

Nutritional Composition, Antinutritional Potential, Antioxidant Capacity, and Consumption Frequency of *Physalis peruviana* and *Physalis angulata* Fruits

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Abstract

Physalis fruits, once widely consumed, are now neglected and underutilized. The aim of this study was to determine the nutritional composition, antinutritional potential, antioxidant properties, and consumption frequency of *Physalis peruviana* and *Physalis angulata* fruits. To achieve this objective, macronutrients, minerals, and antinutritional compounds were analyzed using standard AOAC methods. Antioxidant capacity was assessed through the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay and the Ferric Reducing Antioxidant Power (FRAP) assay. In addition, a dietary survey was conducted to evaluate the frequency of fruit consumption. The results showed that moisture ($80.82 \pm 0.45\%$ and $72.95 \pm 1.82\%$), lipids (8.07 ± 1.51 and 1.57 ± 0.35 g/100 g FM), and carbohydrates (67.68 ± 1.68 and 76.79 ± 1.48 g/100 g FM) differed significantly between *Physalis peruviana* and *Physalis angulata*, respectively. *Physalis peruviana* was richer in calcium (74.3 ± 1.24 mg/100 g FM), magnesium (7.84 ± 1.10 mg/100 g FM), potassium (1287.70 ± 13.62 mg/100 g FM) and sodium (16.02 ± 0.20 mg/100 g FM), whereas *Physalis angulata* contained higher levels of iron (2.81 ± 0.30 mg/100 g), phosphorus (46.38 ± 2.98 mg/100 g FM) and zinc (25.48 ± 1.67 mg/100 g FM). Carotenoid contents were higher in *Physalis peruviana*. The IC₅₀ values determined by the DPPH assay were 0.76 mg/mL for *Physalis peruviana* and 0.32 mg/mL for *Physalis angulata*. Both species demonstrated strong antioxidant potential. Despite their valuable nutritional properties, both *Physalis* species were poorly consumed by the surveyed populations. The fruits of both *Physalis* species could serve as an excellent dietary supplement to help combat nutritional deficiencies in children.

Keywords: *Physalis peruviana*, *Physalis angulata*, nutritional composition, antioxidant

1. Introduction

Fruits are defined as the edible parts of cultivated or wild plants, consumed either fresh or in a minimally processed form (FAO, 2021). They are rich in natural compounds that provide health benefits beyond basic nutrition (Shenstone et al., 2020). Fruits also possess remarkable biological properties and are widely used in various fields, including medicine and pharmacology, as well as in balanced diets due to their high nutritional value (Kafia, 2024). Among the different fruit families, the Solanaceae family stands out. The *Solanaceae* is a plant family comprising nearly 2,500 species distributed worldwide and containing a wide range of important phytochemical compounds. This family includes wild species such as *Physalis*, commonly known as ground cherries, which represents the fifth largest genus within the *Solanaceae*, with approximately 100 species (Mirzaee et al., 2019; Miri & Shamsolshoara, 2023). These exotic fruits have gained popularity in many countries across Europe, Asia, the Americas, and Africa (Petkova et al., 2021). Among the numerous species within the *Physalis* genus, *Physalis peruviana* L. and *Physalis angulata* L. are particularly noteworthy. *Physalis peruviana* L. is an annual herbaceous plant native to South America (Petkova et al., 2021). Its fruits, weighing

approximately 4–5 g, are enclosed within an enlarged calyx and covered with a bright yellow skin (El-Beltagi et al., 2019). These fruits have been reported to possess numerous health-promoting properties, including anti-inflammatory, hepatoprotective, and anticancer activities. In traditional medicine, *Physalis peruviana* is used to treat a variety of conditions such as kidney disorders, leishmaniasis, skin infections, asthma, wounds, hemorrhoids, bladder dysfunction, helminthic infections, and liver diseases (Mirzaee et al., 2019). *Physalis angulata* is a less well-known species found in certain regions of Africa, Asia, and the Americas (Ritawati et al., 2023) and is widely distributed in tropical and subtropical areas (Novitasari et al., 2024). It can grow up to one meter in height, has a short stem, and produces edible yellow fruits (Vieceli et al., 2021). *Physalis angulata* has been reported to exhibit a broad range of pharmacological activities, including antibacterial, anticancer, cytotoxic, and immunomodulatory effects (Nguyen et al., 2021). In Asia, it has traditionally been used as a diuretic and anti-inflammatory agent, and for the treatment of muscle pain, asthma, diabetes, chickenpox, hypertension, and back pain (Fadhli et al., 2023). With the rising prevalence of these diseases, consumers are increasingly seeking foods that offer health benefits beyond their basic nutritional value. Fruits may serve as a valuable alternative, particularly *Physalis* fruits, which are rich in antioxidants and phenolic compounds, dietary fiber, vitamins, minerals, carotenoids, phytosterols, and numerous other bioactive compounds (Popova et al., 2020). However, despite these recognized benefits, *Physalis* fruits remain relatively unknown among the Cameroonian population. It is therefore important to determine whether their nutritional composition and antioxidant properties, as reported in previous studies conducted elsewhere, are similar under Cameroonian conditions.

The overall objective of this study was to determine the nutritional composition, antinutritional potential, antioxidant properties, and consumption frequency of *Physalis peruviana* and *Physalis angulata* fruits.

2. Material

2.1 Plant Material

The plant material consisted of fruits of *Physalis angulata* and *Physalis peruviana* harvested in the city of Douala (Littoral Region) and in the village of Bandjoun (West Region), Cameroon, respectively. The harvested *Physalis* species were taxonomically identified and authenticated under voucher specimen numbers **66862/HNC** for *Physalis peruviana* Linn. and **8983/SRF** for *Physalis angulata* Linn.

3. Methods

After harvesting, *Physalis peruviana* and *Physalis angulata* fruits were transported to the Biochemistry Laboratory of the University of Douala, where they were used for the various analyses.

3.1 Drying of Fruits and Preparation of Powders

Upon arrival at the Biochemistry Laboratory of the University of Douala, the samples were sorted, the calyces were removed, and the whole fruits were thoroughly washed. The fruits were then dried in a ventilated oven at 45 °C for 72 h. After drying, they were ground using a laboratory blender, and the resulting powders were used for the different analyses.

3.2 Determination of Moisture and Dry Matter Content

Moisture content was determined according to the AOAC (2012) method by measuring the loss in mass of fresh fruit samples after oven drying at 105 °C until a constant weight was obtained. Dry matter content was calculated from the moisture content. Total ash content was also determined following the AOAC (2012) method, which consisted of incinerating the samples in a muffle furnace at 560 °C under oxidizing conditions until a constant residue mass was obtained.

3.3 Determination of Macronutrient Content

3.3.1 Protein Content

Total nitrogen content was determined after sample mineralization using the Kjeldahl method according to AOAC (1990). Nitrogen quantification was performed by measuring absorbance at 412 nm using a UV–VIS spectrophotometer (Metertech SP8001, Germany). Crude protein content was calculated by multiplying the total nitrogen content by the conventional nitrogen to protein conversion factor of 6.25.

3.3.2 Lipid Content

Total lipid content was determined using the Soxhlet extraction method with hexane, according to AOAC (2012). Briefly, 1 g of fruit powder was placed in an extraction thimble and extracted with 600 mL of hexane. After completion of the extraction and cooling, the solvent was recovered, and the extracted oil was concentrated using a rotary evaporator (Büchi Rotavapor R-205). The lipid content was then determined gravimetrically.

3.3.3 Crude Fiber Content

Dietary fiber content was determined using the enzyme-gravimetric method according to AOAC (1990). Briefly, 0.2 g of the sample was sequentially treated with heat-stable α -amylase, protease, and amyloglucosidase to hydrolyze starch and proteins. The resulting residue was precipitated and washed with ethanol and acetone. Dietary fiber content was then determined gravimetrically.

3.3.4 Total Carbohydrate Content

Total carbohydrate content was calculated by the difference method according to AOAC (1990), by subtracting the sum of ash, crude fiber, protein, and lipid contents from the dry matter. All analyses were performed in triplicate.

3.4 Determination of Mineral Content

Mineral analysis was carried out in two stages: mineralization and quantification. Dried samples (45 °C) were finely ground, weighed, and incinerated in a muffle furnace at 450 °C for 5 h. The resulting ash was cooled in a desiccator and weighed. Subsequently, 10 mL of 20% nitric acid was added to dissolve the ash, and the solution was filtered through Whatman filter paper. The concentrations of magnesium (Mg), calcium (Ca), potassium (K), sodium (Na), iron (Fe), zinc (Zn), and manganese (Mn) were then determined using standard AOAC (1990) methods. Calcium and magnesium contents were determined by complexometric titration, while total phosphorus was quantified by colorimetric analysis at 430 nm using the mineralized extract. Iron content was determined by orthophenanthroline colorimetry, with maximum absorbance measured at 510 nm. Copper, sodium, potassium, and manganese contents were quantified by atomic absorption spectrophotometry following ash solubilization.

3.5 Determination of Total Carotenoid Content

Total carotenoid content was determined according to the AOAC (1975) method. Absorbance was measured using a spectrophotometer by scanning the extract between 430 and 450 nm to obtain the maximum optical density. Carotenoid concentration (mg/L) was calculated using the following formula:

$$C = (OD_{\max} \times f) / (196 \times m)$$

where C is the carotenoid content, $OD_{\max}$ is the optical density at maximum absorbance, f is the dilution factor, and m is the sample mass.

3.6 Determination of Antinutritional Compounds

3.6.1 Oxalate Content

Oxalate content was determined using the colorimetric titration method described by Day and Underwood (1986) with potassium permanganate. Briefly, 1 g of the sample was mixed with 75 mL of 1.5 M sulfuric acid in an Erlenmeyer flask, stirred, and filtered. An aliquot of 25 mL of the filtrate was transferred to a beaker and titrated at 80–90 °C with 0.1 M potassium permanganate ($KMnO_4$) until a persistent pink coloration lasting 30 s was observed. The oxalate content was then calculated from the volume of titrant used.

3.6.2 Phytate Content

Phytate content was determined according to the AOAC (1990) method. Briefly, 2 g of the sample powder was mixed with 100 mL of 2% HCl in an Erlenmeyer flask and allowed to stand for 3 h. The mixture was then filtered, and 50 mL of the filtrate was transferred into a 250 mL Erlenmeyer flask and diluted with 107 mL of distilled water. Subsequently, 10 mL of 0.3% ammonium thiocyanate was added as an indicator. The solution was titrated with a standard $FeCl_3$ solution until a persistent yellow coloration appeared, and the phytate content was calculated based on the volume of titrant used.

3.6.3 Tannin Content

Total tannin content was determined following the method described by Ndhlala et al. (2007). Briefly, 0.5 g of *Physalis* fruit powder was mixed with 3 mL of butanol–HCl reagent (95:5, v/v) and 0.1 mL of ferric reagent (2% ferric ammonium sulfate in 2 N HCl) in a 10 mL test tube. The mixture was thoroughly mixed and incubated in a boiling water bath at 100 °C for 1 h. After cooling, absorbance was measured at 550 nm using a spectrophotometer, and tannin content was calculated accordingly.

3.7 Evaluation of Antioxidant Properties of Physalis Fruits

The antioxidant properties of *Physalis* fruit extracts were evaluated *in vitro* by assessing their free radical scavenging activity using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay and their ferric reducing antioxidant

power (FRAP).

3.7.1 DPPH Radical Scavenging Assay

The DPPH radical scavenging activity was evaluated according to the method described by Brand-Williams et al. (1995), with slight modifications. A 0.04 mg/mL DPPH solution and a 20 mg/mL ascorbic acid solution (used as the reference antioxidant) were prepared in methanol. Aliquots of 100 µL of sample extracts at different concentrations (2, 1, 0.5, 0.25, and 0.125 mg/mL) were mixed with 1,900 µL of the DPPH methanolic solution (0.04 mg/mL). The mixtures were shaken and incubated in the dark at room temperature for 30 min. Absorbance was then measured at 517 nm using a spectrophotometer. Methanol was used as the negative control, while ascorbic acid served as the positive control.

3.7.2 Ferric Reducing Antioxidant Power (FRAP) Assay

The ferric reducing power of *Physalis* fruit extracts was evaluated according to the method described by Oyaizu (1986). Briefly, 250 µL of aqueous extract at different concentrations (2, 1, 0.5, 0.25, and 0.125 mg/mL) was mixed with 625 µL of phosphate buffer (0.2 M, pH 6.6) and 625 µL of 1% potassium ferricyanide solution [$K_3Fe(CN)_6$]. The mixture was incubated in a water bath at 50 °C for 20 min. The reaction was then stopped by adding 625 µL of 10% trichloroacetic acid. After incubation, the tubes were centrifuged at 3,000 rpm for 10 min. An aliquot of 625 µL of the supernatant was then mixed with 625 µL of distilled water and 125 µL of 0.1% ferric chloride ($FeCl_3$) solution. The absorbance of the resulting reaction mixture was measured at 700 nm using a spectrophotometer. The mean inhibitory concentration (IC_{50}) and antiradical potential were determined according to the classification scale described by Souris et al. (2008). As antioxidant activity is inversely proportional to the IC_{50} value, lower IC_{50} values indicate higher antioxidant activity and greater ferric reducing power.

3.8 Dietary Survey

A dietary survey was conducted to assess the frequency of consumption of various fruits, including *Physalis* species. The survey was carried out among populations in Douala and Bandjoun, without discrimination based on gender, ethnic group, or educational level. After explaining the objectives of the study, informed consent was obtained from all participants. Data were collected using a structured questionnaire specifically designed for this purpose. All responses were recorded in writing and carefully reviewed to ensure completeness and accuracy of the questionnaires.

3.9 Sample Size Determination

The sample size was calculated using the following formula:

$$N = Z^2 \times P(1 - P) / M^2$$

where N is the required sample size, Z represents the confidence level ($Z = 1.96$ for a 95% confidence interval), P is the estimated proportion of the population, M is the tolerated margin of error.

3.10 Statistical Analyses

Quantitative data were expressed as mean $\pm$ standard deviation. All chemical analyses were performed in triplicate ($n = 3$). Differences between samples were assessed using Student's t -test for pairwise comparisons. Statistical significance was set at $P < 0.05$.

4. Results

4.1 Nutritional Composition of *Physalis* Fruits

Table 1 shows that *Physalis peruviana* had significantly higher lipid and moisture contents compared with *Physalis angulata*. In contrast, the total carbohydrate content was higher in *Physalis angulata* than in *Physalis peruviana*. Similarly, protein content was greater in *Physalis angulata* compared to *Physalis peruviana*. There is no significant difference between the crude fiber contents of *Physalis peruviana* and *Physalis angulata*.

Table 1. Proximate composition of fresh *Physalis peruviana* and *angulata* fruits

Variables	<i>Physalis peruviana</i>	<i>Physalis angulata</i>
Moisture content (%)	80.82 $\pm$ 0.45 ^a	72.95 $\pm$ 1.82 ^b
Protein (%)	3.49 $\pm$ 0.12 ^a	4.47 $\pm$ 0.49 ^a
Lipids (%)	1.55 $\pm$ 0.32 ^a	0.42 $\pm$ 0.11 ^b
Total carbohydrates (%)	12.97 $\pm$ 0.04 ^a	20.73 $\pm$ 1.05 ^b
Crude fiber (%)	0.89 $\pm$ 0.02 ^a	1.28 $\pm$ 0.09 ^a
Ash (%)	1.17 $\pm$ 0.03 ^a	1.43 $\pm$ 0.19 ^a

Values are expressed as mean $\pm$ standard deviation ($n = 3$); Values in the same line sharing the same superscript letter do not differ significantly ($P > 0.05$).

Table 2 presents the mineral composition of fresh *Physalis peruviana* and *Physalis angulata* fruits. *Physalis peruviana* exhibited higher levels of magnesium, calcium, potassium and sodium compared with *Physalis angulata*. The phosphorus, iron, and zinc contents in *Physalis angulata* differed significantly ($P < 0.05$) compared to those in *Physalis peruviana*. In contrast, no significant difference was observed in carotenoid content between *Physalis peruviana* and *Physalis angulata*.

Table 2. Mineral and carotenoid contents in of *Physalis peruviana* and *Physalis angulata* fruits

Variables		<i>Physalis peruviana</i>	<i>Physalis angulata</i>
Macronutrients (mg/100g FM)	Mg	7.84 $\pm$ 1.10 ^a	4.77 $\pm$ 0.3 ^b
	Ca	74.3 $\pm$ 1.24 ^a	66.39 $\pm$ 4.33 ^b
	P	34.42 $\pm$ 0.64 ^a	46.38 $\pm$ 2.98 ^b
	K	1287.70 $\pm$ 13.62 ^a	230.52 $\pm$ 15.11 ^b
	Na	16.02 $\pm$ 0.20 ^a	13.61 $\pm$ 0.89 ^b
Microelements (mg/100g MF)	Fe	1.09 $\pm$ 0.08 ^a	2.81 $\pm$ 0.3 ^b
	Zn	4.52 $\pm$ 0.04 ^a	25.48 $\pm$ 1.67 ^b
	Cu	0.0001 $\pm$ 0.00 ^a	0.0002 $\pm$ 0.00 ^a
	Mn	0.0001 $\pm$ 0.00 ^a	0.0008 $\pm$ 0.00 ^a
Carotenoids (μg/g MF)		2.52 $\pm$ 0.21 ^a	1.65 $\pm$ 0.69 ^a

Values are expressed as mean $\pm$ standard deviation ($n = 3$); Values in the same line sharing the same superscript letter do not differ significantly ($P > 0.05$); FM: fresh matter.

4.2 Antinutritional Potential of *Physalis* Fruits

Tannin and oxalate levels were higher in *Physalis angulata* than in *Physalis peruviana* (Table 3). Significant differences ($P < 0.05$) were observed between the two species for these compounds. Tannins were the predominant antinutritional compounds in *Physalis peruviana*, whereas oxalates were more abundant in *Physalis angulata*. Phytate content was also higher in *Physalis angulata* than in *Physalis peruviana* (Table 3) The calculated molar ratios of phytate/Zn, phytate/Ca, phytate/Fe, oxalate/Ca, and oxalate/Zn were all below critical threshold values, suggesting a low risk of mineral bioavailability impairment.

Table 3. Antinutritional compound contents and mineral molar ratios in *Physalis peruviana* and *angulata* fruits

Variables	<i>Physalis peruviana</i>	<i>Physalis angulata</i>	Standard values
Phytates (mg/100g FM)	0.08 $\pm$ 0.11 ^a	0.14 $\pm$ 0.08 ^a	-
Oxalates (mg/100g FM)	1.16 $\pm$ 0.31 ^a	2.01 $\pm$ 1.37 ^b	-
Tannins (mg/100g FM)	0.11 $\pm$ 0.31 ^a	1.65 $\pm$ 1.13 ^b	-
Phytate/Zn	0.02	0.01	< 10.00
Phytate/Ca	0.001	0.002	< 0.24
Phytate/Fe	0.07	0.05	< 0.15
Oxalate/Ca	0.26	0.03	< 1.00
Oxalate/Zn	0.02	0.09	< 1.00
Oxalate/Fe	1.06	0.72	< 1.00

Values are expressed as mean $\pm$ standard deviation ($n = 3$). Values in the same line sharing the same superscript letter do not differ significantly ($P > 0.05$). FM: fresh matter.

Table 4 presents the IC₅₀ values of *Physalis peruviana* and *Physalis angulata* extracts obtained from the DPPH radical scavenging assay, as well as their ferric reducing antioxidant power (FRAP). The IC₅₀ values allowed the antioxidant capacity of the extracts to be ranked relative to vitamin C and to each other. In the DPPH assay, *Physalis angulata* exhibited stronger radical scavenging activity compared to *Physalis peruviana*. For the FRAP assay, the IC₅₀ values for *Physalis peruviana* and *Physalis angulata* indicated comparable ferric-reducing capacities between the two species. *Physalis angulata*, which exhibited the lowest IC₅₀ in the DPPH assay, demonstrated the highest antiradical activity compared with *Physalis peruviana*. In contrast, *Physalis peruviana* showed the strongest ferric reducing power in the FRAP assay. *Physalis angulata* displayed higher antiradical

activity than vitamin C in the DPPH test, whereas *Physalis peruviana* exhibited greater reducing power than vitamin C in the FRAP assay. However, *Physalis peruviana* showed lower antioxidant activity than vitamin C in the DPPH assay.

Table 4. Antioxidant potential of *Physalis peruviana* and *angulata* extracts

Parameters		Vitamin C	<i>Physalis peruviana</i>	<i>Physalis angulata</i>
IC ₅₀ (mg/mL)	DPPH	0.59 ± 0.12 ^a	0.78 ± 0.12 ^a	0.32 ± 0.01 ^a
	FRAP	1.99 ± 0.55 ^a	1.29 ± 0.15 ^b	1.64 ± 0.30 ^{ba}

Values are expressed as mean ± standard deviation (n = 3); Values in the same line followed by different superscript letters are significantly different (P < 0.05). IC₅₀: inhibitory concentration.

4.3 Frequency of *Physalis* Fruit Consumption

A total of 244 individuals participated in the dietary survey, including 124 (50.82%) from the rural area of Bandjoun and 120 (49.18%) from the city of Douala. Women accounted for 126 participants (51.64%), while 118 were men (48.36%), with ages ranging from 17 to 70 years. Table 5 presents the diversity of fruits consumed by the surveyed population. The table shows that *Physalis* fruits were very poorly consumed by the population. The most frequently consumed fruits were orange, mangoes, pineapples, papaya, sweet banana, watermelon and avocado.

Table 5. Fruits consumed by the surveyed population

No.	Scientific names	Common names	Frequency (%)
1	<i>Nephelium lappaceum</i>	Rambutan	0.13
2	<i>Physalis sp.</i>	Ground cherry	0.54
3	<i>Fragaria vesca</i>	Strawberry	0.54
4	<i>Cola nitida</i>	Cola	0.67
5	<i>Cocos nucifera</i>	Coconut	0.67
6	<i>Annona muricata</i>	Soursop	1.07
7	<i>Cucumis melo</i>	Melon	1.47
8	<i>Dacryodes edulis</i>	Plum	1.48
9	<i>Spondias dulcis</i>	Cassia	1.57
10	<i>Cyperus esculentus</i>	Tigernut	1.67
11	<i>Solanum betaceum</i>	Cherry	2.42
12	<i>Malus domestica</i>	Apple	2.55
13	<i>Phoenix dactylifera</i>	Date	2.61
14	<i>Passiflora edulis</i>	Passion fruit	3.22
15	<i>Citrus paradisi</i>	Grapefruit	3.90
16	<i>Psidium guajava</i>	Guava	4.97
17	<i>Citrus reticulata</i>	Mandarin	4.97
18	<i>Citrus limon</i>	Lemon	5.40
19	<i>Persea americana</i>	Avocado	7.39
20	<i>Citrullus lanatus</i>	Watermelon	7.66
21	<i>Musa acuminata</i>	Sweet banana	8.20
22	<i>Carica papaya</i>	Papaya	8.27
23	<i>Ananas comocus</i>	Pineapple	8.87
24	<i>Citrus sinensis</i>	Orange	14.65
25	<i>Mangifera indica</i>	Mango	13.17

5. Discussion

The aim of this study was to determine the nutritional composition, antinutritional potential, antioxidant properties, and consumption frequency of *Physalis peruviana* and *Physalis angulata* fruits. The proximate composition results presented in Table 1 showed the mean moisture content of *Physalis peruviana* fruits which was lower than the value reported by Petkova et al. (2021) in Bulgaria (83.07 ± 0.27%), but higher than those reported by Pereda et al. (2018) and Iwansyah et al. (2020) in Argentina (79.11 ± 1.24%) and Indonesia (76.50 ± 0.04%), respectively. These variations may be attributed to differences in geographical location and harvest season. Indeed, Harper (2024) reported that soil composition significantly influences plant growth and chemical

composition. In the present study, the moisture content of *Physalis angulata* was significantly lower than that of *Physalis peruviana* (Table 1) and also lower than the value reported for *Physalis angulata* ($76.50 \pm 0.04\%$) by Iwansyah et al. (2020) in Indonesia. The observed differences between the two *Physalis* species may also be attributed to species-specific water absorption capacities and physiological characteristics (Shenstone et al., 2020). The protein content of *Physalis peruviana* fruits in Table 1 differed from values reported by Iwansyah et al. (2020) in Indonesia ($4.03 \pm 0.03\%$) and by Obregon et al. (2023) in Peru (0.28 ± 0.04 to $0.40 \pm 0.02\%$). For *Physalis angulata*, the protein content was higher than the 3.41% reported by Azeez & Faluyi (2019) in Nigeria but lower than the $6.44 \pm 0.05\%$ reported by Popova et al. (2022). Overall, *Physalis angulata* exhibited a higher protein content than *Physalis peruviana*. These findings suggest that both *Physalis* species can contribute to dietary protein intake, supporting immune function as well as enzyme and hormone synthesis, and may therefore serve as valuable components of dietary supplementation (Ortega, 2025). The lipid content of *Physalis peruviana* fruits was higher than that of *Physalis angulata* (Table 1). The lipid content of *Physalis peruviana* observed in this study was lower than the $4.70 \pm 0.05\%$ reported by Iwansyah et al. (2020), but higher than the 0.49% reported by Ortega (2025) for the same species. In contrast, *Physalis angulata* exhibited a very low lipid content and can be classified as a fat-free food, as its lipid level was below 0.5% (Ortega, 2025). The carbohydrate content of *Physalis peruviana* was lower than the 61% reported by Kasali et al. (2022), whereas that of *Physalis angulata* was higher than the $14.13 \pm 0.50\%$ reported by Petkova et al. (2021) for *Physalis peruviana*. The crude fiber contents of *Physalis peruviana* and *Physalis angulata* fruits were lower than those reported by Petkova et al. (2021) (7.89%), and Iwansyah et al. (2020) (4.48%), all of whom studied *P. peruviana*. These differences may be attributed to variations in soil composition (Harper, 2024), but may also reflect differences in analytical methodologies, which can influence fiber quantification. The ash contents of *Physalis peruviana* and *Physalis angulata* fruits (Table 1) were lower than the values reported by Popova et al. (2022) for *Physalis alkekengi* ($6.18 \pm 0.05\%$) and by Iwansyah et al. (2022) for *Physalis peruviana* (2.10%). The ash content reflects the total mineral matter and provided the basis for quantifying individual mineral elements in the present study.

Table 2 presents the mineral composition of *Physalis peruviana* and *Physalis angulata* fruits. The mean zinc contents of both *Physalis* species were higher than the 3.46 ± 0.11 mg/100 g FM reported by Petkova et al. (2021) for *Physalis angulata*. The potassium content of *Physalis peruviana* fruits was markedly higher than the values reported by Petkova et al. (2021) (446.71 ± 12.99 mg/100 g FM) and Popova et al. (2021) (452.70 ± 12.31 mg/100 g FM). The potassium content obtained in *Physalis angulata* fruits was lower than the values reported by Kasali et al. (2022) (560 mg/100 g FM) and Pereda et al. (2018) (373.25 ± 15.50 mg/100 g FM). This potassium content in *Physalis* has a nutritionally important in human being, such as plays a key role in regulating water balance, nerve transmission, and muscle contraction (EFSA, 2017). The sodium contents of *Physalis peruviana* and *Physalis angulata* were markedly lower than the 170 mg/100 g reported by Kasali et al. (2022). A low sodium content combined with a high potassium content is considered beneficial for cardiovascular health and may be suitable for the dietary management of metabolic syndrome. Indeed, such a mineral profile contributes to maintaining intra- and extracellular electrolyte balance and may help in the prevention and control of hypertension (Bamigboye et al., 2015). The mineral profile of *Physalis peruviana* and *Physalis angulata*, characterized by low sodium and relatively high potassium contents, suggests that these fruits could contribute to dietary strategies aimed at the prevention of high blood pressure. The manganese contents of both *Physalis* fruits were markedly lower than the value reported by Petkova et al. (2021) (1.63 ± 0.01 mg/100 g FM). In contrast, the calcium content of *Physalis peruviana* fruits was higher than that of *Physalis angulata*. Both values were considerably higher than those reported by Pereda et al. (2018), Petkova et al. (2021) and Popova et al. (2022), who reported calcium contents of 11.17 ± 0.50 , 0.90 ± 0.06 , and 0.14 ± 0.01 mg/100 g FM, respectively. Calcium plays a crucial role in bone mineralization, muscle contraction and relaxation, blood coagulation, and the maintenance of fluid balance, highlighting the nutritional relevance of these fruits as dietary calcium sources (Edeke et al., 2021). The copper contents of *Physalis peruviana* and *Physalis angulata* fruits were considerably lower than the values reported by Pereda et al. (2018) (0.35 ± 0.02 mg/100 g) and Petkova et al. (2021) (3.92 ± 0.14 mg/100 g). The phosphorus contents in *Physalis peruviana* and *Physalis angulata* were lower than those reported by Kasali et al. (2022) (130 mg/100 g). Nevertheless, the phosphorus levels observed in both fruits remain below the recommended daily intake for adults (750 mg), indicating that they contribute modestly to daily phosphorus requirements. Phosphorus plays an essential role in energy storage and release, as well as in bone mineralization through its interaction with calcium, underscoring its nutritional importance (Achu et al., 2021). The iron contents in both *Physalis* fruits were higher than the ranges of 0.03 – 2.53 mg/100 g and 1.31 – 1.43 mg/100 g reported by Shenstone et al. (2020) and Obregon et al. (2023), respectively. The presence of iron in these fruits may contribute to hemoglobin synthesis, which is essential for oxygen transport in the body (Fadhli et al., 2023). The magnesium contents in *Physalis peruviana* and *Physalis angulata* fruits were lower

than those reported by Shenstone et al. (2020) (48.7 mg/100 g FM), Petkova et al. (2021) (15.46 ± 0.57 mg/100 g FM), and Popova et al. (2021) (33.73 ± 0.18 mg/100 g FM). Overall, the mineral composition of *Physalis peruviana* and *Physalis angulata* fruits highlights their nutritional relevance, although marked variations were observed between species and among studies. These differences may be attributed to factors such as geographical origin, harvest conditions, and soil chemical composition (Harper, 2024). Table 2 shows that the carotenoid content of *Physalis peruviana* fruit was higher than that of *Physalis angulata*. However, both values were markedly lower than the carotenoid contents reported by Popova et al. (2022) for *Physalis alkekengi* fruits in Bulgaria (22.85 ± 0.20 and 18.88 ± 0.12 µg/g MF) and those obtained by Petkova et al. (2021) for *Physalis peruviana* fruits in South America (20.75 ± 0.18 µg/g MF). Carotenoids are important bioactive compounds in fruits, playing key roles as provitamin A sources and antioxidants that contribute to human health (Petkova et al., 2021).

Table 3 shows that phytic acid, oxalates, and tannins were present in the fruits of *Physalis peruviana* and *Physalis angulata*, with significant differences between species. The oxalate contents were 1.64 ± 0.31 and 2.14 ± 1.37 mg/100 g FM for *Physalis peruviana* and *Physalis angulata*, respectively. These values were lower than the 3.21 ± 0.34 mg/100 g reported by de Aliero & Usman (2016) for *Physalis angulata* fruits. The phytate contents recorded in *Physalis peruviana* (0.08 ± 0.11 mg/100 g MF) and *Physalis angulata* (0.14 ± 0.08 mg/100 g MF) were also markedly lower than the 8.59 ± 0.64 mg/100 g reported by Aliero & Usman (2016) for *Physalis angulata*. The low phytate levels observed in the present study could be attributed to the activity of endogenous phytase enzymes, which contribute to the degradation of phytic acid in plant tissues (Sharma et al., 2020). The tannin contents measured in *Physalis peruviana* and *Physalis angulata* fruits were 0.11 ± 0.31 and 1.65 ± 1.13 mg/100 g FM, respectively. These values were markedly lower than the 14.82 ± 0.62 mg/100 g reported by El-Beltagi et al. (2019) for *Physalis peruviana*. High concentrations of antinutritional compounds such as phytic acid, oxalates, and tannins are known to negatively affect the bioavailability of essential minerals by forming insoluble complexes, thereby reducing their absorption and utilization in the human body (Petroski et al., 2020). In the present study, the Phytate/Zn, Phytate/Ca, Phytate/Fe, Oxalate/Ca, and Oxalate/Zn molar ratios were all below their respective critical threshold values. This indicates a favorable mineral bioavailability and suggests that the iron, calcium, and zinc present in *Physalis peruviana* and *Physalis angulata* fruits could be efficiently absorbed by the body. These findings are consistent with those reported by Aliero & Usman (2016).

The extracts of *Physalis peruviana* and *Physalis angulata* exhibited average inhibitory concentrations (IC_{50}) of 0.78 ± 0.12 and 0.32 ± 0.01 mg/mL respectively, in the DPPH radical scavenging assay (Table 4). In the FRAP assay, the IC_{50} values were 1.29 ± 0.15 mg/mL for *Physalis peruviana* and 1.64 ± 0.30 mg/mL for *Physalis angulata*. These differences in antioxidant activity may be explained by variations in extraction solvents and assay mechanisms. In the present study, distilled water was used as the extraction solvent, whereas El-Beltagi et al. (2019) employed ethanol, which is known to extract a broader range of phenolic compounds. Furthermore, variations in IC_{50} values may also be attributed to differences in the chemical composition of the fruits, particularly flavonoids and polyphenols, which are influenced by environmental conditions and genetic factors (Abou et al., 2014). Overall, *Physalis peruviana* extracts demonstrated greater ferric-reducing capacity, while *Physalis angulata* extracts showed stronger free radical scavenging activity.

The survey revealed that among the 25 fruit species consumed, *Physalis* fruits were rarely consumed, accounting for only 0.54% of total fruit intake (Table 5). This low level of consumption may be attributed to limited awareness of these fruits among the study population, as well as their low availability in local markets and supermarkets, therefore, it becomes very important to promote the value of this fruit.

6. Conclusion

The fruits of *Physalis peruviana* and *Physalis angulata* exhibit good nutritional value and significant antioxidant properties. The complementary nutritional and antioxidant profiles of these two species suggest that a mixture of their fruits could serve as an effective dietary supplement for combating nutritional deficiencies, particularly among children.

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Author contributions

Nicolas Policarpe Nolla were responsible for study design, drafted the manuscript and revising it. Isabelle

Meyengue Moke and Erine Verina Metegoussong were responsible for data collection and drafted the manuscript. Jules Christophe Koule Manz supervised the lab manipulation. Marlyne Josephine Mananga and Wilfred Ngaha Damndja drafted and revised the manuscript. Inocent Gouado supervised all the study. All authors read and approved the final manuscript.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

“Not applicable.”

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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