

# Nutritional, Phytochemical, and Toxicological Evaluation of Black Olives (*Canarium schweinfurthii*) Seed Kernel: A Potential Resource from Environmental Waste

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## Abstract

*Canarium schweinfurthii* (black olive) seed is an underutilized tropical seed often discarded as waste despite its nutritional and medicinal potential. This study evaluated the nutritional, phytochemical, mineral, amino acid, and toxicological properties of *C. schweinfurthii* seed kernel using standard methods. Proximate analysis showed moisture (7.12%), ash (3.10%), crude fibre (12.14%), crude fat (38.23%), protein (22.10%), carbohydrate (10.11%), dry matter (92.88%), and energy value (472.91 kcal/100g), indicating a nutrient-dense profile. Phytochemical screening revealed the presence of saponins, tannins, flavonoids, alkaloids, cardiac glycosides, phenolics, and steroids. Quantitative values were tannins (355.27 ± 0.24 mg/100g), flavonoids (351.00 ± 0.67), alkaloids (321.10 ± 0.01), cardiac glycosides (321.00 ± 0.11), resins (248.00 ± 0.21), and saponins (29.50 ± 0.05). Mineral analysis indicated calcium (36.1 ± 0.03), potassium (24.2 ± 0.02), phosphorus (18.0 ± 0.04), magnesium (16.0 ± 0.01), sodium (10.2 ± 0.01), zinc (8.0 ± 0.01), iron (7.4 ± 0.01), copper (4.3 ± 0.00), manganese (0.2 ± 0.00 mg/100g), with undetectable lead and cadmium, affirming its safety. Amino acid profiling revealed total amino acids (97.63 ± 0.18 g/100g protein), including phenylalanine (9.10), isoleucine (8.10), arginine (7.01), leucine (6.10), histidine (5.81), aspartic acid (13.25), and glutamic acid (12.12). Acute toxicity studies showed no adverse effects at 5000 mg/kg, indicating non-toxicity. These results support the valorization of *C. schweinfurthii* seed

kernel as a safe, nutrient-rich resource for functional food applications.

## Keywords

*Canarium schweinfurthii*, Seed Kernel, Proximate, Nutritional, Toxicological, Mineral, Amino Acid Profile

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## 1. Introduction

Plant-based by-products, often generated during food processing and transformation, include components such as seeds, husks, peels, and spent plant materials like tea and coffee grounds [1]. Once considered waste, these residues are now increasingly recognized for their nutritional and functional potential. Rich in dietary fiber, bioactive compounds, and essential nutrients, they are being repurposed into innovative food applications that support sustainable development and efficient resource use. Their integration into food systems, particularly in functional foods and edible packaging, aligns with global goals to minimize food waste while enhancing nutritional value [2]-[4]. These efforts also support circular nutrition models, where by-products from one process serve as raw materials for another, reducing environmental burdens such as greenhouse gas emissions [5].

Within the field of nutrition and health sciences, these plant by-products are being increasingly explored as affordable, health-promoting ingredients. Their application offers a dual advantage, improving consumer well-being and adding economic value for food producers. As highlighted by [6], functional ingredients derived from plant residues have the potential to fortify food products and address nutritional deficiencies. Moreover, numerous studies are now investigating the therapeutic potential of these by-products in managing chronic diseases such as diabetes and metabolic disorders [6] [7]. This growing body of research underscores the importance of re-evaluating plant residues not just as waste, but as valuable nutritional assets in the development of sustainable, health-oriented food systems.

The nutritional relevance of plant seeds is largely attributed to their macronutrient content such as proteins, lipids, and carbohydrates as well as their micronutrients and bioactive compounds [8] [9]. In this context, *Canarium schweinfurthii*, commonly referred to as the African elemi or “atili” in Hausa, has gained attention for its promising nutritional properties. The structural morphology of Black Olives (*Canarium schweinfurthii*), illustrating the entire plant and seeds with intact pulp (A), seeds without pulp and partially consumed pulp (B), as well as cracked and uncracked seeds with the exposed inner kernel (C) is shown in **Figure 1**. Prior investigations have reported that its fruit yields a substantial amount of oil, reaching up to 68%, along with a moderate protein content ranging from 6% - 9% [10], suggesting its potential for addressing nutritional deficiencies, especially in resource-limited settings. Although seeds of other plants are frequently

used in traditional African diets as sources of protein and energy [11], [12]. The nutritional value of *C. schweinfurthii* seeds remains insufficiently characterized. Detailed exploration of their amino acid composition, lipid profile, and mineral content could uncover their utility as a functional food ingredient or dietary supplement, especially in regions where nutrient diversification is a challenge.

In many rural Nigerian communities, especially those in arid and semi-arid zones, indigenous fruits like *C. schweinfurthii* serve as essential components of daily diets and household economies. Ethnobotanical records emphasize the local importance of *Canarium* species for both medicinal and nutritional purposes, as the seeds are reported to contain not only healthy fats and natural flavor compounds but also vitamins, minerals, and antioxidants [13]. The tree is native to tropical Africa and thrives in various Nigerian states such as Plateau, Bauchi, Niger, and Southern Kaduna, where its fruits are abundantly harvested during the rainy season, typically between April and September. Commonly known as “ube okpoko” in Igbo and “atili” in Hausa, the fruit is typically consumed after boiling to soften the pulp, from which a high-quality oil is extracted. Notably, the oil is characterized by low acid and peroxide values, making it a promising candidate for use as a vegetable cooking oil or for industrial applications [13]. Despite its traditional use, the nutritional potential of *Canarium schweinfurthii* seed kernels remains poorly documented. Scientific data on safety are limited, hindering their validation as a functional food. Comprehensive evaluation is therefore essential to unlock their potential role in promoting food security and public health through sustainable nutrition.



(A) [14]



(B)



**Figure 1.** The structural illustration of Black Olives (*Canarium schweinfurthii*) illustrating the entire plant and seeds with intact pulp (A), seeds without pulp and partially consumed pulp (B), as well as cracked and uncracked seeds with the exposed inner kernel (C).

## 2. Materials and Methods

### 2.1. Sample Collection, Taxonomic Identification, and Pre-Analytical Preparation

Mature fruits of *Canarium schweinfurthii* (commonly known as African black olive) were collected from a local farmer in Pankshin Local Government Area, Plateau State, Nigeria. The botanical identity of the fruit was authenticated by Mr. Jeffrey Joseph Azila, a certified taxonomist at the Federal College of Forestry, Jos, Nigeria, and a voucher specimen was archived for future reference. Authenticated samples were transported to the Biochemistry Laboratory of Plateau State University, Boko, Nigeria, for processing. Initial sorting was conducted manually to eliminate damaged or spoiled fruits. Selected healthy fruits were soaked in warm water at 65°C for 20 minutes to soften the outer pulp. The pulp was then carefully removed using a sterile stainless-steel knife, and residual mesocarp was eliminated by washing thoroughly with distilled water. Clean seeds were manually cracked under controlled laboratory conditions using a food-grade stainless-steel hammer to obtain intact seed kernels. Viable kernels were carefully selected, separated, and preserved under appropriate conditions. The extracted kernels were then ground into a fine powder using a Marlex Excella laboratory grinder. The resulting sample was transferred into sterile, airtight, screw-capped plastic containers and refrigerated at 4°C until further analysis.

### 2.2. Determination of Proximate Composition

The moisture, crude protein, fibre, fat, and ash contents were determined according to the method of the Association of Official Analytical Chemists [15]; and carbohydrate was determined by difference.

### 2.3. Determination of Qualitative and Quantitative Phytochemical Composition

Preliminary qualitative phytochemical screening was carried out to detect the presence of major secondary metabolites, including alkaloids, flavonoids, tannins, saponins, terpenoids, phenols, and glycosides. The procedures followed standard protocols as described by [16], which involved colorimetric and precipitation reactions indicative of each phytochemical group. Quantitative estimation of the phytochemicals was performed using the gravimetric method as outlined by [17]. This involved solvent extraction of the plant material followed by drying and weighing of the isolated phytochemical constituents. Specific groups such as alkaloids, saponins, and flavonoids were individually quantified to determine their relative abundance in the sample.

### 2.4. Determination of Mineral Composition

Atomic Absorption Spectrophotometry (AAS) method was adopted for analysis of minerals *i.e.* Ca, Mg, Zn, Fe, Cu, Pb, Mn, and Cd, while Na and K were analyzed using flame photometry, and P was analyzed using the vanado-molybdate method.

### 2.5. Determination of Amino Acid Profile

The amino acids were quantitatively measured by the method described by [18], using an automatic amino acid analyzer (Technico TSM Sequential Multisample Analyzer).

### 2.6. Acute Toxicity Study (LD<sub>50</sub> Determination)

The acute oral toxicity assessment was conducted in accordance with the standard method described by [19] as reported by [20], to determine the median lethal dose (LD<sub>50</sub>) of the Black Olive seed aqueous extract. The study was carried out in two distinct phases using adult mice. In the first phase, nine mice were randomly divided into three groups ( $n = 3$  per group) and administered graded doses of the aqueous extract of Black Olive seeds (e.g., 10, 100, and 1000 mg/kg body weight) orally. The animals were observed for signs of toxicity, behavioural changes, and mortality over a 24-hour period. Based on the results of the first phase, a second phase was conducted using refined doses (1600, 2900, and 5000 mg/kg) administered to an additional set of mice. Observations were continued for another 24 hours and subsequently for up to 14 days to monitor delayed toxicity or mortality. The LD<sub>50</sub> was calculated as the geometric mean of the lowest dose that caused death and the highest dose at which no mortality was observed.

### 2.7. Statistical Analysis

All experimental data were expressed as mean  $\pm$  standard deviation (SD) based on triplicate determinations ( $n = 3$ ). Statistical analysis was performed using one-way analysis of variance (ANOVA) to evaluate significant differences be-

tween groups. Post hoc comparisons, where applicable, were conducted to determine the specific differences among means. Analyses were carried out using the Statistical Package for the Social Sciences (SPSS), version 16.0 (SPSS Inc., Chicago, IL, USA). A p-value of less than 0.05 ( $p < 0.05$ ) was considered statistically significant.

### 3. Results and Discussion

**Table 1.** Proximate Composition (%) of *Canarium schweinfurthii* (Black olive) Seeds kernel.

Parameters	Results
Moisture	7.12 ± 0.01
Ash	3.10 ± 0.01
Crude fibre	12.14 ± 0.02
Crude fat	38.23 ± 0.01
Protein	22.10 ± 0.02
Carbohydrate	10.11 ± 0.02
Dry matter	92.88 ± 0.03
Energy Kcal/100g	472.91 ± 8.15

Mean ± standard deviation of the triplicate determinations (n = 3).

The proximate composition of *Canarium schweinfurthii* seed kernel is presented in **Table 1**. Moisture content, which indicates the amount of water in a sample, plays a crucial role in determining storage stability. A moderate to low moisture level generally suggests a reduced risk of microbial spoilage and extended shelf life [21]. The moisture content of *C. schweinfurthii* seed kernel was found to be 7.12%, which is comparatively lower than the 8.07% reported for soybean nuts [17], and the 10.99%, 9.68%, and 5.12% reported for raw, boiled, and roasted *Tre-culia africana* seeds, respectively [22]. It is also notably lower than the 16.66% recorded for *Vitex doniana* pulp [23]. This relatively low moisture content suggests that the kernel is less susceptible to microbial contamination and has prolonged storage potential. Nonetheless, it should be stored in a cool, dry environment to avoid moisture reabsorption, mechanical damage, and loss of viability. Ash content reflects the total mineral composition of a food sample and is indicative of its inorganic nutrient profile. The ash content of the *Canarium schweinfurthii* seed kernel was found to be 3.10%, which is relatively higher than that of the seed pulp, which recorded 1.86 [21], and 2.8% reported for cashew nuts (*Anacardium occidentale*) by [21], and the 2.1% recorded for the fruit of *Nauclea latifolia* by [21]. This suggests a potentially richer mineral composition. In addition to its low moisture content, the seed kernel also demonstrated appreciable levels of lipids, proteins, and carbohydrates, highlighting its nutritional significance and potential value as a food or nutraceutical ingredient. The crude fibre content of *Canarium*

*schweinfurthii* seed kernel was determined to be 12.14%, which is significantly higher than the value reported for the seed pulp by [21]. This value also surpasses the crude fibre content found in soybeans, as documented by [24], and is notably greater than the 1.4% reported for cashew nuts [21]. Furthermore, it exceeds the values reported for *Treculia africana* seeds under different processing methods 1.44% (raw), 1.04% (boiled), and 1.19% (roasted)—as reported by [21]. The high crude fibre content observed in *Canarium schweinfurthii* seed kernel (12.14%) indicates its potential as a valuable dietary fibre source, surpassing several commonly consumed seeds and legumes. This suggests its usefulness in promoting gastrointestinal health and aiding in dietary fibre supplementation. The crude fat content of *Canarium schweinfurthii* seed kernel was found to be 38.23%, indicating a substantial lipid composition. This value is notably higher than that of soybeans, as reported by [22], yet slightly lower than the 42.8% recorded for cashew nuts by [21], and considerably lower than the fat content range of 46.20% - 49.34% reported for *Mucuna* species by [25]. However, it is relatively comparable to the 34.62% fat content observed in *Vitex doniana*, as documented by [24]. The high fat content of *C. schweinfurthii* seed kernel suggests its potential utility as a promising source of edible oils. Moreover, its lipid profile makes it a viable candidate for incorporation into high-fat food formulations such as margarine, shortening, and other industrial food products requiring stable oil matrices. The crude protein content of *Canarium schweinfurthii* seed kernel was determined to be 22.10%, reflecting a moderate level of protein relative to commonly consumed plant protein sources. This value is lower than the protein content reported for the seeds of *Moringa oleifera* (40.1%), *Detarium microcarpum* (35.96%), and *Bauhinia monandra* (33.09%), as documented by [26]. However, it is comparable to the protein content of several widely consumed legumes, including cowpea (22.7%), chickpea (19.4%), lima beans (19.8%), and big brown beans (21.3%), as reported by [27]. Additionally, it surpasses the 8.24% protein content recorded for the fruit of *Vitex doniana* [24]. These findings suggest that *C. schweinfurthii* seed kernel could serve as a valuable supplementary protein source in regions where access to conventional legumes or animal proteins is limited. The carbohydrate content of the *Canarium schweinfurthii* seed kernel was determined to be 10.11%, which is notably lower than the 16.31% reported for soybeans [22], as well as the 17.24% observed in the seed pulp of *C. schweinfurthii*. This comparatively low carbohydrate content may be advantageous, particularly in the context of developing functional foods or dietary formulations aimed at individuals with metabolic disorders such as diabetes or obesity. Foods with reduced carbohydrate levels are associated with lower glycemic responses and may contribute to better blood glucose regulation and weight management. Therefore, the *C. schweinfurthii* seed kernel, with its low carbohydrate profile, could be a suitable candidate for incorporation into low-glycemic or energy-restricted diets.

Qualitative phytochemical screening of the crude aqueous extract of *Canarium schweinfurthii* seed kernel as shown in **Table 2** revealed the presence of several

bioactive secondary metabolites. The analysis confirmed the presence of saponins, tannins, flavonoids, alkaloids, cardiac glycosides, phenolic compounds, and steroids. These constituents are known to contribute to various pharmacological effects, including antioxidant, anti-inflammatory, and cardioprotective activities. Notably, anthracene glycosides (also referred to as anthraquinone glycosides) were absent in the seed kernel extract, as indicated by negative results in standard phytochemical detection assays. The absence of these compounds, which are typically associated with strong laxative effects and potential gastrointestinal irritation, may enhance the safety profile of the extract for potential therapeutic use. The diversity of phytochemicals identified supports the potential of *C. schweinfurthii* seed kernel as a valuable source of natural compounds for pharmacological and nutraceutical applications.

**Table 2.** Qualitative phytochemical composition of *Canarium schweinfurthii* (Black olive) seed kernel.

Test	<i>C. schweinfurthii</i> seed kernel
Anthracene glycosides	–
Saponins	+
Tannins	+
Flavonoids	+
Alkaloids	+
Cardiac Glycosides	+
Phenolic group	+
Steroids	+

KEY: – = Absent Negative result + = Positive Result.

**Table 3.** Quantitative phytochemical composition of *Canarium schweinfurthii* (Black olive) seed kernel.

Parameters	Result (mg/100 g)
Saponins	29.50 ± 0.05
Tannins	355.27 ± 0.24
Resin	248.00 ± 0.21
Alkaloid	321.10 ± 0.01
Cardiac glycosides	321.00 ± 0.11
Flavonoid	351.00 ± 0.67

The values represent means ± standard deviation of three determinations.

The quantitative phytochemical analysis of *Canarium schweinfurthii* seeds (**Table 3**) reveals a rich diversity of bioactive compounds, supporting the plant's ethnomedicinal relevance and potential nutraceutical value. The presence of high concentrations of secondary metabolites such as tannins, flavonoids, alkaloids,

and cardiac glycosides indicates the pharmacological potential of the seeds. Tannins were the most abundant phytochemical component ( $355.27 \pm 0.24$  mg/100g). Tannins are polyphenolic compounds known for their antioxidant, antimicrobial, and anti-inflammatory properties. Their high levels in *C. schweinfurthii* seeds suggest strong free radical scavenging potential, which could be exploited in the prevention and management of oxidative stress-related diseases [28]. Moreover, tannins contribute to astringency and have been traditionally used in wound healing and treatment of gastrointestinal disorders [29]. Flavonoids were also significantly present ( $351.00 \pm 0.67$  mg/100g), further enhancing the antioxidant profile of the seeds. Flavonoids exhibit antioxidant, anti-inflammatory, and anticancer properties, which collectively decrease the risk of various diseases [30]. Their high levels may support the traditional use of *C. schweinfurthii* in managing inflammatory and respiratory disorders, and suggest potential in functional food formulations aimed at chronic disease prevention. Alkaloids ( $321.10 \pm 0.01$  mg/100g) and cardiac glycosides ( $321.00 \pm 0.11$  mg/100g) were also abundantly detected. Alkaloids are nitrogen-containing compounds with potent pharmacological effects, including analgesic, antimicrobial, and cytotoxic activities [31]. Their presence implies potential application in the development of antimicrobial or anticancer agents. Cardiac glycosides, as the name suggests, were originally used in the clinical treatment of heart failure. Their mechanism involves increased intracellular sodium levels, which result in enhanced sodium-calcium exchange, leading to elevated intracellular calcium levels and increased myocardial contractility [32]. However, their narrow therapeutic index requires caution in pharmacological applications. The seeds also contained considerable amounts of resins ( $248.00 \pm 0.21$  mg/100g), which have been reported to possess antimicrobial, anti-inflammatory, and expectorant properties [33]. The substantial resin content may contribute to the seed's traditional use in treating respiratory ailments, possibly aiding mucolytic activity and easing bronchial constriction. Saponins, although present in relatively lower concentrations ( $29.50 \pm 0.05$  mg/100g), exhibit diverse pharmacological activities, including anti-tumor, anti-inflammatory, hypocholesterolemic, and hypoglycemic attributes. Due to their antimicrobial, antifungal, molluscicidal, and anti-parasitic properties, saponins play a crucial role in the defensive systems of plants [34]. Specific saponin subtypes, such as dioscoresides, are linked to cardiovascular and cerebrovascular protection, while others like pseudo-protodioscin, dioscin, and gracillin, have therapeutic potential for rheumatism and chronic diseases [35]. Collectively, these findings demonstrate that *Canarium schweinfurthii* seeds are a rich source of phytochemicals with potential pharmacological and therapeutic applications. The significant presence of tannins, flavonoids, alkaloids, and cardiac glycosides provides scientific justification for the plant's traditional use in African ethnomedicine. These bioactive constituents suggest that the seeds could serve as a valuable raw material for developing nutraceuticals, phytopharmaceuticals, or functional food products aimed at managing oxidative stress, cardiovascular disorders, and inflammatory conditions.

**Table 4.** Mineral composition of *Canarium schweinfurthii* (Black olive) seed kernel.

Minerals	Results
Potassium	24.2 ± 0.02
Calcium	36.1 ± 0.03
Sodium	10.2 ± 0.01
Iron	7.4 ± 0.01
Magnesium	16.0 ± 0.01
Zinc	8.0 ± 0.01
Copper	4.3 ± 0.00
Lead	BDL
Manganese	0.2 ± 0.00
Phosphorous	18.0 ± 0.04
Cadmium	BDL

Mean ± standard deviation of the triplicate determinations (n = 3).

The mineral profile of *Canarium schweinfurthii* seed kernel as shown in **Table 4** reveals significant concentrations of essential macro- and micro-elements, underscoring its potential as a nutritionally valuable component of the human diet. Among the macronutrients, potassium (K) was present in appreciable amounts (24.2 ± 0.02 mg/100g) in the seed kernel, exceeding the value reported for the pulp (21.4 ± 0.02 mg/100g) by [21]. Potassium, as a vital intracellular cation, plays a central role in maintaining osmotic balance, regulating nerve impulse transmission, and facilitating muscle contraction [36]. The higher potassium content in the kernel suggests a greater capacity to support cardiovascular health, particularly in blood pressure modulation. Calcium (Ca) was also found in substantial quantities in the seed kernel (36.1 ± 0.03 mg/100g), higher than the amount in the pulp (32.0 ± 0.03 mg/100g) as reported by [21]. These levels are comparable to those found in calcium-rich legumes such as soybean (*Glycine max*), further emphasizing the potential of *C. schweinfurthii* as a dietary calcium source in calcium-deficient populations [22]. Calcium is indispensable for skeletal development, neuromuscular function, and cellular signaling. In contrast, the sodium (Na) content of the seed kernel (10.2 ± 0.01 mg/100g) was lower than that of the pulp (15.3 ± 0.01 mg/100g) [21]. Sodium plays a key role in extracellular fluid regulation and neuromuscular excitability; however, excessive intake has been implicated in the etiology of hypertension and cardiovascular diseases [37]. The moderate sodium concentrations in both parts of the fruit suggest a beneficial contribution to dietary sodium intake without posing a substantial risk. The iron (Fe) content was notably higher in the seed kernel (7.4 ± 0.01 mg/100g) compared to the pulp (5.6 ± 0.01 mg/100g) [21]. Iron is essential for hemoglobin synthesis and oxygen transport, and its adequate intake is critical in preventing iron-deficiency anemia, a condition still prevalent in sub-Saharan Africa [38]. Similarly, the seed kernel contained higher levels of zinc (Zn) (8.0 ± 0.01 mg/100g) and copper (Cu) (4.3 ± 0.00

mg/100g) than the pulp ( $6.3 \pm 0.01$  mg/100g and  $2.1 \pm 0.00$  mg/100g, respectively) [21]. Both trace elements are integral to immune function, antioxidant defense, and various enzymatic activities, highlighting the superior micronutrient density of the kernel. Conversely, magnesium (Mg) was found in lower amounts in the kernel ( $16.0 \pm 0.01$  mg/100g) compared to the pulp ( $24.0 \pm 0.02$  mg/100g) [21]. Magnesium is a cofactor in over 300 enzymatic reactions, including those involved in energy metabolism and neuromuscular transmission [39]. Despite the relatively lower content in the kernel, it remains a valuable dietary source of magnesium. The phosphorus (P) content in the kernel was slightly higher ( $18.0 \pm 0.04$  mg/100g) than in the pulp ( $16.8 \pm 0.04$  mg/100g) as reported by [21]. Phosphorus contributes to bone mineralization and is a key component of ATP and nucleic acids, thus playing a central role in energy production and genetic function [40]. Manganese (Mn) was detected in trace amounts in the seed kernel ( $0.2 \pm 0.00$  mg/100g), while the pulp had a slightly higher concentration ( $0.3 \pm 0.00$  mg/100g) [21]. Manganese supports bone development and is essential for the activity of antioxidant enzymes such as superoxide dismutase [41]. Importantly, both lead (Pb) and cadmium (Cd) were below detectable limits (BDL) in the seed kernel. The absence of these toxic heavy metals suggests minimal environmental contamination and affirms the safety of the seed kernel for human consumption. This finding aligns with international food safety standards established by [42], further supporting the suitability of *C. schweinfurthii* as a functional food ingredient. Overall, the *C. schweinfurthii* seed kernel exhibits a rich mineral profile, particularly in calcium, potassium, iron, zinc, and copper, while maintaining safe levels of potentially harmful heavy metals. These findings reinforce the kernel's potential in combating micronutrient deficiencies and its value in the development of nutraceuticals and functional foods (Table 5).

**Table 5.** Amino acid composition of *canarium schweinfurthii* (Black olive) seed kernel.

Amino acid	Results
Lysine*	$4.01 \pm 0.01$
Histidine*	$5.81 \pm 0.01$
Arginine*	$7.01 \pm 0.01$
Aspartic acid	$13.25 \pm 0.02$
Threonine*	$2.70 \pm 0.00$
Serine	$2.77 \pm 0.00$
Glutamic acid	$12.12 \pm 0.02$
Proline	$2.43 \pm 0.01$
Glycine	$3.98 \pm 0.02$
Alanine	$3.60 \pm 0.02$
Cysteine*	$2.30 \pm 0.00$
Valine*	$5.00 \pm 0.02$
Methionine*	$2.53 \pm 0.01$

## Continued

Isoleucine*	8.10 ± 0.02
Leucine*	6.10 ± 0.01
Tyrosine	2.62 ± 0.01
Phenylalanine*	9.10 ± 0.02
<b>Total amino acids</b>	<b>97.63 ± 0.18</b>

Mean ± standard deviation of the triplicate determinations (n = 3).

**Table 6.** Classification of Amino Acid Composition of *Canarium sweinfurthii* Seeds kernel.

Classifications	Results
Total amino acid (TAA)	97.63
% (TAA)	100.0
Total essential amino acid (TEAA)	43.35
% (TEAA)	44.39%
Total Non-Essential + Conditional (TNEAA)	(38.15 + 11.93)
(TNEAA)	54.28 g
% (TNEAA)	55.6%

The amino acid composition of *Canarium schweinfurthii* seed kernel as shown in **Table 6** revealed a total amino acid (TAA) content of  $97.63 \pm 0.18$  g/100 g protein, indicating a protein profile rich in both essential and non-essential amino acids. This high TAA suggests that the seed kernel possesses substantial nutritive potential, especially in regions where dietary protein intake is inadequate. Essential amino acids (EAAs), which must be obtained through the diet, accounted for 43.35 g/100 g protein, representing 44.39% of the total amino acids. This proportion aligns with the [43] recommendation that essential amino acids should constitute at least 40% of total amino acids in a high-quality protein source. Particularly noteworthy among the EAAs were phenylalanine (9.10 g), isoleucine (8.10 g), and leucine (6.10 g), all of which are branched-chain amino acids vital for muscle protein synthesis and metabolic regulation [44]. The non-essential and conditionally essential amino acids comprised 54.28 g/100 g protein, making up 55.61% of the total amino acid content. Aspartic acid (13.25 g) and glutamic acid (12.12 g) were the most abundant amino acids in the kernel, consistent with their roles in nitrogen metabolism and neurotransmission [45]. Other notable non-essential amino acids included glycine (3.98 g) and alanine (3.60 g), which are important for collagen synthesis and glucose metabolism, respectively. When compared with the seed pulp composition reported by [21], which had a TAA of 83.01 g/100 g protein, the seed kernel exhibited a higher overall amino acid content, confirming its superior protein quality. The kernel also contained higher levels of several key EAAs: lysine (4.01 vs. 3.51 g), arginine (7.01 vs. 6.09 g), methionine (2.53 vs. 1.63 g), and phenylalanine (9.10 vs. 8.63 g). These differences are significant, particularly for lysine and methionine, which are often limiting in plant-based diets [46].

Interestingly, while the kernel had a slightly lower percentage of EAAs (44.39%) compared to the pulp (54.39%), the absolute quantity of EAAs was higher in the kernel (43.35 g vs. 45.15 g in pulp), indicating a greater total amino acid pool. The pulp also exhibited a lower concentration of sulfur-containing amino acids, particularly cysteine (0.80 g), compared to 2.30 g in the kernel, which is essential for the synthesis of glutathione, a key antioxidant. These findings demonstrate that *Canarium schweinfurthii* seed kernel is a promising source of high-quality plant protein, offering a broader spectrum and higher concentration of amino acids compared to the pulp. Given the global interest in alternative and sustainable protein sources, the seed kernel could be utilized in functional foods, protein supplements, or dietary fortification programs.

**Table 7.** Results of Acute Oral Toxicity Test (LD<sub>50</sub> Determination) of aqueous seed kernel extract of *Canarium schweinfurthii* (Black Olive) with mice as described by Lorke (1983).

	Dose (mg/kg)	Mortality
Stage one	10	0/3
	100	0/3
	1000	0/3
Stage two	1600	0/1
	2900	0/1
	5000	0/1

The acute oral toxicity of the crude aqueous seed kernel extract of *Canarium schweinfurthii* as shown in **Table 7** was assessed using the method described by [19]. In the initial phase of the experiment, no mortality or observable signs of toxicity such as piloerection, tremors, salivation, lethargy, or altered locomotor activity were recorded in any of the three groups of mice administered 10, 100, and 1000 mg/kg body weight of the extract. In the second phase, higher doses of 1900, 2600, and 5000 mg/kg body weight were administered, and similarly, no clinical signs of toxicity or behavioural abnormalities were observed across all treatment groups throughout the 24-hour and 14-day observation periods. These findings indicate that the crude aqueous extract is well tolerated and exhibits no acute toxic effects at doses up to 5000 mg/kg body weight. Accordingly, the median lethal dose (LD<sub>50</sub>) is estimated to be greater than 5000 mg/kg, suggesting that the extract is practically non-toxic according to the classification criteria of Lorke.

#### 4. Conclusion

The seed kernel of *Canarium schweinfurthii* demonstrates remarkable nutritional quality, characterized by high crude protein content and a complete amino acid profile rich in essential and non-essential amino acids; it is further endowed with vital minerals such as calcium (36.1 mg/100g), potassium (24.2 mg/100g), and iron (7.4 mg/100g), which are essential for metabolic and physiological functions. Qualita-

tive and quantitative phytochemical analyses revealed the presence of key bioactive compounds, including flavonoids, alkaloids, tannins, and cardiac glycosides, indicating significant therapeutic and antioxidant potential. Importantly, acute oral toxicity assessment showed no mortality or adverse effects at doses up to 5000 mg/kg, establishing its safety for potential dietary and nutraceutical use. These findings support the utilization of *C. schweinfurthii* seed kernel as a nutritionally rich, pharmacologically promising, and toxicologically safe candidate for functional food development and waste-to-resource bioconversion.

## Statement

Figure B and C. Image Created by the Author Solomon (2025).

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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