

AAUJPAS

AMBROSE ALLI UNIVERSITY JOURNAL OF PHYSICAL & APPLIED SCIENCES

ISSN: 2756-3200



Volume 5, Number 1, June 2025

International coverage of all aspects of Physical Sciences

Published by the Faculty of Physical Sciences

Ambrose Alli University, Ekpoma

AMBROSE ALLI UNIVERSITY
JOURNAL OF PHYSICAL & APPLIED SCIENCES.
(AAUJPAS)
Volume 5, No 1, June, 2025

AMBROSE ALLI UNIVERSITY JOURNAL OF PHYSICAL & APPLIED SCIENCES. Volume 5, No 1, June, 2025

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COMPARATIVE EVALUATION OF SEED QUALITY AND PHYSICO-CHEMICAL
PROPERTIES OF GROUNDNUT VARIETIES CONSUMED IN NIGERIA.

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Abstract

Groundnuts have been established to have great health benefits due to their biochemical constituents. Varieties abound, differing in their quality of seed and oil characteristics; hence, the need to continually assess the characteristics of the seeds, most importantly the improved varieties, whose chemical composition and physico-chemical properties are scant in the literature. In this study, the proximate, mineral and physico-chemical properties of five groundnut varieties (KAMPALA, SAMNUTS 23, 24, 25 and 28) were evaluated using standard procedures. The results revealed that crude protein, fat and fibre were higher in SAMNUT 23 when compared to other varieties. Aside from ash and carbohydrate, the KAMPALA variety recorded the lowest values of all parameters. Regardless of varietal differences in mineral elements, the seeds were rich in phosphorus, sodium, potassium, and magnesium, compared to other essential elements such as zinc, iron, copper, and nitrogen. However, the mineral elements were significantly higher in SAMNUT varieties when compared to KAMPALA. The physico-chemical properties did not show appreciable differences except for acid value, iodine value and saponification values, which were significantly lowest in SAMNUT 28. The findings revealed that all the SAMNUT varieties, especially SAMNUT 23, 24 and 25, had superior quality; hence, their use in seed certification, food processing and breeding programmes within the groundnut value chain in Nigeria should be encouraged.

Keywords: Groundnut, minerals, oil, proximate, physico-chemical properties, seed quality

Introduction:

Groundnut is an important oil crop grown in the tropics and semi-tropics of the world. As a legume, with the ability to fix atmospheric nitrogen in their nodules, makes it a boom for farmers in West Africa, thereby reducing their reliance on fertiliser to sustain crop productivity. Nigeria, the largest groundnut producer in West Africa, contributes to 10% of global production and 39% of Africa's total (Ahmed *et al.*, 2020). Depending on the varieties, groundnut typically contains 47-55 % oil and 26.56-35.20% protein (Musa and Serap, 2003; Ingale and Shrivastava, 2011; Abdulkabi *et al.*,

2022). In addition to oil, groundnuts are used extensively in the manufacturing of peanut butter, candy, roasted peanuts, snack foods, meat product extenders, soups, and desserts (Ingale and Shrivastava, 2011). Groundnut seeds and oil are commonly referred to as "groundnut products" (Balasubramanian *et al.*, 2024).

Groundnut varieties, most importantly the improved varieties, have been found to be useful in increasing food production and improving rural incomes and livelihoods (Melesse *et al.*, 2023). In Nigeria, the most recent groundnut types to be registered and issued are SAMNUT 24, SAMNUT 25, and SAMNUT 26 (Vabi *et al.*, 2019). In the year 2001, three short-duration varieties, SAMNUT 21, 22, and 23, were released for Nigeria's savanna zone. Early maturing varieties, SAMNUT 24 was released in 2011, while SAMNUT 25 and 26 were released in succession in 2013 (Aliyu *et al.*, 2020). These varieties differed in their agronomic characteristics and offered improved yields, animal

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feed, early maturity, and higher oil content, compared to conventional varieties such as KAMPALA, with an average yield of 2-2.5 tons/ha (Vabi *et al.*, 2019). YeniKalayci (2021) evaluated the yield and quality characteristics of some groundnut varieties across different locations, recorded a significant difference among the tested groundnut varieties and seed oil contents, which ranged from 49.14 to 51.58%, however, there was no significant difference among the tested groundnut varieties in terms of seed pod weight per plant. Kumar *et al.*, (2019) also found that all twenty genotypes studied differed significantly in both agronomical characteristics, oil and protein contents.

The foregoing discourses have shown that evaluating varietal differences is imperative, as this provides the basis for seed certification, suitability of different groundnut varieties for use in the manufacture of various products and breeding programmes. On these premises, the present study was designed to assess the seed quality and physico-chemical properties of five improved groundnut varieties with the aim of identifying those with superior chemical composition and physico-chemical properties of the oil.

MATERIALS AND METHODS

Collection and seeds preparation

Five varieties of healthy groundnut seeds (KAMPALA, SAMNUTs 23, 24, 25 and 28) were used for the experiment. The pods of all five varieties were collected from the Institute of Agricultural Research, Zaria, Kaduna State. The pods were shelled manually and screened to remove bad ones. The seeds were milled using a mechanical grinder, packed in an air-tight container and stored in desiccators to avoid moisture reabsorption until they were used for the analyses.

Seed quality

The seed quality, encompassing proximate composition and mineral quantification, was determined following the standard procedure. To ensure quality assurance, the chemicals used for this quantification were of analytical grade.

Proximate composition

Percentage moisture, ash, fibre, crude protein, crude fat, and carbohydrate as a measure of proximate composition were estimated according to the method of the Association of Official Analytical Chemists (AOAC, 2005). It should be emphasized here that the percentage carbohydrate content was

calculated by subtracting the sum of moisture, ash, protein, crude fat, and crude fibre percentage from hundred. The calorific value in each variety was estimated by multiplying the percentage protein and carbohydrate by 4 and that of fat by 9.

Mineral quantification

The dried sample (0.5 g) was transferred into the digestion glass tube. Ten milliliters (10 ml) of HNO₃ was added to the sample. The resulting mixture was kept overnight at room temperature. Thereafter, 4.0 ml perchloric acid (HClO₄) was added to the mixture and kept in a fume cupboard. The temperature was increased gradually starting from 50°C and increasing up to 300°C in the digestion unit. The digestion was achieved in about 70-80 minutes, as indicated by the appearance of the white fumes. The mixture was allowed to cool and transferred into 100 ml volumetric flasks, and the volume of the contents was made up to 100 ml with distilled water. The resulting solution was filtered. The filtrate was then used for the mineral determination. Nitrogen (N) was determined using micro Kjeldhal method. Sodium (Na), iron (Fe), magnesium (Mg), and zinc (Zn) were determined with the use of an Atomic Absorption Spectrophotometer (AAS) (Shimadzu, Japan AA-6200). Other mineral elements such as potassium (K) were determined by Flame Photometer (Bibby Scientific Limited, UK: Model No PFP7) following the method of Allen (1989).

Oil extraction

Milled seeds were dried to a constant weight in an oven at 105°C. The dried paste of each sample was transferred separately into a thimble. Oil extraction was carried out in a Soxhlet apparatus with petroleum ether as the solvent, and the physico-chemical properties were then determined.

Physical properties of oil

Specific gravity

A dry and empty specific gravity bottle was cleaned and weighed. It was filled with water, maintained at 25°C and then weighed again. Thereafter, the bottle was emptied, dried and filled with oil and then weighed at the same temperature. The value of specific gravity was calculated using the equation:

$$\text{Specific gravity} = \frac{\text{Weight of bottle and oil at } 25^{\circ}\text{C} - \text{weight of bottle at } 25^{\circ}\text{C}}{\text{weight of bottle at } 25^{\circ}\text{C}}$$

Refractive index

The refractive index was determined using a

refractometer (Erma hand refractometer) with a range of 0 to 32 % measuring capacity. A drop of the oil was placed on the surface of the refractometer, and the reading was taken (Ayo and Agu, 2012). The colour and odour of the various groundnut oils under investigation were determined at room temperature (25°C) by visual approach.

Chemical characteristics of oils

Iodine value

Dam's reagent 5 ml was added to 0.2 g of oil dissolved in 5 ml of chloroform. The mixture was kept in the fume cupboard for 10 minutes. 5 ml of 10% potassium iodide (KI) and 20 ml of water were then added. The mixture was thoroughly mixed and titrated to a colourless end point with 0.025 M of sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) solution. A blank (control) was treated in a similar way. The iodine value was calculated according to AOAC (2000).

Iodine value = $(B - S) \times N$ Weight of oil

Where, B= blank titre value, S= sample titre value and N = Normality of $\text{Na}_2\text{S}_2\text{O}_3$

Saponification value of oil extracts

Oil 0.5g was weighed in a quick-fit-reflux flask, and 25 ml alcoholic potassium hydroxide (KOH) was added. It was refluxed for 30 minutes. The flask was cooled, and 1ml of phenolphthalein indicator was added and titrated against 0.5 N hydrochloric acid (HCl). The saponification value was calculated using the formula below (Musa *et al.*, 2012).

$$\text{Saponification value} = \frac{56.1 \times (b-a) \times N}{\text{Weight of sample}}$$

Where W= weight of sample = 0.5 g, b = blank titre value, a= sample titre value, N= Normality of HCl

Determination of Acid Value

Exactly 2.0g $\text{Ba}(\text{OH})_2$ was added to 0.1M KOH solution and left for 5 minutes. The solution was cooled, filtered and stored in a plastic bottle. The resulting solution was standardized using 0.10M $\text{KHC}_8\text{H}_4\text{O}_4$ (potassium hydrogen phthalate) solution. The solvent mixture was neutralized with standard 0.1M KOH solution until a persistent faint pink colour appeared. Then 1.25g of the oil was transferred into a 250ml conical flask, and 125 ml of the solvent mixture was added to the sample. This was dissolved by agitation and warming on a steam bath. At this point, the pink colour disappeared and a clear solution was obtained. The solution was

titrated against the 0.1 M KOH solution. The endpoint was obtained by the restoration of the pink colour. The procedure was repeated three times, and the average endpoint was obtained (Birnin-yauri and Garba, 2011).

Determination of Peroxide Value

Peroxide value is used as a measure of the extent to which rancidity reactions have occurred during storage. The quality and stability of fats and oils can be indicated by using the peroxide value. In the study, soybean oils and palm oil showed the lower peroxide values in the range of 1-2 meq O_2/kg oil, which indicates a relatively good quality of these oils. On the other hand, mustard oils, castor oil, almond oil, and olive oil showed higher values in the range of 5-13 meq O_2/kg oil. There is a successive increase in peroxide value, indicating the rancidity of oils due to relatively higher oxidation in oils. Peroxide value ranges are closely related to the standard value of 10 meq O_2/kg as specified (Sabir *et al.*, 2016).

Statistical analysis

All the data were presented in triplicate (3n); Data collected were subjected to One-Way Analysis of Variance followed by a post-hoc-Duncan Multiple Range Test at $p < 0.05$. Results

RESULTS AND DISCUSSION

Varietal effect on proximate composition

The proximate composition and energy value, as indicated in Table 1, differed significantly by variety. Regardless of varietal effect, percentage moisture ranged from 9.86% to 10.07%, ash content from 1.20% to 1.80%, fibre content from 5.75% to 8.00%, protein content from 29.75% to 32.96% and fat ranged from 30.02% to 31.06% (Table 1). The carbohydrate and energy values ranged from 16.24% to 22.82% and 473.80 to 480.90 kcal, respectively. A critical look into the proximate data revealed that moisture contents were significantly at par for SAMNUTs 24 and 25 but higher than other varieties, where KAMPALA recorded significantly lowest moisture content. The recorded range value for moisture was higher than the range value of 4.14% to 5.46% obtained from local and improved varieties of groundnut grown in Nigeria in the study reported by Abdulbaki *et al.*, (2022) and Olayinka *et al.*, (2022). The high moisture contents recorded in this study, when compared to previous works, could be attributed to the number of days used in drying the seeds before the analysis was carried out.

Generally, samples with low moisture content are expected to have a shelf life longer than those with high moisture content (Ogunniyi, 2006). The reported ash content, which was statistically similar between SAMNUTs 23 and 24, was found to be significantly higher than in other varieties except KAMPALA. The range of ash values recorded in this study was lower than the value of 2.23% to 2.62% as reported by Abdulbaki *et al.*, (2022). SAMNUTs 23 and 26 showed significantly higher fibre contents than other varieties. Samples with high fibre are good sources of roughage that play an important role in peristaltic movement (Olayinka and Etejere, 2015). The protein and fat contents were higher in SAMNUTs 23 when compared to other varieties. Samples rich in protein and fat have been considered to be excellent for growth and development (Olayinka *et al.*, 2022). The carbohydrate ranged value was generally higher than the values (9.98 % to 15.41%) reported by Asibou *et al.*, (2008) and Olayinka *et al.*, (2022). The observed variation could be attributed to low fat accumulation in this study. Samples with high carbohydrate contents, especially SAMNUT 25 and KAMPALA, will be an excellent source of energy as indicated in their calorific values. The variation recorded among the varieties in all the proximate compositions could be attributed to environmental and genetic factors (Chelangat *et al.*, 2023).

Varietal effect on mineral elements

The mineral elements, in terms of macro and micro, showed significant variations among the varieties. Regardless of varietal differences, the seeds were richest in sodium (158.18 to 162.09 mg/100g) and followed in decreasing order of magnitude by those of phosphorus (130.90 to 160.00 mg/100g), potassium (118.13 to 120.39), magnesium (27.10 to 30.10 mg/100g), iron (12.01 to 12.68 mg/100g), zinc (2.11 to 2.99) and copper (2.00 to 2.09 mg/100 g). Among all the mineral elements, nitrogen was the lowest with a range value of 0.048 mg/100g in KAMPALA to 0.53 mg/100 g in SAMNUT 23 (Table 2). Varietal differences showed significantly greater amounts of all the mineral elements except phosphorus and zinc. Aside from iron, all other mineral elements were significantly higher in all the SAMNUT varieties when compared to the KAMPALA variety (Table 2.) Earlier researchers had reported that groundnut seeds are rich sources of mineral elements such as Potassium, Phosphorus, Magnesium and Sodium (Sufiyanu

and Na'ala, 2022). These elements, most importantly potassium, magnesium, and sodium, were abundant in all the SAMNUT varieties, particularly SAMNUT 23 and as such, useful for the overall wellbeing of humans and livestock. For instance, potassium plays an important role in osmoregulation, cell turgidity and enzyme activity (White and Karley, 2010). Magnesium has been established to be required by many enzymes, particularly the sugar and protein kinase families that catalyze ATP-dependent phosphorylation reactions (Chandran and Parimelazhagan, 2012). The Na/K ratio was greater than one, and this implies that caution needs to be taken on the consumption of groundnut seeds for patients with a history of cardiovascular challenges. This is because Na/K ratio in the body is of great concern for the prevention of high blood pressure. Na/K ratio less than one is recommended (Daffodil *et al.*, 2016). It should be noted that sodium and potassium are important intracellular and extracellular cations, respectively, which are involved in the regulation of plasma volume, acid-base balance, nerve and muscle contraction (Akpanyung, 2005). As earlier stated, the variation in mineral elements among the varieties could be attributed to genetic factors (Chelangat *et al.*, 2023).

Varietal effect on physico-chemical properties

Varietal effect on physico-chemical properties of the oil was not significantly different except for acid, iodine, and saponification values. In the oil properties determined, the acid, iodine and saponification values of SAMNUT 28 showed significantly the lowest values of the parameters (Table 3). The pH, specific gravity, refractive index, iodine value, peroxide value, acid value and saponification value ranged from 6.70 to 7.10, 0.89 to 0.94, 1.46 to 1.49, 95.08 to 103.83, 8.91 to 8.97, 4.52 to 5.66 and 188.62 to 190.71, respectively. These range values of the physico-chemical properties compared well with other varieties of groundnuts studied by other researchers (Musa *et al.*, 2010; Bello and Olawore, 2012; Hussain *et al.*, 2015; Abubaki *et al.*, 2022). However, slight variations that existed among the varieties were largely due to genetic and environmental factors (Chelangat *et al.*, 2023). It should be noted that the determination of oil quality indicates the condition and edibility of the oil (Adesipe-Olugbemi and Makanjuola, 2019).

TABLE 1: PROXIMATE COMPOSITION OF FIVE GROUNDNUT VARIETIES

Varieties	Moisture	Ash	Fibre	Protein	Fat	Carbohydrate	Energy value (kcal)
KAMPALA	9.86d	1.80b	5.75c	29.75b	30.02c	22.82a	480.46a
SAMNUT 23	9.95c	1.79a	8.00a	32.96a	31.06a	16.24c	476.34b
SAMNUT 24	10.07a	1.76a	7.06b	30.30b	30.97a	19.84b	479.29a
SAMNUT 25	10.05a	1.20d	7.30b	30.34b	31.02c	20.09ab	480.90a
SAMNUT 28	9.99b	1.74c	7.97a	31.50ab	30.52b	18.28c	473.80b
SE	0.021	0.061	0.225	0.376	0.126	0.658	0.860
P-value	<0.0001	<0.0001	<0.0001	0.002	<0.0001	<0.0001	<0.0001

Means followed by the same letter within the column are statistically similar at $p < 0.05$

TABLE 2: MINERAL ELEMENTS IN THE SEEDS OF FIVE GROUNDNUT VARIETIES

Varieties	N	P	K	Mg	Cu	Fe	Zn	Na
KAMPALA	0.048b	130.9c	118.13b	27.99d	2.00d	12.44b	2.11c	158.18c
A								
SAMNUT 23	0.053a	152.1b	120.37a	30.10a	2.09a	12.68a	2.16b	162.09a
SAMNUT 24	0.049b	160.0a	120.09a	28.2d	2.02ab	12.00c	2.99a	160.00b
SAMNUT 25	0.049b	160.0a	120.02a	29.02c	2.03b	12.02c	2.13bc	160.09b
SAMNUT 28	0.050ab	159.8a	120.00a	29.73b	2.09a	12.01c	2.13bc	159.82b
SE	.0001	19.09	0.22	0.22	0.01	0.01	0.09	0.34
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Means followed by the same letter within the column are statistically similar at $p < 0.05$

TABLE 3: PHYSICAL PROPERTIES OF THE OILS IN THE FIVE GROUNDNUT VARIETIES

Varieties	pH	SG	RI	IV	PV	AV	SV
KAMPALA	6.70a	0.89a	1.46a	103.20a	8.91a	5.63a	190.24a
SAMNUT 23	6.80a	0.93a	1.49a	103.37a	8.93a	5.65a	190.28a
SAMNUT 24	7.10a	0.91a	1.48a	103.40a	8.92a	5.65a	190.27a
SAMNUT 25	6.90a	0.94a	1.47a	103.83a	8.92a	5.66a	190.71a
SAMNUT 28	6.80a	0.92a	1.47a	95.08b	8.97a	4.52b	188.62b
SE	0.036	0.005	0.003	0.897	0.742	0.120	0.240
p-value	0.15	0.13	0.23	<0.0001	<0.13	<0.000	0.02

1

Means followed by the same letter within the column are statistically similar at $p < 0.05$

KEY: SG= Specific gravity, RI= Refractive index, IV= iodine value, PV=peroxide value, AV.= Acid value and SV= Saponification value

CONCLUSION

The results of this work have demonstrated that all the SAMNUT varieties, particularly SAMNUT 23, 24 and 25, exhibited superior nutritional contents, in terms of proximate and mineral composition, physico-chemical properties of the oil, making them promising candidates for use in seed certification and breeding programmes in regions where protein and mineral deficiencies are prevalent.

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