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Research article

Nutritional value and phytochemical relevance of *Dioscorea comorensis*, an endemic yam from the Comoros Islands

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Abstract: The Comoros Islands present a large variety of products and food items, but most of the people lack awareness about the nutritional value and quality of these local resources, contributing to food insecurity. *Dioscorea comorensis*, a yam species endemic to the Comoros Islands, may represent a valuable crop, meeting the health-promoting needs of the local population. This research aimed to assess the chemical composition of *D. comorensis* flour for potential food applications. Standardized methods were used for proximate analysis. Mineral elements were evaluated by UV-visible spectrophotometry and atomic absorption spectrometry, while dietary fiber and starch were assessed by formic acid insolubility and polarimetric assays, respectively. Phytochemical characterization involved spectrophotometric tests for total antioxidant capacity (FRAP assay) and total polyphenols (Folin–Ciocalteu method), complemented by HPLC analyses for individual phenolics, vitamin C, organic acids, and sugars. The results showed a high dry matter (86.84%) and carbohydrate (79.52%) content, with significant levels of dietary fiber (19.6%) and protein (5.42%), supporting its role as a health-promoting and energy-rich food source. Mineral analysis highlighted excellent potassium amounts (869.6 mg/100 g), together with relevant quantities of copper, magnesium, and phosphorus. Phytochemical fingerprinting identified significant levels of total polyphenols [42.01 mg GAE/100 g of dried weight (DW)], phenolic acids, flavonols, and organic acids, contributing to a significant antioxidant capacity (8.65 mmol Fe^{2+}/kg). Although vitamin C content was limited, the species showed a large spectrum of health-promoting molecules. This preliminary study highlighted

that *D. comorensis* may be considered as a culturally relevant and nutritionally rich crop with potential for integration into sustainable dietary strategies in the Comoros Islands, even if further studies are recommended to evaluate its potential as a health-promoting food application.

Keywords: endemic crops; food insecurity; Comoros; antioxidants; health-promoting foods; nutritional supplements; flour

1. Introduction

Agriculture plays a crucial role in both daily life and the economy in the Comoros Islands. Despite a large variety of food items and products, the Comorian population lacks awareness about the quality and nutritional value of local resources [1]. The economy is heavily reliant on agriculture [i.e., about 33.5% of the Gross Domestic Product (GDP)] and exhibits limited diversification. The tendency to import more food items than the potential to export them, leading to a reliance on external food sources and financial problems for the local population, is very widespread. For this reason, the trade balance is very negative, resulting in a deficit of about 20.7% of the GDP [2].

Challenges to food security have often been linked to malnutrition, in particular among children. The valorization and diversification of local crops may reduce import dependency and improve diet quality [3]. In the Comoros Islands, about 60% of the diet of the local population is based on locally grown staple foods such as potatoes, yams, manioc, and bananas. However, the remaining 40% of food consumption relies on imported commodities, including rice, sugar, oil, chicken, and meat [4]. This strong dependence on imports exposes the country to external economic shocks, price fluctuations, and disruptions in the supply chain. For this reason, the Comoros National Pact for Food and Agriculture has established ambitious targets to reduce food imports from 75% to 50% between 2023 and 2028. [5].

Moreover, the local government has integrated agricultural modernization as a central part of the Emerging Comoros Plan (ECP), in order to revamp traditional farming practices into more effective, sustainable, and productive systems to bolster food self-sufficiency and resilience against food shortages [6]. Food insecurity has resulted in widespread malnutrition, especially among children under the age of five. Different studies highlighted high levels of childhood malnutrition in the Comoros Islands. About 30% of children have chronic malnutrition, including 15% of severely malnourished cases, while 11% of children show acute malnutrition (about 4% in severe cases). Moreover, 15% are underweight children (about 4% severely underweight) [1]. This highlights the necessity to enhance initiatives on local nutrition and ensure the productivity and well-being of future generations, improving agricultural output and increasing public education on good eating habits.

Yams, one of the main staple crops in the Comoros Islands, are a very important component in the diet of the local people, particularly in rural areas. Yams, belonging to the *Dioscorea* genus, are tuberous plants with high levels of sugars and carbohydrates and many nutritional advantages [7,8]. In the tropical areas, several *Dioscorea* species are economically significant and cultivated [9]. *D. rotundata* and *D. alata* are the main species, with average yields of 15–30 $t \cdot ha^{-1}$ and up to 40 $t \cdot ha^{-1}$, respectively. Their tubers present about 1%–2% protein, 0.2%–0.4% lipids, 0.8%–1.5% fiber (dry-weight basis), and 60%–75% starch, together with appreciable levels of phosphorus and potassium [10]. The production of *D. esculenta* and *D. cayenensis* generally shows lower yields (10–20 $t \cdot ha^{-1}$) with

similar levels of carbohydrates, while *D. bulbifera* is known for high amounts of phenolic compounds in its aerial bulbils. However, little information is available on the nutritional and agronomic traits of *D. comorensis*. In particular, *D. comorensis* is a native species of the Comoros Islands used by the local population as a source of essential nutrients and energy [11]. This species is found in dry forests between 0 and 200 m above sea level. The vegetation receives precipitation of less than 1500 mm per year and temperatures ranging from 23 to 27 °C. The soil is composed of a heterogeneous mixture of fine pebbles, basaltic fragments, and ancient white sand [12]. The Comorian population consumes tubers cooked in coconut milk with fish or meat or, often, grilled [11,13].

From a socio-economic and agronomic perspective, promoting the cultivation and consumption of this species aligns with the goals of sustainable agricultural development and food sovereignty. *D. comorensis* is a culturally accepted species and a climate-resilient crop that may be intensively cultivated in the future with low input requirements, making it suitable for rural livelihoods and local farming systems in the Comoros Islands. Concerning climate change, increasing malnutrition, and agrobiodiversity erosion, the valorization of *D comorensis* may offer a practical and locally grounded solution. Its integration into public health programs, agricultural policies, and dietary strategies may support the aim of preserving biodiversity and traditional knowledge and improving Comorian population health [14]. However, agronomic data (yield, resistance, productivity) are still lacking for this species. Since the crop may be recommended for integration into local farming systems, studies or even qualitative descriptions could support the claim.

This preliminary study aimed to assess the nutritional and chemical traits of *D. comorensis*. This research may offer valuable information regarding the potential of this species as a significant food resource and its role in improving food security and nutrition in the Comoros. Encouraging the cultivation and utilization of indigenous yams may be a way for this country to decrease reliance on external food sources and improve the nutritional content of the local diet.

2. Materials and methods

2.1. Plant material

The plant material consists of *Dioscorea comorensis*, a species endemic to the Comoros. It was harvested in Grande Comore (Ngazidja) during the period between the end of the rainy season and the early part of the dry season (2023). The sample was collected in the Mboinkou region in the north of Grande Comore. The geographical coordinates of the study area are 11°25'1" south latitude and 43°24'1" east longitude. The plant material collected for the present research originated from nine single plants (about 5 kg for each plant) at the same site in Grande Comore. The nine plants were selected to be representative of the whole sampling site. The original plants were then grouped into three blocks, and tubers from different plants of the same block were processed to produce flour. Flours from different blocks were then considered as field replications (N = 3).

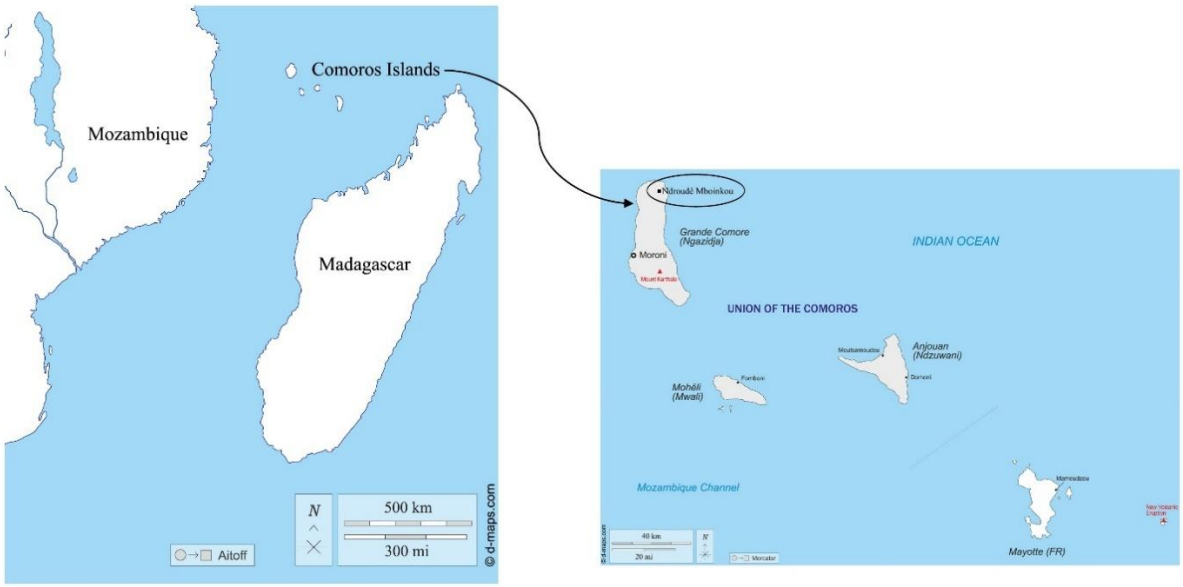

Figure 1. Map of the Comoros Islands and sampling site.

2.2. Processing for D. comorensis *flour*

Processing started in order to transform yams into flour (Figure 2). After harvesting, good-condition plant material was washed with bleach to avoid contamination. The tuber, without its skin, was cut into small pieces and then dried in the sun for three days. The drying time was adapted depending on weather conditions and the amount of sunlight. The process was complete when the weight no longer varied. After drying, the tuber pieces were ground using a mill (EUROLUX brand) and then sieved. The resulting flour was stored in waterproof bags at room temperature and in a dry place.

2.3. Determination of water content

5 g of *D. comorensis* flour was introduced into an empty capsule of known weight and tared beforehand. The entire assembly was placed in an oven for 24 h at ±103 °C. After proofing, the capsules were cooled in a desiccator for 30 min and then weighed [15].

The humidity content was calculated according to the following equation:

$$H\% = \frac{m1-m2}{m1-m0} x100 \quad (1)$$

H%: humidity in grams per 100 g of sample; m0: mass in grams of the empty capsule; m1: mass in grams of the sample and capsule before steaming; m2: mass in grams of the sample and capsule after steaming.

The dry matter content was therefore determined by the following formula:

$$DM\% = 100 - H\% \quad (2)$$

DM%: dry matter content per 100 g of sample; H%: humidity in grams per 100 g of sample.

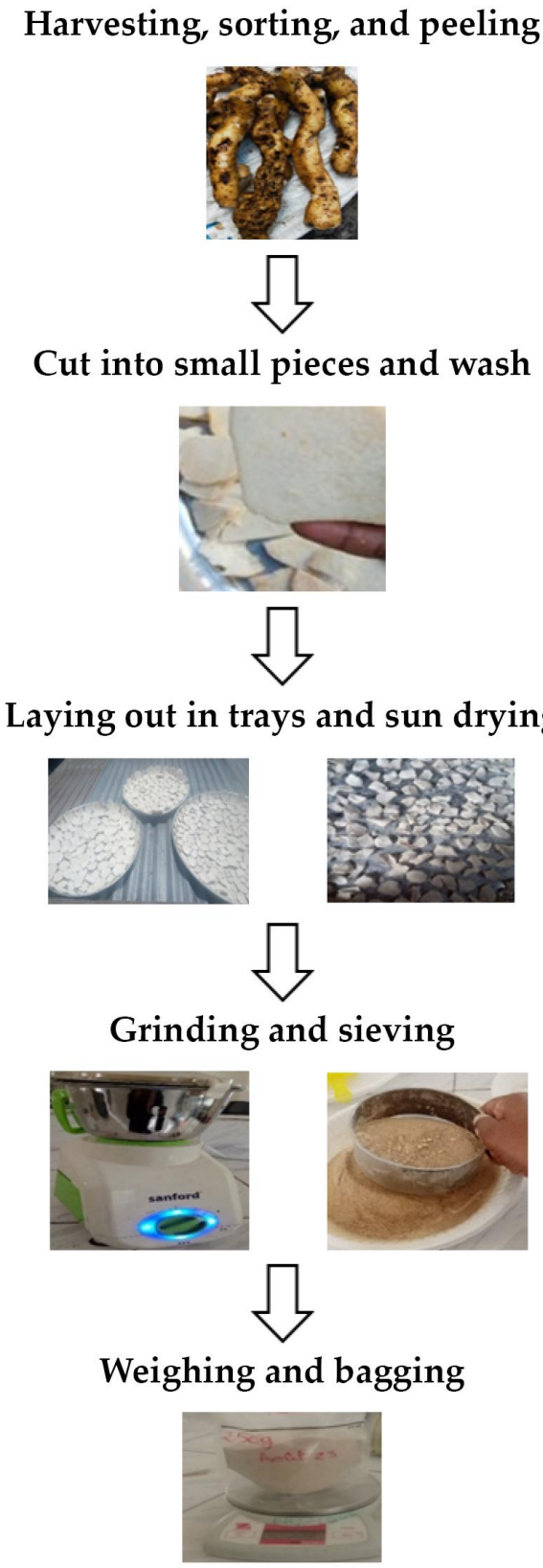

Figure 2. Processing steps for yam flour production.

2.4. Determination of lipid content

The Soxhlet method was used to determine lipid content [1]. 5 g of the sample was weighed and then placed in Joseph paper, securely wrapped. The Joseph paper containing the sample was introduced into an extraction cartridge, which was then placed in the Soxhlet. 100 mL of hexane solution were poured into a 150 mL flask of known weight and placed in a heating mantle. Pure hexane was heated to 70 °C for 6 h. The flask containing the hexane with the extracted lipids was plunged into a rotary evaporator at 70 °C for 10–15 min. The same flask containing the lipids was placed in an oven at 103 °C for 1 h and then cooled in a desiccator for 1 h.

The total lipid content was calculated according to the following equation:

$$MG\% = \frac{m2-m1}{m0} x100 \quad (3)$$

MG% = total lipids in grams per 100 g of sample; m0 = mass in grams of the sample; m1 = mass in grams of the empty flask; m2 = mass in grams of the flask and sample after evaporation.

2.5. Determination of total protein content

Total protein content was determined by the Kjeldahl method, an indirect analytical technique based on the quantification of total nitrogen. The protein content was subsequently calculated using a nitrogen-to-protein conversion factor of 6.25 [1]. Approximately 0.25 g of the sample was weighed and transferred into a Kjeldahl flask. A volume of 10 mL of concentrated sulfuric acid (H_2SO_4) and a potassium sulfate (K_2SO_4) catalyst tablet were added. The mixture was digested in a Kjeldahl apparatus at an elevated temperature (365–420 °C) for 3 h 15 min until the solution became clear. The digest was then allowed to cool to room temperature over approximately 2 h.

Distillation was conducted over 3 min. The cooled digest was neutralized with a sodium hydroxide (NaOH) solution. Concurrently, a recovery solution (0.65 M) comprising 4% (w/v) boric acid with a few drops of Tashiro's indicator was prepared and homogenized using a magnetic stirrer on a hot plate. The indicator imparted a purple color to the recovery solution.

The digest was distilled, and the released ammonia was trapped in 10 mL of the boric acid solution. Upon contact, the solution turned green, indicating the presence of ammoniacal nitrogen. The resulting distillate was titrated with standardized 0.1 N sulfuric acid until a violet endpoint was observed, signifying complete neutralization. The volume of titrant consumed was recorded for protein content calculation.

The total nitrogen content was obtained by the following formula:

$$N\% = \frac{(V-Vo) \text{ x } N \text{ x } 0{,}014 \text{ x } 100}{m} \quad (4)$$

N%: total nitrogen content (%); Vo: volume of sulfuric acid required to turn the blank (mL); V: volume of sulfuric acid required to turn the sample (mL); N: normality of the sulfuric acid (H_2SO_4) used; m: mass of the sample (g).

The crude protein content was evaluated according to the following formula:

$$P\% = N\% \; x \; F \tag{5}$$

P%: total protein content (%); N%: total nitrogen content (%); F: protein conversion factor equal to 6.25.

2.6. Evaluation of mineral elements

2.6.1. Determination of the crude ash content

The ash content was determined by incineration of the sample at 550 °C in a muffle furnace [1]. A 5 g portion of the sample was weighed into a pre-washed, dried, and tared porcelain crucible of known mass. The crucible was then placed in a muffle furnace preheated to 550 °C. Incineration was carried out for a minimum of 4 h 30 min until the organic matter was completely oxidized. The resulting ash was whitish, greyish, or reddish, indicating the absence of residual carbonaceous material.

Following incineration, the crucibles were cooled in a desiccator to room temperature. The crucibles were then reweighed, and the ash content was calculated as the difference between the final and initial weights. The crude ash content was obtained by the following formula:

$$C\% = \frac{P2-P0}{P1-P0} x100 \tag{6}$$

P0: weight in grams of the empty incineration capsule; P1: weight in grams of the sample and capsule before incineration; P2: weight in grams of the sample and capsule after incineration; C%: total ash content in grams per 100 g of sample.

2.6.2. Preparation of mineral extract and quantification

Approximately 5 g of each sample was placed in a pre-weighed incineration crucible and introduced into a muffle furnace set at 550 °C for a minimum of 4 h 30 min. Each sample was analyzed in duplicate. Following incineration, the crucibles were cooled in a desiccator and weighed to determine ash content.

The resulting ash was moistened with distilled water and mineralized by the addition of approximately 2 mL of concentrated hydrochloric acid (12 M HCl). The mixture was transferred to a beaker, and the total volume was brought to 50 mL with distilled water to obtain the mineral extract.

Each mineral extract was boiled on a hot plate at 300 °C for 15 minu. After heating, the solution was filtered through standard filter paper into a 100 mL volumetric flask. The filtrate was brought to the correct volume by adding distilled water. The flasks were sealed with parafilm and gently agitated to ensure homogeneity.

Depending on the specific mineral element to be quantified, absorbance measurements were performed using either atomic absorption spectrometry (AAS) or UV-visible spectrophotometry [1].

Copper content was determined by atomic absorption spectrometry (PerkinElmer, PinAAcle 900T, Waltham, MA, USA) at a wavelength of 324.7 nm. Calibration was performed using a standard solution of copper (II) chloride ($CuCl_2$), prepared from elemental copper, hydrochloric acid (HCl), and

hydrogen peroxide (H_2O_2) to ensure complete dissolution. A series of standard solutions was prepared by serial dilution to establish a calibration curve within the expected concentration range. Following instrument calibration and setup, the absorbance of the mineral extracts was measured, and copper concentration was calculated based on the standard curve.

Magnesium concentration was determined using atomic absorption spectrometry at a wavelength of 285 nm. Standard solutions of magnesium chloride ($MgCl_2$) were prepared from magnesium powder dissolved in hydrochloric acid (HCl), then diluted with distilled water to the desired concentrations. These standards were used to generate a calibration curve. A lanthanum chloride buffer, prepared from lanthanum oxide dissolved in HCl and diluted with distilled water, was used as an ionization suppressant to enhance measurement accuracy. Following instrument calibration, the absorbance of the mineral extracts was measured, and magnesium concentrations were calculated from the standard curve.

Potassium content was measured by atomic absorption spectrometry at a wavelength of 766.5 nm. Standard solutions of potassium chloride (KCl) were prepared by dissolving KCl in hydrochloric acid (HCl) and diluting with distilled water to the desired concentrations. A calibration curve was established from these standards. A buffer solution was prepared using caesium chloride (CsCl), aluminum nitrate [$Al(NO_3)_3$], and distilled water. The buffer was used to minimize ionization interference during the measurement. Following instrument calibration, the absorbance of the prepared mineral extracts was measured, and potassium concentrations were determined based on the calibration curve.

Phosphate concentration was determined by colorimetric analysis using a UV-visible spectrophotometer (1600-PC, VWR International, Radnor, PA, USA) at a wavelength of 430 nm. The method is based on the principle that the intensity of color formed is proportional to the concentration of phosphate present in the sample. Standard solutions were prepared using potassium dihydrogen phosphate (KH_2PO_4) dissolved in distilled water. A vanado-molybdic reagent, composed of ammonium heptamolybdate, ammonium monovanadate, and nitric acid, was used to develop a yellow complex with phosphate ions. The absorbance of both standards and sample solutions was measured after color development. Phosphate concentrations in the samples were calculated from a calibration curve constructed using standard solutions.

In general, mineral content was determined using the following formula:

$$X(mg/100g)=\frac{Z * 10^{-3} \text{ x d x V}}{Pe} x100 \quad (7)$$

X: mineral element studied; Z: value read from the spectrum (mg); d: inverse of the dilution factor; V: volume used (mL); Pe: sample in grams per 100 g of sample.

2.7. Determination of total carbohydrate content

Carbohydrate content was estimated by difference, based on the values obtained for other proximate components. The calculation was performed using the following formula:

$$G\% = 100\% - (H\% + P\% + L\% + C\%) \quad (8)$$

G%: total carbohydrate content (%); H%: water content (%); P%: total protein content (%); L%: total lipid content (%); C%: crude ash content (%).

All values were expressed on a wet weight basis. This method assumes that the remaining portion of the sample mass is attributable to carbohydrates.

2.8. Determination of starch content

Starch content was determined using the polarimetric method [1], based on optical rotation measurements following chemical treatment and clarification of the samples. In the first treatment, each sample was hydrolyzed with 1.128% hydrochloric acid under heat. The hydrolysate was clarified using CARREZ I and CARREZ II solutions, decolorized with activated carbon, and filtered. The optical rotatory power (P) of the solution was then measured using a polarimeter. In the second treatment, the same procedure was applied to an ethanolic extract (40% v/v) of the sample, followed by hydrolysis with 25% hydrochloric acid. After clarification and filtration as described above, the optical rotatory power (P′) was again measured. The difference in rotatory power between the two treatments was used to calculate starch content according to established calibration.

2.8.1. Determination of total rotatory power (P): Acid hydrolysis and polarimetric measurement

Approximately 2.5 g of each sample was placed in a 100 mL volumetric flask containing 50 mL of 0.31 M hydrochloric acid (HCl). The flasks were placed in a boiling water bath under reflux. During the first 3 min of hydrolysis, the flasks were vigorously agitated without removal from the water bath to prevent the formation of agglomerates, ensuring efficient acid hydrolysis. After 15 min of hydrolysis, the flasks were removed from the bath and cooled to room temperature. Subsequently, 5 mL of Carrez I solution was added, and the mixture was stirred for 1 min. This action was followed by the addition of 5 mL of Carrez II solution and further stirring for 1 min to achieve clarification. Depigmentation was performed by adding a small amount of activated carbon to the mixture. The solution was then brought to the specific volume by adding distilled water, homogenized, allowed to stand for several minutes, and filtered. The optical rotatory power (P) of the filtrate was measured using a polarimeter with a 200 mm (2 dm) measurement tube.

2.8.2. Determination of the rotatory power P' (substances soluble in ethanol 40%): Ethanolic extraction and polarimetric measurement

Approximately 5 g of each sample was dissolved in 40% ethanol. The mixture was homogenized at room temperature for 1 h. Subsequently, 2.1 mL of 25% hydrochloric acid (HCl) was added, and the total volume was adjusted to 50 mL with distilled water. The solution was then placed in a boiling water bath for 15 min to complete hydrolysis. After cooling to room temperature, the hydrolysate was clarified with Carrez I and II solutions, depigmented with activated carbon, and filtered as previously described. The optical rotatory power (P′) was measured using a polarimeter with a 200 mm (2 dm) measurement tube.

The starch content, expressed in grams per 100 g of sample, was calculated as follows:

$$\text{Am\%} = \frac{(\text{P}-\text{P}\prime)\ \text{x L x}\ 100}{[\alpha]_{\text{D}}^{20^{\circ}\text{C}}\ \text{x m}} \tag{9}$$

Am%: starch content in grams per 100 g of sample; P: total rotatory power in degrees of arc; P':

rotatory power in degrees of arc (substances soluble in ethanol 40%); m: mass of the sample in grams of dry matter; L: length of polarimetric tube in dm (2 dm); $[\alpha]_D^{20°C}$: specific rotation of pure starch (conventional value = 184°).

2.9. Determination of dietary fiber

Formic insoluble matter (IF%) was quantified [16]. The principle of this method relies on the insolubility of cellulose, lignin, and minor amounts of mineral salts in boiling 80% formic acid (20 M). 1 g DW of yam flour was weighed into an Erlenmeyer flask and mixed with 50 mL of 80% formic acid. The mixture was heated under reflux in a boiling water bath at 100 °C for 75 min. Following the heating period, the mixture was filtered through an ashless filter paper. The retained residue was collected into a crucible, washed thoroughly with warm distilled water, and subsequently dried in an oven at 100 °C until a constant weight (P1) was achieved. The dried residue was then incinerated in a muffle furnace at 600 °C for 30 min to obtain the ash, which was weighed and recorded as P2.

The percentage of formic insoluble matter (IF%) was calculated using the formula:

$$IF\% = (P1 - P2) \times 100 \quad (10)$$

IF%: formic insoluble matter per 100 g of the sample; P1: weight of the dried residue; P2: weight of the ash.

This method allowed for the quantification of the lignocellulosic fraction present in the yam flour samples.

2.10. Phytochemical composition of D. comorensis

2.10.1. Preparation of extracts for spectrophotometric and chromatographic analysis

Fresh yam tubers were peeled, cut into small pieces, and sun-dried for a minimum of three days under ambient conditions. The dried tubers were then crushed using a ceramic mortar and further ground into a fine powder with a SANFORD automatic mill. Approximately 10 g of the resulting flour was weighed for subsequent analyses.

Different methods were used to extract phytochemicals and nutritional compounds according to previous studies [17,18]. The detailed description of methods (Table SM1) is reported in the Supplementary Material.

2.10.2. Antioxidant capacity

The antioxidant capacity of *D. comorensis* flour was assessed using the ferric reducing antioxidant power (FRAP) assay. This method is based on the reduction of ferric ions (Fe^{3+}) complexed with 2,4,6-tripyridyl-S-triazine (TPTZ) to ferrous ions (Fe^{2+}) under acidic conditions [19]. The extracts and the reference were incubated in a water bath at 37 °C for 30 min. After incubation, the optical density was measured at 595 nm using a UV-visible spectrophotometer (1600-PC, VWR International, Radnor, PA, USA). Antioxidant capacity was expressed as millimoles of Fe^{2+} equivalents per gram of sample.

2.10.3. Determination of total polyphenolic content (TPC)

Total polyphenolic content was determined using the Folin–Ciocalteu method. The Folin–Ciocalteu reagent, consisting of a mixture of phosphotungstic acid (0.025 M) and phosphomolybdic acid (0.0087 M), was reduced during the oxidation of phenolic compounds to form a blue complex containing tungsten and molybdenum oxides [20]. The absorbance of the reaction mixtures was measured at 750 nm using a UV-visible spectrophotometer. Results were expressed as milligrams of gallic acid equivalents (GAE) per 100 g of dry weight (DW), as already reported by similar studies [21].

2.10.4. Chromatographic analysis

HPLC analyses were carried out on an Agilent 1200 HPLC-UV-Vis Diode Array Detector (Agilent Technologies, Santa Clara, CA, USA). Details about analytical methods are reported in Supplementary Material (Table SM2), in accordance with previous studies [22,23]. Cinnamic acids, flavonols, benzoic acids, catechins, tannins, vitamin C, organic acids, and sugars were analyzed. All the substances were identified by comparing their retention times and UV-Vis spectra with those of standards under identical chromatographic conditions. Quantitative determination was carried out using the external standard method. Calibration curves were prepared using standard solutions with concentrations ranging from 125 to 1000 mg/L.

2.11. Statistical analysis

The outcomes for each of the nutritional and phytochemical categories under consideration were compared using Tukey's HSD post hoc comparison test at a significance level of $p < 0.05$ ($n = 3$), following the implementation of a one-factor ANOVA test. The comparison was expressed as the mean value ± standard deviation (SD). Any statistically significant differences at $p < 0.05$ are indicated by distinct letters based on the results of the Tukey test.

3. Results and discussion

3.1. Nutritional analysis

Table 1 provides valuable information on the nutritional content of *D. comorensis* flour, highlighting its high dry matter content (86.84%) and low water content (13.16%), differing from the pattern observed in other *Dioscorea* species such as *D. alata*, *D. rotundata*, *D. cayenensis*, and *D. esculenta*. It was also identified as a rich source of carbohydrates, with a content of 79.52%, making it a suitable option for meeting energy needs. Other *Dioscorea* species were also characterized by high carbohydrate content (approximately 78–85 g/100 g dry weight), mainly as starch [24,25]. The high dry matter and carbohydrate contents observed in *D. comorensis* flour suggest that it may serve as an important energy source, particularly in regions where food security is a concern, as the Comoros Islands. The low water content enhances its shelf life, making it suitable for storage and transport without significant risk of microbial spoilage. This feature may be especially advantageous in tropical climates where preservation of perishable goods is challenging [26].

Table 1. Nutritional data in grams per 100 g of product.

Species	Water	Protein	Ash	Lipids	Dry matter	Carbohydrates	Energy (kcal) by the Atwater system
D. comorensis	13.16 ± 0.07	5.42 ± 0.01	1.68 ± 0.06	0.22 ± 0.01	86.84 ± 0.01	79.52 ± 1.21	341.74 ± 3.01

Results (n = 3, except for ash) are detailed as mean value ± standard deviation (SD). The reported replicates (duplicates for ash and triplicates for the other cases) refer to analytical replicates for each flour sample (in total, three flour samples were analyzed as field replications).

Although *D. comorensis* flour exhibited a low lipid content (about 0.22%), it contained significant amounts of protein (5.42%), making it a potential source of essential amino acids, similar to other *Dioscorea* species [24,27], which show a protein content ranging from 5 to 8 g/100 g dry weight (in particular, *D. alata* and *D. esculenta*). The protein content was very significant for a tuber-based food, and it may contribute to improving protein intake in populations with limited access to animal-based proteins. The low lipid content implies that *D. comorensis* may not sufficiently meet essential fatty acid requirements, and its consumption should be complemented with other lipid-rich foods [28]. Indeed, lipid levels were also lower than in other *Dioscorea* species, such as *D. alata*, *D. rotundata*, *D. bulbifera*, and *D. cayenensis* (<2.5 g/100 g dry) [10]. Information on nutritional composition and bioactive compounds of the main *Dioscorea* species is reported in Supplementary Materials (Table SM3). Nutritional composition of *Dioscorea* species tubers in relation to adult WHO/FAO reference needs is also reported in Table SM4 (Supplementary materials).

Furthermore, *D. comorensis* flour was relatively rich in crude ash (1.68%), reflecting a potentially significant mineral content, and provided an energy value of 341.74 kcal per 100 g of sample. In other *Dioscorea* species, ash content ranges depending on species, with *D. alata* and *D. esculenta* presenting the highest amounts (approximately 4.5–5.0 g/100 g dry), with similar energy values (approximately 320–360 kcal per 100 g of product) [27].

These results are similar to local species of *Dioscorea* spp. (e.g., *D. bako nov*. sp. Wilkin, *D. maciba* Jum. et Perr., *D. ovinala* Bak., *D. fandra* H. Perr., *D. antaly* Jum. et Perr., *D. bemarivensis* Jum. et Perr., and *D. sansibarensis* Pax) in Madagascar and *Cycas* spp. in Comoros [29,30], highlighting the potential of *D. comorensis* as a promising complementary food item for inclusion in nutritional programs. For this reason, its cultivation and utilization could be promoted as part of local food security strategies against malnutrition. However, its agronomic potential (e.g., adaptability, propagation, yield performance, etc.) remains to be better evaluated. Only preliminary field evaluations were carried out, and they showed that *D. comorensis* produces about 5–7 kg of fresh tuber per plant, a value comparable to other *Dioscorea* species under similar ecological conditions. Moreover, its tolerance to semi-arid conditions and adaptability to poor soils suggest a good agronomic potential. For this reason, more detailed agronomic studies are necessary to evaluate its synergistic potential with other tuber crops and suitability for inclusion in food security strategies for the local population in the Comoros Islands. Moreover, further studies are necessary to evaluate its glycemic index, antinutritional factors, and digestibility to fully understand its suitability for widespread dietary use, in addition to the already mentioned agronomic evaluations for assessing its yield potential and resilience to local environmental stresses.

In addition to its macronutrient profile, *D. comorensis* flour was particularly notable for its high starch content (42.70%) and dietary fiber level (19.6%) (Table 2), with values higher than those of other *Dioscorea* spp. (e.g., approximately 3%–7% of fiber in *D. rotundata*, *D. bulbifera*, and *D.*

cayenensis) as reported by other studies [27]. These results show that the starch values of *D. comorensis*, even if lower than the starch content of *Cycas* species (73.03%) as reported by other studies [30], may propose this flour as an important source of complex carbohydrates, offering sustained energy release when consumed. Indeed, starch, combined with a high dietary fiber content, contributes to a more favorable glycemic response compared to rapidly digestible starch sources [31]. Moreover, dietary fiber is not digested or absorbed in the human small intestine and plays a critical role in gastrointestinal health, including the regulation of glycemic control, bowel movements, and satiety [32]. The amount of dietary fiber of *D. comorensis* was significant, especially if compared with other local staples. The similarity to breadfruit in fiber composition [28] showed the potential of this product as a dietary fiber source in the Comorian diet. The fiber content was also higher than that of *Cycas* (1.30%) [30], making this flour a candidate for dietary strategies aimed at improving digestive health and reducing the risk of cardiovascular diseases [32].

Table 2. Amounts of starch and dietary fiber in grams per 100 g of product.

Species	Starch	Dietary fiber
D. comorensis	42.70 ± 0.10	19.60 ± 0.18

Results (n = 3) are detailed as mean value ± standard deviation (SD). The reported replicates referred to analytical replicates for each flour sample (in total, three flour samples were analyzed as field replications).

3.2. Mineral elements

The mineral profile of *D. comorensis* flour added high value to its nutritional potential, since each of the considered mineral elements plays a vital role in human physiology. Indeed, this flour was particularly rich in potassium (K), with a concentration of approximately 870 mg per 100 g of sample, making it the most abundant mineral identified (Table 3), followed by phosphorus (P) at 61.62 mg/100 g, magnesium (Mg) at 33.68 mg/100 g, and copper (Cu) at 0.56 mg/100 g. These values are similar to those of other *Dioscorea* species, as reported in previous studies [24]. Indeed, potassium is the main mineral among all the other common *Dioscorea* species, with amounts ranging from approximately 500 to over 1500 mg/100 g of dried weight, while magnesium and phosphorus show moderate values, typically in a range of 80–245 mg/100 g DW [24,25]. Potassium is essential for maintaining fluid balance, nerve transmission, and muscle function, while phosphorus is involved in the formation of bones and teeth and is a critical component of DNA and RNA [33–35]. Moreover, magnesium is required for numerous enzymatic reactions, particularly those involving energy production and protein synthesis; copper, although needed in trace amounts, is important in iron metabolism and the formation of connective tissue [36]. The contents of potassium and copper were higher than those found in *Cycas* flour, as reported by similar studies [30], which contain approximately 590 mg/100 g and 0.45 mg/100 g, respectively. On the other hand, phosphorus and magnesium levels were higher in *Cycas* (approximately 155 mg/100 g and 65 mg/100 g) and in breadfruit (approximately 73 mg/100 g and 42 mg/100 g), based on previous studies [1,30].

Table 3. Mineral elements in milligrams per 100 g of product.

Species	Copper (Cu)	Magnesium (Mg)	Phosphorus (P)	Potassium (K)
D. comorensis	0.56 ± 0.02	33.68 ± 0.08	61.62 ± 0.42	869.60 ± 0.10

Results (n = 3) are detailed as mean value ± standard deviation (SD). The value of n = 3 represented three independent measures carried out on each digest, while the digestions were performed in duplicate.

However, it is important to highlight that even if *D. comorensis* was rich in specific essential minerals, its relative deficiency in others (e.g., magnesium and phosphorus compared to local alternatives) implies that it should be consumed together with other plant-based foods to achieve a balanced mineral intake. This issue reinforces the importance of dietary diversity in regions at risk of micronutrient malnutrition [37,38].

3.3. Phytochemical composition

The presence of a significant polyphenolic fraction in *D. comorensis* flour with antioxidant capacity enhances its value as a health-promoting food. Indeed, this flour exhibited a total polyphenol content of 42.01 ± 2.64 mg GAE/100 g and a significant antioxidant capacity of 8.65 ± 1.03 mmol Fe^{2+}/kg (Table 4).

Table 4. Antioxidant capacity and total polyphenolic content in *D. comorensis* flour.

Species	Antioxidant capacity (AOC) (mmol Fe^{2+}/kg DW)	Total polyphenolic content (TPC) (mg GAE/100 g DW)
D. comorensis	8.65 ± 1.03	42.01 ± 2.64

Results (n = 3) are detailed as mean value ± standard deviation (SD). DW = dried weight. GAE = gallic acid equivalent.

Although these values are lower than those observed in tubers of *Cyperus esculentus*, a species widely used as a food ingredient in Africa (about 190–900 mg GAE/100 g DW) [39], TPC remained significant and exceeded values described in breadfruit flours from Mbadjini and Hamahamet regions (Grande Comore), as reported by previous studies [1,28]. Moreover, *D. comorensis* tubers showed TPC values similar to *D. alata* and *D. batatas* (30–110 mg GAE/100 g DW) [40]. Thanks to their antioxidant and health-promoting properties (i.e., mainly their ability to reduce oxidative damage and scavenge free radicals) [41], their presence in *D. comorensis* may be beneficial for the human health by helping to avoid disorders linked to oxidative stress (e.g., neurodegenerative disorders, cardiovascular diseases, and certain cancers), modulating oxidative stress responses, and protecting blood vessels [28]. Moreover, the antioxidant capacity of *D. comorensis* flour was also higher than breadfruit from other Comoros regions (about 5–6 mmol Fe^{2+}/kg DW) [28] and similar to *D. alata* and *D. batatas* [40]. For these reasons, the polyphenolic content and relative antioxidant properties of *D. comorensis* highlight its potential not only as a nutritional staple but also as a health-promoting food application with functional relevance.

The presence of derivatives of cinnamic acid (Table 5), such as caffeic, ferulic, and chlorogenic acids, in *D. comorensis* flour further emphasizes its phenolic richness. These molecules are well-

documented for their potential anti-carcinogenic, anti-inflammatory, and antioxidant properties [42], contributing to the health benefits for the local population in accordance with plant-based diets.

Table 5. Cinnamic acid content in *D. comorensis* flour.

Species	Cinnamic acids (mg/100 g DW)			
	Caffeic acid	Chlorogenic acid	Coumaric acid	Ferulic acid
D. comorensis	1.40 ± 0.07^{a}	3.09 ± 0.30^{b}	n.d.	2.75 ± 0.30^{b}

Results (n = 3) are detailed as mean value ± standard deviation (SD). Significant statistical differences for $p < 0.05$ are reported with different letters. n.d. = not detected.

Among the cinnamic acids identified in the considered flour, chlorogenic acid is the most abundant, with a concentration of approximately 3 mg/100 g of dried weight, followed by ferulic acid and caffeic acid, at 2.75 and 1.40 mg/100 g DW, respectively. Coumaric acid was not detected in the sample. The absence of coumaric acid was not unusual, as its concentration in tuberous crops is often variable and it may be influenced by genetic and environmental factors [43]. When compared to breadfruit flour, the caffeic acid content *of D. comorensis* was slightly lower, whereas its ferulic acid content was higher. Moreover, the chlorogenic acid amounts were markedly lower than values identified in breadfruit, according to the data reported by Soifoini, Donno, and Jeannoda et al. [1].

The presence of phenolics confirms the antioxidant profile of the species, already valorized by total polyphenol content and antioxidant capacity.

Similar to cinnamic acids, flavonols in *D. comorensis* flour (Table 6) contributed additional evidence supporting it as a functional food with antioxidant potential. These molecules are a subgroup of phenolic compounds known for their strong anti-inflammatory antioxidant properties, together with vascular-protective effects [44].

Table 6. Flavonol amounts in *D. comorensis* flour.

Species	Flavonols (mg/100 g DW)			
	Hyperoside	Isoquercitrin, Quercitrin	Quercetin	Rutin
D. comorensis	1.29 ± 0.03^{b}	n.d.	1.41 ± 0.05^{b}	1.12 ± 0.05^{a}

Results (n = 3) are detailed as mean value ± standard deviation (SD). Significant statistical differences for $p < 0.05$ are reported with different letters. n.d. = not detected.

HPLC analysis of flavonols in *D. comorensis* showed that isoquercitrin and quercitrin were not detected in the sample. The absence of these compounds does not significantly detract from the overall phenolic profile, especially given the presence of other bioactive flavonols. Among the identified compounds, quercetin was the most abundant, with a concentration of approximately 1.40 mg/100 g DW, followed by hyperoside and rutin, present at approximately 1.30 and 1.10 mg/100 g DW, respectively. Notably, rutin was identified in *D. comorensis* but has not been reported in breadfruit [1,28], highlighting a distinct phytochemical fingerprint. Moreover, the hyperoside content in this species was significantly higher than in breadfruit, while the quercetin amounts were lower than in breadfruit.

The presence of benzoic acid derivatives (Table 7), such as gallic acid (2.18 ± 0.27 mg/100 g DW) and ellagic acid (2.65 ± 0.28 mg/100 g DW), add more complexity to the phenolic composition of this flour. Both molecules are known for their anti-mutagenic, anti-inflammatory, and antioxidant

properties [45]. Although their amounts were slightly lower than in breadfruit [1], they still positively contribute to the overall antioxidant capacity of the *D. comorensis* flour.

Table 7. Benzoic acid and catechin content in *D. comorensis* flour.

Species	Benzoic acids (mg/100 g DW)		Catechins (mg/100 g DW)	
	Ellagic acid	Gallic acid	Catechin	Epicatechin
D. comorensis	2.65 ± 0.28[a]	2.18 ± 0.27[a]	2.12 ± 0.30[a]	9.88 ± 0.35[b]

Results (n = 3) are detailed as mean value ± standard deviation (SD). Significant statistical differences for $p < 0.05$ are reported with different letters.

In the class of catechins (Table 7), epicatechin was present at higher levels (9.88 ± 0.35 mg/100 g DW) than catechin (2.12 ± 0.30 mg/100 g DW). Despite the relatively lower content of catechin, it remains a very important molecule thanks to its role in cardiovascular disease prevention and antioxidant capacity, as reported by Leverve and Weststrate [46]. If compared with breadfruit from Grande Comore, *D. comorensis* flour exhibited higher levels of catechins, highlighting its high potential in terms of cardiovascular protective effects, while breadfruit demonstrated higher amounts than *D. comorensis* for benzoic acids [28].

The high amounts of organic acids detected in *D. comorensis* flour (Table 8) reinforce its nutritional and functional potential. Succinic acid, involved in cellular energy metabolism for its participation on the citric acid cycle [47], was identified as the most abundant, with a concentration of 1343.37 ± 0.57 mg/100 g DW, followed by citric acid (282.22 ± 0.53 mg/100 g DW), malic acid (163.20 ± 1.16 mg/100 g DW), and oxalic acid (117.73 ± 1.53 mg/100 g DW). Citric acid mainly plays a very important role in metabolic pathways, enhancing mineral bioavailability in humans, in particular for magnesium and calcium [48]. Furthermore, this compound is useful for food preservation and flavor enhancement [49]. Malic acid adds further value due to its involvement in energy metabolism and potential as a mild natural detoxifying agent [50], while oxalic acid contributes to taste and shows a potential antioxidant capacity [51], but its excessive intake may interfere with calcium absorption, increasing the kidney stone formation. In any case, the *D. comorensis* levels of oxalic acid are similar to those of other edible tubers and do not present a dietary issue in recommended consumption patterns [52].

Quinic and tartaric acids, even if present in trace amounts, still contribute to the complex matrix of the flour. Indeed, quinic acid and tartaric acid were the least represented, at 25.16 ± 1.56 and 11.23 ± 1.35 mg/100 g, respectively.

Table 8. Organic acids in *D. comorensis* flour.

Species	Organic acids (mg/100 g DW)					
	Citric acid	Malic acid	Oxalic acid	Quinic acid	Succinic acid	Tartaric acid
D. comorensis	282.22 ± 0.53[c]	163.20 ± 1.16[b]	117.73 ± 1.53[b]	25.16 ± 1.56[a]	1343.37 ± 0.57[d]	11.23 ± 1.35[a]

Results (n = 3) are detailed as mean value ± standard deviation (SD). Significant statistical differences for $p < 0.05$ are reported with different letters.

When compared to breadfruit [1], *D. comorensis* exhibited higher amounts of oxalic, citric, and succinic acids. In particular, malic acid was identified in *D. comorensis* flour at a significant level, while it was not detected in breadfruit; moreover, the contents of tartaric and quinic acids were higher

in breadfruit [28].

The relatively low vitamin C amount in *D. comorensis* (Table 9) reflects a limitation in its micronutrient profile, in particular in relation to antioxidant vitamins. This is mainly due to the low levels of vitamin C derivatives, dehydroascorbic acid (1.05 ± 0.06 mg/100 g DW) and ascorbic acid (0.70 ± 0.04 mg/100 g DW). In any case, vitamin C values were expected to degrade due to the thermal processing, as reported in similar studies [28,53]. However, the vitamin C levels were higher than in other *Dioscorea* species (e.g., *D. alata*, *D. rotundata*, *D. bulbifera*, and *D. cayenensis*) as reported by Chinelo and Regina [10]. The combined total of 1.75 mg/100 g DW in *D. comorensis* flour is lower than the amounts detected in breadfruit flour (approximately 30 mg/100 g DW) [1,28], which may limit its dietary effectiveness as a primary vitamin C source. For this reason, its consumption should be complemented with vitamin C–rich vegetables (e.g., *Moringa* leaves) or fruits, such as guava, papaya, or tamarind.

Table 9. Vitamin C and simple sugar content in *D. comorensis* flour.

Species	Vitamin C (mg/100 g DW)		Sugars (g/100 g DW)		
	Ascorbic acid	Dehydroascorbic acid	Fructose	Glucose	Sucrose
D. comorensis	0.70 ± 0.04^{a}	1.05 ± 0.06^{b}	0.93 ± 0.14^{a}	1.01 ± 0.16^{a}	2.27 ± 0.02^{b}

Results (n = 3) are detailed as mean value ± standard deviation (SD). Molecules involved in vitamin C and sugars were subjected to two different ANOVA tests. Significant statistical differences for $p < 0.05$ are reported with different letters.

Regarding simple sugars (Table 9), *D. comorensis* presented a balanced profile (a total sugar content of approximately 4–5 g/100 g DW). Other *Dioscorea* species present low levels of simple sugars (<2 g/100 g dry), except for *D. esculenta*, often recognized for its sweeter taste [40,54,55]. The slightly higher fructose content compared to breadfruit [1] may positively contribute to natural sweetness and energy density with a low influence on glycemic peak, as fructose shows a lower glycemic index than glucose [56]. The lower glucose level may also be beneficial for human health in managing blood sugar levels [57].

4. Conclusions

D. comorensis represents an underutilized and valuable staple crop in the Comoros Islands. As a tuberous plant integrated into the local diet, it holds very good potential not only as a nutritive source but also as a strategic component in national and local efforts to address nutritional deficiencies and food security. In any case, the compositional and chemical data do not fully support the above claim. This study may be considered as an exploratory nutritional baseline to be complemented by socio-economic, yield, market, and agronomic studies before considering promotion or adoption of *D. comorensis* as a health-promoting crop.

The nutritional profile of *D. comorensis* flour highlights it as an excellent source of energy, mainly thanks to its high carbohydrate levels, making it an important food for meeting the caloric needs of urban and rural Comorian populations. It may also offer moderate protein amounts and dietary fiber, contributing to digestive health, satiety, and overall dietary balance. The presence of several flavonols, phenolics, and organic acids enhances its antioxidant potential. The nutritional and phytochemical properties of *D. comorensis* proved interesting in comparison to breadfruit and other

similar traditional local plant-based food items. However, the study suggested the potential of *D. comorensis* flour for food applications, but further analysis and tests should be performed to identify other important nutritive and bioactive molecules and antinutritional factors (e.g., oxalates, alkaloids, protease inhibitors) to confirm these preliminary results. Moreover, the harvesting of plant material from a single location may be considered a limitation of the present work. The results described the nutritional profile of flour from tubers collected at the specific site, and they may not be generalized to the whole island or species without further investigations. For this reason, future studies will be performed to analyze tubers from plants across different sites and across all the archipelago islands to distinguish plant-related variability from environmental effects.

In conclusion, *D. comorensis* may be considered more than a traditional food crop; it could be a potential strategic resource for promoting health, improving nutrition, and reinforcing food security in the Comoros Islands. Its potential should be further explored by an interdisciplinary approach, including targeted public awareness initiatives and the development of value-added products, which make this species very important for development efforts and sustainable nutrition in the region.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

Dario Donno is an editorial board member for AIMS Agriculture and Food and was not involved in the editorial review or the decision to publish this article. All authors declare no conflicts of interest.

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Supplementary

Table SM1. Protocols for the extraction of bioactive compounds and nutritional substances.

Chemical class	Sample weight	Extraction solvents	Time of extraction	Homogenization	Centrifugation	Number of successive extractions	Other actions
Polyphenolic compounds	10 g	Methanol:bi-distilled water, 95:5 v/v, pH adjusted with 1.5 mL of 37% HCl (25 mL)	60 min in the dark	1 min	15 min at 3,000 rpm	3	/
Organic acids, sugars, and monoterpenes	10 g	80% ethanol (25 mL)	60 min in the dark	1 min	15 min at 3,000 rpm	2	/
Vitamin C	10 g	0.1 M citric acid, 2 mM EDTA disodium salt, and 4 mM sodium fluoride in methanol:water, 5:9,5 v/v (10 mL)	20 min in the dark	1 min	10 min at 4,000 rpm	2	Supernatant acidified with 4 N HCl (pH = 2.2–2.4) and centrifuged for 5 min at 12,000 rpm at 4 °C

Table SM2. Chromatographic conditions of each method used.

Method	Classes of interest	Stationary phase	Mobile phase	Wavelength (nm)
A	Cinnamic acids, flavonols	KINETEX – C18 column (4.6 × 150 nm, 5 µm)	A: 10 mM KH_2PO_4/H_3PO_4, pH = 2.8 B: CH_3CN	330
B	Benzoic acids, catechins, tannins	KINETEX – C18 column (4.6 × 150 nm, 5 µm)	A: $H_2O/CH_3OH/HCOOH$ (5:95:0.1 v/v/v), pH = 2.5 B: $CH_3OH/HCOOH$ (100:0.1 v/v)	280
C	Monoterpenes	KINETEX – C18 column (4.6 × 150 nm, 5 µm)	A: H_2O B: CH_3CN	250
D	Organic acids	KINETEX – C18 column (4.6 × 150 nm, 5 µm)	A: 10 mM KH_2PO_4/H_3PO_4, pH = 2.8 B: CH_3CN	214
E	Vitamins	KINETEX – C18 column (4.6 × 150 nm, 5 µm)	A: 5 mM $C_{16}H_{33}N(CH_3)_3Br$/50 mM KH_2PO_4, pH = 2.5 B: CH_3OH	261, 348
F	Sugars	SPHERECLONE – NH_2 column (4.6 × 250 mm, 5 µm)	A: H_2O B: CH_3CN	267, 286

Method A, gradient analysis: 5% B to 21% B in 17 min + 21% B in 3 min (2 min conditioning time); flow: 1.5 mL min^{-1}.

Method B, gradient analysis: 3% B to 85% B in 22 min + 85% B in 1 min (2 min conditioning time); flow: 0.6 mL min^{-1}.

Method C, gradient analysis: 30% B to 56% B in 15 min + 56% B in 2 min (3 min conditioning); flow: 1.0 mL min^{-1}.

Method D, gradient analysis: 5% B to 14% B in 10 min + 14% B in 3 min (2 min conditioning time); flow: 0.6 mL min^{-1}.

Method E, isocratic analysis: ratio of phase A and B: 95:5 in 10 min (5 min conditioning time); flow: 0.9 mL min^{-1}.

Method F, isocratic analysis: ratio of phase A and B: 5:85 in 12 min (3 min conditioning time); flow: 0.5 mL min^{-1}.

Table SM3. Nutritional composition range of the most common *Dioscorea* species tubers expressed per 100 g of dry weight.

Nutrient	*D. alata*	*D. rotundata*	*D. cayenensis*	*D. esculenta*
Moisture (% fresh weight)	63–77	55–67	54–66	68–83
Protein (g)	6.0–8.0	4.5–5.9	4.3–5.7	7.0–9.0
Ash (g)	4.0–5.0	2.8–3.6	2.2–2.8	4.3–5.7
Lipids (g)	0.6–0.8	0.9–1.1	2.0–2.6	0.4–0.6
Carbohydrates (g)	74–90	74–90	77–93	70–86
Energy (kcal)	300–360	310–380	325–385	290–350
Starch (g)	72–88	70–86	72–88	63–77
Total dietary fiber (g)	6–8	2.5–3.5	n.d.	n.d.
Copper (mg)	n.d.	0.8–1.2	n.d.	n.d.
Magnesium (mg)	85–115	72–98	68–92	n.d.
Phosphorus (mg)	170–230	210–280	195–265	n.d.
Potassium (mg)	1350–1650	1850–2350	1850–2350	1600–2000
Phenolic compounds (mg GAE)	95–150	n.d.	n.d.	n.d.
Vitamin C (mg)	0.30–0.60	0.30–0.45	0.40–0.70	0.45–0.85
Simple sugars (g)	1.4–2.0	1.0–2.4	1.0–2.4	1.6–3.9

Source: [7–9,14,24].

Table SM4. *Dioscorea* species tuber composition in relation to adult WHO/FAO reference needs.

Nutrient (per 100 g DW)	*Dioscorea* species	WHO/FAO adult reference needs (for a 70 kg adult)	Contribution from *Dioscorea* tubers (100 g)
Energy (kcal)	320–355 kcal	Approximately 2000–2500 kcal/day	Approximately 13%–18% of daily energy, significant levels for a staple root crop
Protein (g)	Approximately 5–8 g	Approximately 56 g/day	Approximately 9%–14% of protein needs (modest, but meaningful in diets based on tubers/cereals)
Carbohydrates/starch (g)	Approximately 70–85 g	No fixed RNI (carbohydrates should be the main source of energy)	Main carbohydrate source; significant as a staple food for providing energy
Total fat (g)	Approximately 0.5–2.3 g	<30% of total energy	Low levels; need to integrate fat from other foods
Dietary fiber (g) (if available)	Approximately 3–7 g	Recommendation of adequate levels of fiber (no specific range)	Moderate intake is useful if part of a varied diet
Minerals (i.e., Mg, P, K)	Mg: approximately 80–115 mg P: approximately 170–280 mg K: approximately 1350–2350 mg	300–350 mg/day (Mg) 700 mg/day (P) 3500 mg/day (K)	25%–35% (Mg) Approximately 35% (P) Approximately 60% (K) In general, an appreciable mix of mineral elements (in particular, potassium); positive effects if consumed in large amounts
Vitamin C/phenolics	Vitamin C: approximately 0.3–0.8 mg Phenolics: approximately 95–150 mg GAE	75–90 mg/day (vitamin C) No fixed values for phenolics	<1% (vitamin C) In general, insufficient to meet the vitamin C adult needs

The provided reference values represent general guidelines from the WHO/FAO database; more specific values depend on different conditions, such as activity level, physiological status, sex, and age. DW = dried weight; GAE = gallic acid equivalent.

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