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Proximate, mineral and vitamin composition of *Uvaria chamae* P. Beauv. (Annonaceae) seed flour from Korhogo, northern Côte d'Ivoire

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ABSTRACT

Uvaria chamae P. Beauv. (Annonaceae) is a wild shrub widely distributed in the savannas and forest edges of West Africa, whose seeds remain largely underutilised despite the recognised ethnomedicinal value of the species. This study aimed to determine the proximate, mineral and vitamin composition of seed flour from *Uvaria chamae* fruits harvested at three sites (Kpatrakaha, Lamehkaha and Natio) in the Korhogo department, northern Côte d'Ivoire. Seeds separated from 253 ripe fruits collected between June and August 2025 were dried and ground into powder. Physicochemical parameters were determined according to AOAC methods, mineral elements by plasma emission spectrometry, and vitamins by HPLC, with each analysis performed in triplicate. The results indicated 93.30 ± 0.02% dry matter, 10.17 ± 0.06% lipids, 0.76 ± 0.01% protein, 2.84 ± 0.04% ash and 79.54 ± 0.53% carbohydrates, corresponding to an energy value of 412.73 ± 1.95 kcal/100 g. Calcium (477.61 mg/kg) and potassium (425.39 mg/kg) were the predominant minerals, followed by magnesium, manganese, phosphorus, sodium, zinc and iron. The flour was particularly rich in vitamin C (23.75 ± 0.25 mg/100 g) and vitamin E (4.45 ± 0.05 mg/100 g), and also contained appreciable amounts of B-group vitamins (B1, B2, B3, B6, B9), while vitamin B5 remained below the limit of quantification. These results indicate that *Uvaria chamae* seed flour is an energy-dense resource, rich in minerals and vitamins, with strong potential for valorisation as a functional food ingredient or nutritional supplement contributing to food and nutrition security in northern Côte d'Ivoire.

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INTRODUCTION

Food and nutrition security in sub-Saharan Africa increasingly relies on the valorisation of underused wild plant species that grow spontaneously and require little or no agricultural input (Bvenura and Afolayan, 2015; Agbebi *et al.*, 2022). This need is particularly acute in northern Côte d'Ivoire, a Sahel-fringe region where severe malnutrition is reported to affect approximately 39.3% of the population and where the poverty rate reaches 46%, well above levels observed elsewhere in the country (Kone *et al.*, 2025). At the national level, repeated household surveys report persistently high rates of anaemia, vitamin A deficiency and stunting among children under five, reflecting a chronic burden of micronutrient deficiencies that current diets fail to address (Leyvraz *et al.*, 2016; FAO, 2024). In this context, wild food resources, which require neither irrigation, fertiliser nor phytosanitary inputs and which can be harvested during lean seasons, represent a valuable and currently under-exploited lever for dietary diversification and improved micronutrient intake. Among these, the valorisation of local phytogenic resources, and more specifically wild fruits from local biodiversity, represents a sustainable alternative. These resources, often overlooked by conventional commercial supply chains, nonetheless hold nutritional potential capable of effectively addressing micronutrient and protein deficiencies among local populations (Bvenura and Afolayan, 2015; Agbebi *et al.*, 2022).

Among these resources, the genus Uvaria (Annonaceae) comprises shrubs and lianas producing edible fruits whose nutritional potential remains poorly documented compared with cultivated species. *Uvaria chamae* P. Beauv. is a common shrub of savanna formations and forest edges, bearing clusters of yellow finger-shaped fruits whose sweet pulp surrounds numerous small seeds (Abu *et al.*, 2018; Aja *et al.*, 2019). The fruit of *Uvaria chamae* contains numerous seeds that constitute a biological matrix of major interest: on the one hand, they could represent a source of essential nutrients capable of alleviating dietary deficiencies (Okwu and Friday, 2009; Sani *et al.*, 2023). On the other hand, they are likely to contain high-value secondary metabolites (Popoola *et al.*, 2016).

Uvaria chamae is a plant of the Ivorian biodiversity used in traditional medicine to treat numerous conditions, including haemorrhage, dysentery, wounds, sore throat, abdominal pain, fatigue, respiratory disorders and anaemia (Adomou *et al.*, 2012; Kone *et al.*, 2013).

The roots and leaves of *Uvaria chamae* have been the subject of extensive phytochemical and ethnopharmacological investigations, supporting their traditional use against malaria, microbial infections and various ailments (Ogbuanu *et al.*, 2020; Popoola *et al.*, 2021; Agbebi *et al.*, 2024). By contrast, the nutritional value of the seeds, generally discarded after consumption of the pulp, has received considerably less attention, and the few available studies concern populations from other agro-ecological zones (Abu *et al.*, 2018; Houndeton *et al.*, 2025), without providing a complete profile (physicochemical, mineral and vitamin) obtained using a single standardised protocol.

Beyond their nutritional interest, wild species such as *Uvaria chamae* also hold agroecological value in a context of increasing climatic variability: requiring neither irrigation nor agrochemical inputs, they can contribute to more resilient food systems in the Sudano-Sahelian fringe of northern Côte d'Ivoire. Characterising their nutritional value could further support their integration into local valorisation chains (composite flours, food supplements), generating supplementary income for the rural communities of Kpatrakaha, Lamehkaha and Natio, who already traditionally harvest this fruit.

Despite these promising prospects, a scientific gap remains regarding the precise composition of *Uvaria chamae* seeds in Côte d'Ivoire. In this context, characterising the nutritional composition of *Uvaria chamae* seeds could support their valorisation as a novel food ingredient and contribute to local dietary diversification strategies. The present study therefore aimed to determine the proximate and physicochemical composition, mineral content and vitamin profile of *Uvaria chamae* seed flour collected at three sites in the Korhogo department, in order to establish a baseline nutritional reference for this under-exploited resource.

MATERIALS AND METHODS

Study area and plant material

The plant material consisted of seeds from *Uvaria chamae* fruits (Fig. 1) collected in the Korhogo department (northern Côte d'Ivoire) at three sites : Kpatrakaha, Lamehkaha and Natio. Fruits were harvested between June and August 2025, corresponding to the stage of physiological maturity of the species at each site. In total, 253 ripe fruits were collected, with the number of fruits per site determined by local availability. After harvesting, the fruits were packaged and transported to the laboratory for analysis.

Fig. 1. Fruit (A) and seeds (B) of *Uvaria chamae*

Sample preparation

Physicochemical analyses were performed on ground *Uvaria chamae* seeds. Fruits were carefully washed with clean water to remove impurities, then manually deseeded to separate the seeds from the pulp. The seeds obtained were dried at room temperature (27 ± 2 °C) to constant mass, then ground into fine powder using a blender. The resulting flour was stored in a bottle that had been pre-dried in an oven at 45 °C for 24 h, following the method described by AOAC (1995).

Proximate and physicochemical analysis

Moisture and dry matter contents were determined according to AOAC (2005) ; ash content according to AOAC (2005); crude fibre content according to the method of Wolff (1968) ; lipid content according to the BIPEA (1976) method; and total protein content according to AOAC (1990). Total carbohydrate content was calculated according to the method recommended by AOAC (2005), and the energy value of the flour was calculated according to FAO (2002).

Determination of mineral content

Mineral elements were determined by colorimetric assay following the method of Aremu and Ibrahim (2014), with slight modifications. Samples were digested by wet-ashing using a mixture of nitric, perchloric and sulphuric acids in a 3:2:1 ratio, according to Gorsuch (1959).

Sample processing was carried out in a dust-free room to avoid contamination, using distilled deionised water for all dilutions (Rao and Rao, 1981). Appropriate blanks were included with each batch of samples, and trace elements were quantified using an atomic absorption spectrophotometer, with internationally certified standards analysed alongside the samples to verify accuracy, as knowledge of plant chemical composition provides insight into their nutritional value (Roberts, 1985).

Determination of vitamin profile

Fat-soluble vitamins: Vitamin A was determined by HPLC with ultraviolet (UV) spectrophotometric detection, in accordance with AFNOR standard NF EN 12823-1. A 25 mL volume of hexane was added to 5 g of pre-powdered sample. Extraction was performed by sonication for 30 min. After filtration, the filtrate was evaporated in the dark, and the residue was redissolved in 10 mL of methanol and homogenised by sonication for 10 min. The methanolic solution was filtered through a hydrophobic filter prior to injection.

Chromatographic conditions were as follows: HPLC-grade methanol mobile phase, flow rate of 1 mL/min, UV detection at 313 nm.

Vitamins E (tocopherols) and K were determined in accordance with AFNOR standard NF EN 14663 (2006). Vitamin E was extracted by liquid–liquid extraction, with methanol (100% v/v) used to reconstitute the residue and alpha-tocopheryl acetate as internal standard ; analysis was performed on a C18 column (250 × 4.6 mm × 5 µm) with a methanol/water (99:1, v/v) mobile phase at a flow rate of 1.4 mL/min and detection at 292 nm. Vitamin K was purified on a solid-phase C18 cartridge, followed by liquid–liquid re-extraction under acidic conditions; the evaporated extract was redissolved in 150 µL of mobile phase and injected onto a reversed-phase column (Lichrocart Superspher RP18, 125 × 2 mm, 4 µm), with fluorimetric detection after post-column reduction to the hydroquinone forms via a zinc reactor (excitation 243 nm, emission 430 nm). Results were expressed as mg/100 g dry matter for vitamin E and µg/100 g dry matter for vitamin K.

Water-soluble vitamins: Vitamins B1 (thiamine), B2 (riboflavin), B3 (niacin) and B5 (pantothenic acid) were determined by HPLC with fluorimetric detection, in accordance with AFNOR standard NF EN 12823-2 (2000). Vitamins B6 (pyridoxine) and B9 (folic acid) were analysed according to AFNOR standard NF EN 14663 (2006). Samples were extracted in a 10 mM ammonium acetate/methanol mixture (50:50, v/v) containing BHT as antioxidant, subjected to stirring followed by sonication for 15 min at a temperature below 25 °C, centrifuged at 14,000 g for 12 min, then filtered through a 0.45 µm nylon membrane prior to HPLC injection. Vitamin B9 was analysed under strict light protection owing to its high photosensitivity. Vitamin C was extracted following the method of Boonkasem *et al.* (2015): ten grams of ground sample were suspended in 20 mL of 3% (w/v) metaphosphoric acid, stirred magnetically for 30 min protected from light, then centrifuged at 4,000 rpm for 20 min; the supernatant was filtered through a 0.45 µm membrane prior to HPLC injection. Results were expressed as mg/100 g dry matter, except for vitamin B9, expressed as µg/kg dry matter.

Statistical analysis

All analyses were performed in triplicate, and results were analysed using the Statistical Package for Social Sciences (SPSS), version 27.0; significant differences were established at $p < 0.05$.

RESULTS AND DISCUSSION

Proximate and physicochemical composition

The physicochemical and proximate composition of *Uvaria chamae* seed flour is presented in Table 1. The flour showed a low moisture content (6.70 ± 0.02%) and, correspondingly, a high dry matter content (93.30 ± 0.02%). A moisture content between 8 and 10% is generally considered to limit the risk of microbial spoilage and to favour storage while extending shelf life (Kanakidi *et al.*, 2022; Al-Hamdani *et al.*, 2022). These results are comparable to those reported by Ogbuanu *et al.* (2023) for *Uvaria chamae* seeds (5.20%), and to those obtained by Koffi *et al.* (2013) for *Irvingia gabonensis* seeds (7.10%), two tropical species with high dry matter content.

Table 1. Physicochemical and proximate composition of *Uvaria chamae* seed flour (mean ± SD, n = 3)

Parameter	Value
Moisture content (%)	6.70 ± 0.02
Dry matter (%)	93.30 ± 0.02
Ash content (%)	2.84 ± 0.04
Lipid content (%)	10.17 ± 0.06
Protein content (%)	0.76 ± 0.01
Carbohydrate content (%)	79.54 ± 0.53
Energy value (kcal/100 g)	412.73 ± 1.95

Carbohydrates constituted the dominant fraction (79.54 ± 0.53%), giving the flour a relatively high energy value (412.73 ± 1.95 kcal/100 g), comparable to that of several cereal flours commonly consumed in West Africa. This predominance is consistent with the starchy nature of the seeds of many Annonaceae species. A slightly lower carbohydrate content (75.30%) was reported by Oyeyinka and Oyeyinka (2014) for a species of the same botanical family, confirming the particularly high energy potential of *Uvaria chamae* seeds. This carbohydrate content is nonetheless lower than that reported for other parts of the plant, namely leaves (87.76%), stems (88.67%) and roots (91.83%), according to Godwin *et al.* (2021).

Lipid content (10.17 ± 0.06%) was moderate, while protein (0.76 ± 0.01%) and ash (2.84 ± 0.04%)

contents were low. These values differ markedly from those reported by Ogbuanu *et al.* (2023) for *Uvaria chamae* (Udagu) seeds from Nigeria, who found substantially higher lipid (26.19%), fibre (51.81%) and ash (10.19%) contents, but a lower moisture content (5.20%) and an equally low protein content (0.09%). The presence of an appreciable lipid fraction, combined with the dominant carbohydrate content, contributes directly to the high energy value observed; moreover, oils extracted from Annonaceae seeds are known to be rich in unsaturated fatty acids beneficial to cardiovascular health (Gonzalez *et al.*, 2023). The protein content is markedly lower than that generally reported for seeds of other tropical species, such as bambara groundnut seeds (21.64%) according to Hama *et al.* (2017). This low protein content indicates that *Uvaria chamae* seeds are not a priority source of dietary protein; their nutritional interest instead lies in their contribution of complex carbohydrates, lipids and bioactive compounds. Such discrepancies likely reflect differences in ecotype, soil and climatic conditions between Korhogo and the Nigerian collection sites, as well as differences in sample preparation, since the Nigerian study analysed whole seeds together with their oil fraction rather than a defatted flour. The low protein content observed in both studies nonetheless suggests that *Uvaria chamae* seeds are primarily a source of energy and micronutrients rather than protein, and would be best valorised as a complementary or functional ingredient rather than as a staple protein food.

Mineral composition

The mineral profile of the flour is presented in Table 2. Calcium (477.61 ± 0.80 mg/kg) and potassium (425.39 ± 0.70 mg/kg) were the predominant elements, followed by magnesium (233.32 ± 1.00 mg/kg), manganese (223.57 ± 0.01 mg/kg), phosphorus (41.41 ± 0.01 mg/kg), sodium (29.11 ± 0.02 mg/kg), zinc (30.16 ± 0.00 mg/kg) and iron (20.90 ± 0.00 mg/kg). The predominance of potassium and calcium is consistent with data reported for other Annonaceae species (*Monodora myristica* and *Annona senegalensis*), in which these two elements have similarly been described as the major seed minerals (Yisa *et al.*, 2010; Kouablan *et al.*, 2020; Afolabi *et al.*, 2024). The appreciable calcium, magnesium and zinc contents suggest that *Uvaria chamae* seed flour could contribute significantly to dietary mineral intake, particularly for bone health (Ca, Mg) and immune function (Zn).

Table 2. Mineral composition of *Uvaria chamae* seed flour (mg/kg, mean ± SD, n = 3)

Mineral element	Content (mg/kg)
Calcium (Ca)	477.61 ± 0.80
Potassium (K)	425.39 ± 0.70
Magnesium (Mg)	233.32 ± 1.00
Manganese (Mn)	223.57 ± 0.01
Phosphorus (P)	41.41 ± 0.01
Zinc (Zn)	30.16 ± 0.00
Sodium (Na)	29.11 ± 0.02
Iron (Fe)	20.90 ± 0.00
Nickel (Ni)	0.0082 ± 0.0002

Vitamin profile

The vitamin profile of the flour is presented in Table 3. Vitamin C was the most abundant vitamin quantified (23.75 ± 0.25 mg/100 g), followed by vitamin E (4.45 ± 0.05 mg/100 g) and vitamin B3/niacin (1.62 ± 0.02 mg/100 g). Vitamins B1, B2 and B6 were present in moderate amounts (0.13, 0.19 and 1.43 mg/100 g, respectively), while vitamin B9 (36.1 ± 0.4 µg/100 g) and vitamin K (0.0124 ± 0.0002 mg/100 g) were detected at low but quantifiable levels. Vitamin B5 remained below the limit of quantification (0.0075 mg/100 g) in all assays. Vitamins E and C in particular act as powerful antioxidants protecting cell membranes against lipid peroxidation (Maaliki *et al.*, 2024). B-group vitamins mainly participate in energy metabolism and normal nervous system function (Akpata and Miachi, 2001), while the low vitamin K content is typical of dried seeds (Mackenzie *et al.*, 2003). Overall, the relatively high vitamin C and vitamin E contents indicate a promising antioxidant potential for the seed flour, complementary to the phenolic compounds currently being investigated in a related study on the same plant material. Taken together, the vitamin profile confirms the nutritional interest of valorising *Uvaria chamae* seeds as a dietary supplement or functional ingredient, particularly in regions where access to diverse vitamin sources remains limited.

Table 3. Vitamin profile of *Uvaria chamae* seed flour (mean ± SD, n = 3)

Vitamin	Content	Unit
Vitamin B1 (thiamine)	0.130 ± 0.001	mg/100 g
Vitamin B2 (riboflavin)	0.190 ± 0.002	mg/100 g
Vitamin B3 (niacin)	1.62 ± 0.02	mg/100 g
Vitamin B5 (pantothenic acid)	nd (< 0.0075)	mg/100 g
Vitamin B6 (pyridoxine)	1.43 ± 0.02	mg/100 g
Vitamin B9 (folic acid)	36.1 ± 0.4	µg/kg
Vitamin E	4.45 ± 0.05	mg/100 g
Vitamin C	23.75 ± 0.25	mg/100 g
Vitamin K	0.0124 ± 0.0002	mg/100 g
Vitamin A	0.172 ± 0.003	µg/100 g

nd: not detected (below the limit of quantification, shown in parentheses)

CONCLUSION

This study provides, for the first time, a combined proximate, mineral and vitamin profile of *Uvaria chamae* seed flour from the Korhogo region, northern Côte d'Ivoire. The flour is characterised by a low moisture content favourable to storage, a carbohydrate-dominated composition with a substantial energy value, appreciable calcium, potassium, magnesium and zinc contents, and a vitamin profile marked by notable vitamin C and vitamin E contents. These results position *Uvaria chamae* seeds as a promising, currently underexploited nutritional resource that could be valorised as a functional flour ingredient or dietary supplement to support food and nutrition security in northern Côte d'Ivoire. Further studies on the phenolic and antioxidant profile, antinutritional factors, functional and technological properties, and the in vivo bioavailability of these nutrients are recommended to fully document the food and nutraceutical potential of this species.

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