiraku Y, Kawanishi S. 2001. Protective effect of phytic acid on oxidative DNA damage with reference to cancer chemoprevention. Biochemical and Biophysical Research Communications. 288(3): 552–557. https://doi.org/10.1006/bbrc.2001.5808.

Mitchell T, Kumar P, Reddy T, Wood KD, Knight J, Assimos DG, Holmes RP. 2019. Dietary oxalate and kidney stone formation. American Journal of Physiology - Renal Physiology. 316(3): F409–F413. https://doi.org/10.1152/ajprenal.00373.2018.

Mshelmbula BP, Jummai BF, Mallum SM, Zacharia R. 2017. Studies on four cultivars of groundnut (*Arachis hypogeae*) grown in Mubi, Adamawa State of Nigeria. Nigerian Journal of Technological Research. 12(1): 1. https://doi.org/10.4314/njtr.v12i1.1.

Musalima JH, Ogwok P, Mugampoza D. 2019. Anti-Oxidant Vitamins, Minerals and Tannins in Oil from Groundnuts and Oyster Nuts Grown in Uganda. Food Science & Nutrition Research. 2(2): 1–7. https://doi.org/10.33425/2641-4295.1016.

Njoki L, Okoth S, Wachira P, Ouko A, Kagot V. 2024. Status of Groundnut Production in Africa: A Review From 2012 to 2022. Journal of Agricultural Science. 16(10): 50. https://doi.org/10.5539/jas.v16n10p50.

Okereke AC, Edugbo RE, Nwofia GE, Okocha PI. 2025. Variations in Nutrient and Antinutrient Content of Some Nigerian Bambara Groundnut Accessions. International Journal for Science and Applied Research. 8(1): 1–12.

Olasan J, Aguoru C, Ani N, Agwu A. 2024. Proximate analysis and anti-nutritional factors in three varieties of groundnut (*Arachis hypogaea*). International Journal of Agriculture and Nutrition. 6(1): 13–18. https://doi.org/10.33545/26646064.2024.v6.i1a.134.

Onyeike EN, Oguike JU. 2016. Influence of heat processing methods on the nutrient composition and lipid characterization of groundnut (*Arachis hypogaea*) seed pastes. Biokemistri. 15(1): 34–43.

Ortiz C, Martirosyan D. 2025. Bioactive compounds in peanuts (*Arachis hypogaea* L.): A review of their anti-inflammatory and antioxidant effects. Agriculture and Food Bioactive Compounds. 1(12): 1–18.

Pandey MK, Pandey AK, Kumar R, Nwosu CV, Guo B, Wright GC, Bhat RS, Chen X, Bera SK, Yuan M, Jiang H, Faye I, Radhakrishnan T, Wang X, Liang X, Liao B, Zhang X, Varshney RK, Zhuang W. 2020. Translational genomics for achieving higher genetic gains in groundnut. Theoretical and Applied Genetics. 133(5): 1679–1702. https://doi.org/10.1007/s00122-020-03592-2.

Pardeshi S. 2019. Evaluation of Physico-Chemical Composition of extracted oils from different groundnut varieties grown in India. International Journal of Advanced Scientific Research and Management. 4(8): 25–32. https://doi.org/10.36282/ijasrm/4.8.2019.1635.

Park H, Chung H, Choi S, Bahn YS, Son J. 2024. Evaluation of exposure to cyanogenic glycosides and potential hydrogen cyanide release in commercially available foods among the Korean population. Food Chemistry. 456(May): 139872. https://doi.org/10.1016/j.foodchem.2024.139872.

Pires SMG, Reis RS, Cardoso SM, Pezzani R, Paredes-Osses E, Seilkhan A, Ydyrys A, Martorell M, Sönmez Gürer E, Setzer WN, Abdull Razis AF, Modu B, Calina D, Sharifi-Rad J. 2023. Phytates as a natural source for health promotion: A critical evaluation of clinical trials. Frontiers in Chemistry. 11(April): 1–11. https://doi.org/10.3389/fchem.2023.1174109.

Quirino DF, Palma MNN, Franco MO, Detmann E. 2023. Variations in Methods for Quantification of Crude Ash in Animal Feeds. Journal of AOAC International. 106(1): 6–13. https://doi.org/10.1093/jaoacint/qsac100.
Regassa MD, Miriti PK, Melesse MB. 2023. Farmers' heterogeneous preferences for traits of improved varieties: Informing demand-oriented crop breeding in Tanzania. Experimental Agriculture. 59. https://doi.org/10.1017/S0014479723000169.
Ritter MMC, Savage GP. 2007. Soluble and insoluble oxalate content of nuts. Journal of Food Composition and Analysis. 20(3–4): 169–174. https://doi.org/10.1016/j.jfca.2006.12.001.
Romero-Aguilera F, Alonso-Esteban JI, Torija-Isasa ME, Cámara M, Sánchez-Mata MC. 2017. Improvement and Validation of Phytate Determination in Edible Seeds and Derived Products, as Mineral Complexing Activity. Food Analytical Methods. 10(10): 3285–3291. https://doi.org/10.1007/s12161-017-0890-6.
Shokunbi OS, Fayomi ET, Sonuga OS, Tayo GO. 2012. Nutrient composition of five varieties of commonly consumed Nigerian groundnut (*Arachis hypogaea* L.). Grasas y Aceites. 63(1): 14–18. https://doi.org/10.3989/gya.056611.
Singh P, Pandey VK, Sultan Z, Singh R, Dar AH. 2023. Classification, benefits, and applications of various anti-nutritional factors present in edible crops. Journal of Agriculture and Food Research. 14(June): 100902. https://doi.org/10.1016/j.jafr.2023.100902.
Solanki MV, Rathod PJ, Mahatma MK. 2021. Trends of antinutritional compounds in groundnut pod at development stages during drought conditions. The Pharma Innovation Journal. 10(10): 1107–1111.
Tibe O, Amarteifio J. 2010. Trypsin Inhibitor Activity and Condensed Tannin Content in Bambara Groundnut (*Vigna Subterranea* (L.) Verdc) Grown in Southern Africa. Journal of Applied Sciences and Environmental Management. 11(2). https://doi.org/10.4314/jasem.v11i2.55021.
Yahaya D, Seidu OA, Tiesaah CH, Iddrisu MB. 2022a. The role of soaking, steaming, and dehulling on the nutritional quality of Bambara groundnuts (*Vigna subterranea* (L) Verdc.). Frontiers in Sustainable Food Systems. 6: 887311.
Yahaya D, Seidu OA, Tiesaah CH, Iddrisu MB. 2022b. The role of soaking, steaming, and dehulling on the nutritional quality of Bambara groundnuts (*Vigna subterranea* (L) Verdc.). Frontiers in Sustainable Food Systems. 6: 887311. https://doi.org/10.3389/fsufs.2022.887311.
Yenikalayci A. 2021. Evaluation of Yield and Quality Performance of Groundnut Varieties under the Eastern Mediterranean Condition. International Journal of Agriculture Environment and Food Sciences. 5(4): 488–496. https://doi.org/10.31015/jaefs.2021.4.8.