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Nutritional potential, antinutritional factors, mineral bioavailability and pesticide content of seven herbal spices from Burkina Faso gastronomy

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Introduction: In Burkina Faso, several culinary herbs are commonly used as spices, thus contributing to the national culinary identity. Despite their significant use, they remain insufficiently characterized, which limits their valorization and the assessment of their contribution to food security. This study aims to evaluate the nutritional and antinutritional composition, as well as pesticide contamination, of seven commonly consumed herbal spices.

Materials and methods: Standardized proximal, spectrophotometric, and titrimetric analyses determined the macronutrient content, some essential minerals, and antinutritional factors. Amino acids and pesticides were quantified by chromatography.

Results and discussion: The highest ash content ($2.50\% \pm 0.06\%$ dry matter) was observed in *Apium graveolens*. The highest protein (7.76 ± 0.09 mg/100 mg) and lipid ($14.21\% \pm 0.15\%$) levels were observed in *Allium cepa*. Notable mineral concentrations were observed in *A. graveolens*, including calcium (220.36 mg/100 g), iron (26.75 mg/100 g), and sodium (69.23 mg/100 g); and in *Ocimum basilicum*, with magnesium (53.59 mg/100 g). Except for methionine, which was absent in *A. graveolens* and *A. cepa*, all other essential amino acids were present in the samples. The highest levels of ascorbic acid and lycopene were observed in *Anethum graveolens*. β -carotene and chlorophyll were more abundant in *Petroselinum crispum*. Anthocyanins were present in low concentrations in all samples. Regarding antinutritional factors, the highest levels of phytates and condensed tannins were very low, observed in *Petroselinum crispum* (5.08 ± 0.108 mg/100 g) and *Anethum graveolens* (29.43 ± 0.71 mg/100 g), respectively. *Anethum graveolens*, *O. basilicum*, and *Petroselinum crispum* share a similarity based on their richness in pigments and antioxidant compounds. Contamination

levels exceeding the maximum residue limit were found for aldrin in *A. cepa* and for carbofuran in *O. basilicum*, indicating poor agricultural practices. These results show that these plants have complementary nutritional profiles.

KEYWORDS

amino acid, anthocyanin, anti-nutrient factor, ascorbic acid, carotenoid pigments, mineral, nutritional property, pesticide

1 Introduction

Spices, pungent or aromatic substances, play a fundamental role in African culinary culture. They enhance the flavor, color, and aroma of food and contribute to its overall nutritional value. In many societies, these plant products are ubiquitous, irreplaceable, and traditionally used for their flavor, medicinal, and preservative properties, demonstrating their importance in local food practices (Al-Habsi et al., 2025). Their uses are passed down from generation to generation and constitute the cultural identity of many communities. They can include seeds, stems, leaves, herbs, bulbs, pods, buds, or even plants derived from the roots or bark of a tree (Khan et al., 2024). In Burkina Faso, several culinary herbs are commonly used as spices, incorporated into sauces, broths, and marinades, thereby contributing to the national culinary identity. Their use has generated considerable interest in recent years, due to a growing awareness of the need to reduce or eliminate the consumption of flavor enhancers, preservatives, and chemical additives (Lisboa et al., 2024). They represent an advantageous alternative to these synthetic products. Beyond their sensory appeal, these plant-based products have long been recognized for their digestive, antimicrobial, anti-inflammatory, and antioxidant properties. Several recent studies suggest that regular consumption of spices may help prevent of chronic non-communicable diseases, such as cardiovascular disease, obesity, diabetes, and respiratory conditions (Springmann et al., 2016; Bi et al., 2017). Furthermore, their potential richness in bioactive compounds gives them antitumor, lipid-lowering, digestive-stimulating, and sexual-enhancing properties (Ereifej et al., 2015; Chaudhari et al., 2021; Cicero et al., 2022; Farapti et al., 2024; Khan et al., 2024). In developing countries where malnutrition and micronutrient deficiencies remain a concern, developing local resources is a priority strategic approach. Burkina Faso faces these challenges, which affect nearly 21.3% of the population (FAO, 2018; Savadogo et al., 2023). While dietary supplements represent an option, their cost often limits their accessibility. Conversely, edible herbs, already integrated into traditional diets, could constitute an accessible and sustainable alternative solution. However, despite their nutritional benefits, these plant products can contain antinutritional factors that may affect nutrient bioavailability. For example, tannins bind to proteins and digestive enzymes, affecting nutrient digestion and absorption, while phytates form salts with minerals such as zinc, iron, calcium, and magnesium, reducing their bioavailability and hindering their absorption. Saponins, meanwhile, are associated with hemolytic effects (Pathaw et al., 2022). Assessing the content of these compounds is important for evaluating the true nutritional contribution of herbs. Furthermore, the sanitary quality of these herbs is a major concern. They may contain pesticides

because they are cultivated in peri-urban areas where they are heavily exposed to pesticide spraying. Their capacity to accumulate pesticides is generally higher than that of fruits, due to their larger leaf surface area. Furthermore, they are intensively cultivated, with repeated pesticide applications and frequent harvests, regardless of the growing season. Although studies have been conducted on spices and culinary herbs, these have focused either on pesticide levels (Reinholds et al., 2017; Di Bella et al., 2019) or on antinutritional factor compositions in different countries (Abdi et al., 2022; Borquaye et al., 2017; Ogunka-Nnoka and Mepba, 2008; Rumicha et al., 2025). However, studies that examine both nutritional and antinutritional properties, as well as chemical contamination, within the same sample are rare, particularly in West Africa. The study's innovation and originality, conducted in Burkina Faso, make it a noteworthy contribution to our understanding of the issue. This approach serves as a strategic tool for assessing the nutritional benefits and risks associated with these widely consumed products.

2 Materials and methods

2.1 Biological material, sampling, and sample processing

Sampling was conducted in April 2023 in the city of Ouagadougou (Burkina Faso) (Figure 1A). To account for seasonality, samples were collected during the dry season, when these species are most commonly available in local markets. For each species, randomization was applied by selecting leaf samples from different vendors and households to minimize bias. The biological material used in this study consisted of leaves from seven species commonly used in cooking: *Ocimum basilicum*, *Anethum graveolens*, *Apium graveolens*, *Allium cepa*, *Allium porrum*, *Petroselinum crispum*, and *Mentha piperita* (Figure 1B). The freshly harvested samples were carefully packed in labelled containers and then transported to the Laboratory of Biochemistry, Biotechnology, Food Technology, and Nutrition (LABIOTAN) at the University Joseph Ki-Zerbo. Once at the laboratory, the samples were dried in a dark room at room temperature to preserve their properties. After drying, the samples were ground into powder using an electric grinder (model MINI MOKA GR-0203) and then subjected to aqueous extraction for various biochemical and nutritional analyses. The specimens were deposited in the herbarium of the National Center for Scientific and Technological Research (CNRST) in Ouagadougou for taxonomic confirmation, where a unique identification number, between 8,792 and 8,798, was assigned to each of the seven specimens.

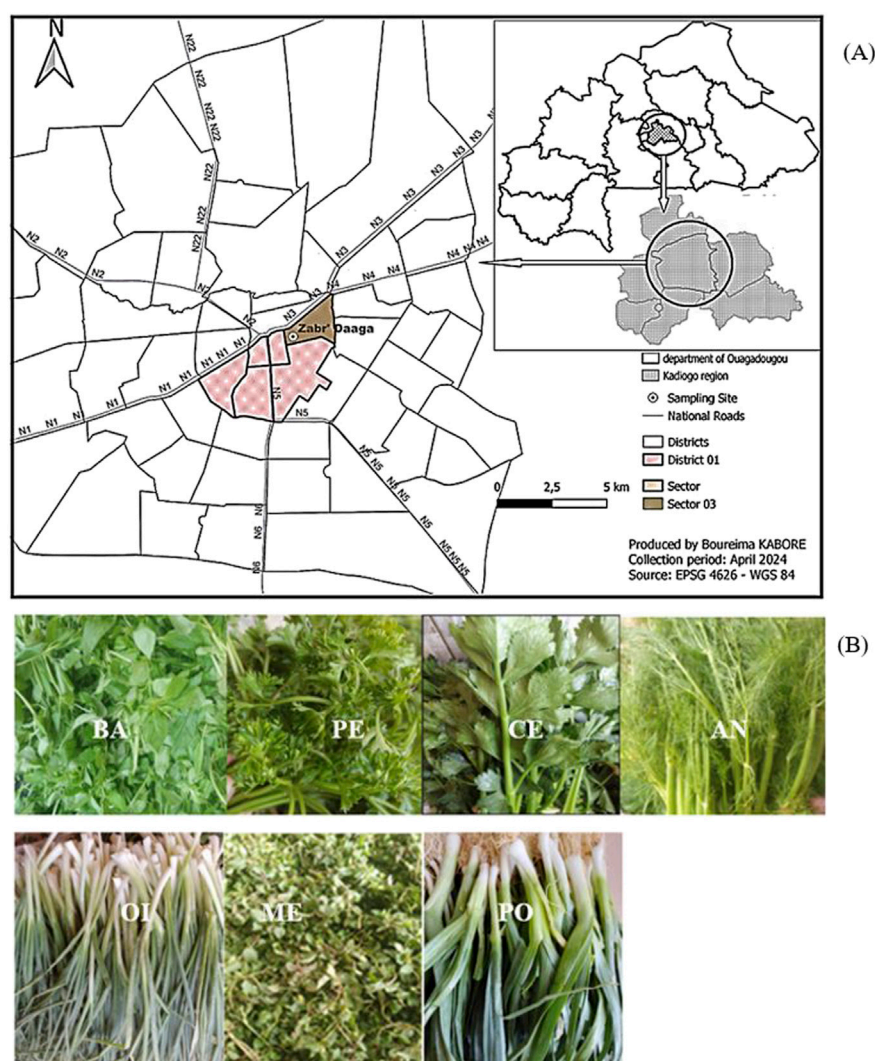


FIGURE 1
Map of the sample collection area (A) and herbal spices analyzed (B). Legend: BA: *Ocimum basilicum*, PE: *Petroselinum crispum*, CE: *Apium graveolens*; AN, *Anethum graveolens*, OI: *Allium cepa*, ME: *Mentha piperita*, PO: *Allium porrum*.

2.2 Determination of proximate composition

2.2.1 Moisture and dry matter

Moisture and dry matter were determined using the thermogravimetric method, as specified in [ISO 712:1 \(2024\)](#). For this, a 5 g test sample of the flour was placed in a crucible and heated in a thermostatically controlled oven at 105 °C for 2 h. After cooling in a desiccator, the crucibles containing the dry matter were weighed. Moisture (H), expressed as a percentage of mass, is calculated using the following formula:

$$\%H = \frac{[Pe - (Pf - Po)]}{Pe} \times 100$$

With: Po: Weight of the empty crucible (g).

Pe: Weight of the fresh sample (g).

Pf: Weight of the crucible + sample after drying (g).

2.2.2 Total ash content

The ash content was determined according to [ISO 2171 \(2023\)](#) by incinerating the samples (5 g) in a muffle furnace (Nabertherm®). Each sample was placed in a pre-weighed crucible, then placed in the furnace, which was maintained at 600 °C for at least 5 h. After cooling in a desiccator for 90 min, the crucibles with the ash were weighed, and the content was calculated using the following equation.

$$\%C = \frac{Pf - Pv}{Pe} \times 100$$

With: Pf: final mass of ash + flask (g).

Pv: mass of empty flask (g).

Pe: mass of the test sample (g).

2.2.3 Protein content

Total protein was measured using the Bradford (1976). Protein levels were determined by extrapolating to a BSA standard curve ($y = 5.5392x + 0.9787$; $R^2 = 0.9879$) and results are reported as mg of BSA equivalent per 100 mg and converted to g/100 g of dry matter. The values were obtained according to the formula:

$$T = \frac{c \times D}{Ci} \times 100$$

T: concentration of the sample in total proteins expressed in % of dry matter.

C: concentration of the sample in total proteins read ($\mu\text{g/mL}$).

D: dilution factor.

Ci: initial concentration of the sample (mg/mL).

2.2.4 Fat content

Fat was measured using the official AOAC 991-36 (2000). Cartridges containing 10 g of sample were placed in a Soxhlet extractor (Electrothermal EME30250/CEB) connected to a flask with 90 mL of hexane. The extraction lasted 4 h, and the residual solvent was removed by evaporation in an oven at 105 °C for 2 h. The oil was then cooled in a desiccator. The fat content was calculated and expressed as a percentage of dry matter (%) using the following equation:

$$\% \text{Fat} = \frac{mf - mi}{me} \times 100$$

With: mf: final mass of fat + flask (g).

mi: mass of empty flask (g).

me: mass of the test sample (g).

2.2.5 Carbohydrate content

2.2.5.1 Total soluble sugars

The soluble sugar content of the samples was determined using the method described by Dubois et al. (2002). For this purpose, 100 mg of powder from each sample was mixed with 10 mL of 80% ethanol and heated to 80 °C for 30 min. After cooling, the mixture was centrifuged at 4,400 rpm for 10 min. The collected supernatant was used to determine the concentration of soluble sugars. The reaction mixture was prepared with 350 μL of the supernatant, 175 μL of 5% phenol, and 875 μL of concentrated sulfuric acid. After incubation for 15 min in a water bath at 37 °C $\pm$ 2 °C, the absorbance was measured at 490 nm against a blank. The obtained values were extrapolated from a glucose calibration curve ($y = 0.0149x + 0.0006$; $R^2 = 0.9989$). The soluble sugar levels are expressed in milligrams glucose equivalent per 100 g of dry sample according to the following formula:

$$T = \frac{C \times D}{Ci} \times 100$$

T: concentration of the sample in total sugars (mg/100 g) of dry matter extract (DM),

C: concentration of the sample in soluble sugars read ($\mu\text{g/mL}$),

D: dilution factor of the sample subjected to assay,

Ci: initial concentration of the sample (mg/mL).

2.2.5.2 Reducing sugars

Reducing sugar levels were determined according to the Miller method (Miller, 1959). The reaction mixture consisted of 1 mL of extract and 1 mL of DNS reagent. The preparations were placed in a boiling water bath for 5 min, then cooled. After cooling, 1 mL of distilled water was added to the preparations, and the absorbance was measured at 540 nm. The reducing sugar content was calculated from the glucose calibration curve ($y = 0.786x + 0.0937$; $R^2 = 0.9957$). The concentration of reducing sugars was calculated using the following formula:

$$T = \frac{c \times D}{Ci} \times 100$$

T: concentration of the sample in reducing sugars expressed in mg/100 g

c: concentration of the sample in reducing sugars read ($\mu\text{g/mL}$).

D: dilution factor.

Ci: initial concentration of the sample (mg/mL).

2.3 Determination of amino acid content

Amino acid analysis was performed by high-performance liquid chromatography (HPLC) using the hydrolysis method, as described by Bidlingmeyer et al. (1984). For the determination, 400 mg of dry sample were weighed into Pyrex hydrolysis vials. Then, 15 mL of 6 N HCl were added, and the vial was placed in an oven at 110 °C for 24 h to induce protein hydrolysis. After hydrolysis, the samples were transferred to 50 mL volumetric flasks, and the volume was adjusted with Milli-Q water. The mixture was homogenised regularly. The amino acid derivatives were then separated by elution through a PICO•TAG pre-column [Nova-Pak C18 guard column, 60 Å, 4 μm , 3.9 mm $\times$ 20 mm] and a column (Waters PICO•TAG C18 column, 3.9 $\times$ 150 mm), and then quantified using a UV detector (1 pmol sensitivity) at 254 nm. The content of each amino acid (Taax) was calculated and expressed as a percentage of the dry weight using the following equation.

$$\text{Taax (\%)} = \frac{\text{Caax}}{\text{Cie}} \times 100$$

Where: Taax = amino acid content x in % w/w relative to the DM; Caax = amino acid concentration x; Cie: Initial concentration of the sample.

2.4 Micronutrient assays

2.4.1 Minerals

Mineral content (Ca, Mg, Fe, Zn, and Na) was determined by inductively coupled plasma atomic emission spectroscopy (ICP AES, JobinYvon Ultima 2) as described by Marmouzi et al. (2015). In a Teflon beaker, 150 mg of sample powder were mixed with 2 mL of nitric acid, HNO_3 (70%) and incinerated at 110 °C. Then, 0.5 mL of hydrofluoric acid was added to the beaker which was placed in a sand bath. The mixture was heated until a clear solution was obtained. After removing the cover, the mixture was evaporated to dryness. Finally, 2 mL of hydrochloric acid (HCl) were added, and the residue was extracted with 25 mL of HCl (2.0 M).

2.4.2 Ascorbic acid (vitamin C)

Ascorbic acid was measured based on the decolorization of 2,6-dichlorophenolindophenol (DCPIP), as described by [Watada \(1982\)](#), with minor modifications. To do this, 150 μL of DCPIP (0.2 mM) was added to 50 μL of aqueous extracts from each spice or culinary herb. The mixture's absorbance was read at 515 nm, and the ascorbic acid content was calculated using the equation ($y = 0.0079x + 0.0395$) and expressed as mg/100 g DM of the sample.

2.4.3 Carotenoid pigments

β -Carotene, lycopene, and total chlorophyll were extracted following the method of [Nagata and Yamashita \(1992\)](#). For this, 100 mg of the powder from the sample was homogenized in 10 mL of an acetone-hexane solvent mixture (4:6) and kept on ice for 10 min, then centrifuged at 4,500 rpm for 1 min.

Absorbances were measured at 663; 505; and 453 nm, and concentrations were calculated with the following formulas:

$$\text{Lycopene (mg/100 mL)} = -0.0458 \times A_{663} + 0.372 \times A_{505} - 0.0806 \times A_{453}$$

$$\beta\text{-carotene (mg/100 mL)} = -0.216 \times A_{663} - 0.304 \times A_{505} + 0.452 \times A_{453}$$

$$\text{Chlorophyll } (\mu\text{g/mL}) = 6.1 \times A_{665} + 20.04 \times A_{649}$$

Concentrations are expressed in mg/100 g DM of β -carotene, lycopene, and chlorophyll, respectively with the following formulas:

$$C = \frac{c \times V}{m} \times 100$$

c: concentration of sample in pigment (mg/100 mL).

V: extraction volume in mL

m: sample mass in g.

Where the A values (A_{663} ; A_{505} and A_{453}), represent the absorbances of the supernatant at the wavelength indicated in the subscript.

2.4.4 Anthocyanins

Anthocyanin content (TAC) was measured using the pH differential spectrometry method described by [Lee et al. \(2005\)](#). Two buffer systems were used: potassium chloride buffer (25 mM, pH 1.0) and sodium acetate buffer (400 mM, pH 4.5). The task is to prepare two series of solutions: one by diluting the extract in a buffer solution at pH 1, and the other by diluting the extract in a buffer solution at pH 4.5. To obtain the required pH, the buffer solution must be in excess. Absorbances were recorded using a spectrophotometer at 520 nm and 700 nm within 15–60 min after preparation. TAC was expressed in cyanidin-3-glucoside equivalents and converted to mg/100 g.

$$\text{TAC (\%)} = \frac{A \times Mw \times DF \times V \times 100}{\epsilon \lambda \cdot W \cdot l}$$

With

$$A = (A_{520\text{nm}} - A_{700\text{nm}})_{\text{pH } 1.0} - (A_{520\text{nm}} - A_{700\text{nm}})_{\text{pH } 4.5}$$

DF: dilution factor.

Mw: molecular weight of cyanidin-3-glucoside = 449.2 g/mol ϵ_{λ} : molar extinction coefficient = 26,900 $\text{M}^{-1} \text{cm}^{-1}$. W: sample weight (g), l: optical path length = 1 cm.

V: extraction volume in L.

2.5 Determination of antinutritional factors

2.5.1 Condensed tannins

Condensed tannins were quantified using the [Julkunen-Tiitto \(1985\)](#) method. The extract absorbance was compared to a catechin calibration curve ($y = 0.0006123x - 0.002053$), with $R^2 = 0.9722$. The condensed tannin amount was determined and expressed as milligrams of catechin equivalents per 100 g of extract (mg/100 g of extract).

2.5.2 Hydrolyzable tannins

Hydrolyzable tannins content (HTC) were measured using the formula provided by [de Sousa Sabino et al. \(2020\)](#). Indeed, 1 mL of extract (5 mg/mL) was added to 3.5 mL of a solution prepared from 0.01 M ferric chloride (FeCl_3) in 0.001 M hydrochloric acid (HCl). After 15 s, the absorbance of the mixture was read at 660 nm. The results were expressed as mg of tannic acid equivalents per 100 g of dry extract (mg/100 g). Hydrolysable tannins were determined using the following formula and converted to mg/100 g

$$\text{HTC (\%)} = \frac{A \cdot Mw \cdot DF}{\epsilon \lambda \cdot W \cdot l} \cdot V \cdot 100$$

Where A: absorbance; Mw: molecular weight of tannic acid (1701.19 g/mol); DF: dilution factor; ϵ_{λ} : 2169 $\text{M}^{-1} \text{cm}^{-1}$; W: sample weight (g), V: extraction volume in L, l: optical path length = 1 cm.

2.5.3 Phytates

Phytates were determined using the method proposed by [Vaintraub and Lapteva \(1988\)](#). Phytate extraction was performed by mixing 250 mg of spice and culinary herb powder with 10 mL of 2.4% HCl for 3 h at room temperature, under constant stirring. The samples were clarified by centrifugation at 6,000 rpm for 20 min at room temperature. Quantification was performed using 2 mL of Wade reagent [0.03% (w/v) FeCl_3 and 0.3% sulfosalicylic acid] and 3 mL of the eluted sample. Absorbance readings were taken at 500 nm using a spectrophotometer (EPOCH, BioTek Instruments Inc., United States). Phytate content was determined using phytic acid as a standard ($y = 0.0017x + 0.0087$; $R^2 = 0.9965$).

2.6 Estimation of the relative bioavailability of minerals

The molar ratios of phytate to zinc (Phy:Zn), phytate to iron (Phy:Fe), phytate to calcium (Phy:Ca), phytate to magnesium (Phy:Mg), and phytate to sodium (Phy:Na) were calculated to estimate the relative bioavailability of calcium, zinc, magnesium, iron, and sodium in the presence of antinutrients. The molar ratios were calculated using the following formula:

$$\text{Molar ratio} = \frac{\text{Moles of antinutrient}}{\text{Moles of minerale}}$$

And the special ratio was calculated using the following formula:

$$\text{Special ratio} = \frac{\text{Moles of Phytate} \times \text{Moles of Ca}}{\text{Mole of Zn}}$$

2.7 Pesticide trace assessment

These operations were performed according to the QuECHERS method. A 5 g sample was homogenized in 10 mL of acetonitrile solution and then vortexed for 1 minute. A mixture containing 1 g of sodium chloride, 1 g of sodium citrate, 0.5 g of anhydrous sodium citrate, and 4 g of magnesium sulfate was added to the mixture. After vigorous vortexing for 1 min, the homogenate was then centrifuged for 5 min at 3,000 rpm. A 6 mL volume of the supernatant was removed and placed in a 15 mL centrifuge tube containing 300 mg of PSA and 900 mg of magnesium sulfate. The contents of the tube were vortexed for 1 minute and then centrifuged at 3,000 rpm for 5 min. Finally, 2 mL of the supernatant was introduced into a vial and analyzed using a gas chromatograph equipped with a Varian® 431-GC micro-electron capture detector (GC-μECD and GC-FPD). The pesticide contents in the analyzed samples were determined using external standards. As the samples were analyzed under the same conditions as the standards, their peaks were compared with the peaks of the standards and their concentrations were deduced (Aaron and Coly, 2000). Thus, the concentrations of the different active ingredients of the pesticides are determined from the values obtained by the chromatograms. The concentration in ng/μL given by the chromatogram was converted into mg/L, and then the following formula was applied to calculate the maximum concentration (mg/kg)

$$CM = \frac{Cc \times Vs}{Pe}$$

with:

CM = Maximum Concentration (mg/kg).

Cc = Chromatogram Concentration (mg/L).

Vs. = Volume of solvent in L.

Pe = Test portion in kg.

2.8 Quality assurance for spectrometric analyses

Appropriate quality assurance procedures and precautions are taken to ensure the reliability of the results. Samples are generally handled with care to prevent contamination. The laboratory's glassware is thoroughly cleaned to the highest standards, and the reagents used are of the finest analytical grade. Double-distilled deionized water is used throughout the study. Blank determinations of the reagents are used to correct the spectrometer readings.

2.9 Statistical analysis

The analytical measurements were performed using technical triplicates from the same experimental sample. The graphs and calculations for the different concentrations were generated

using Excel 2016 and GraphPad Prism software version 8.4.3. XLSTAT 2019 software was used for analysis of variance (ANOVA), and significant differences between the means were revealed via Tukey's test ($p < 0.05$). The dendrograms were produced with R software, version 4.0.2 (2020). All analyses were performed in triplicate (to calculate the reproducibility of the process), and the results were expressed as mean and standard deviation.

3 Results

3.1 Moisture, dry matter, and crude ash content

Moisture, dry matter, and ash contents of the different samples are shown in Figure 2A. The results show significant variation among the culinary herbs. The moisture content of the culinary herbs ranged from $10.48\% \pm 0.140\%$ to $22.11\% \pm 0.105\%$. The lowest levels were found in *O. basilicum*, followed by *M. piperita* and *Anethum graveolens*, with values of $10.48\% \pm 0.140\%$, $10.53\% \pm 0.105\%$, and $10.71\% \pm 0.221\%$, respectively. The highest content was observed in *A. porrum*, which was more than twice as high as in *O. basilicum*, *M. piperita*, and *Anethum graveolens*. For ash, significant differences were seen between species, with values ranging from $1.18\% \pm 0.03\%$ to $2.50\% \pm 0.06\%$. *Apium graveolens* and *Anethum graveolens* had the highest ash contents, at $2.50\% \pm 0.06\%$ and $1.74\% \pm 0.00\%$, respectively.

3.2 Macronutrient contents

Protein, total sugars, reducing sugars, and lipid contents (Figure 2B) varied significantly between species. The protein content of culinary herbs ranged from 5.91 ± 0.088 g/100 g DM for *M. piperita* to 7.7679 ± 0.092 g/100 g DM for *A. porrum*. The lowest soluble sugar content was recorded for *O. basilicum* (1.3 ± 0.011 mg/100 g), while the highest was observed for *A. cepa* (5.41 ± 0.019 mg/100 g). The reducing sugar contents ranged from 0.76 ± 0.21 mg/100 g for *A. graveolens* to 1.64 ± 0.096 mg/100 g for *Anethum graveolens*. The lowest lipid content was found in *M. piperita* ($0.86\% \pm 0.38\%$), and the highest was $1.42\% \pm 0.15\%$ in *A. cepa*.

3.3 Carotenoid and anthocyanin pigment content

The spices studied contained relatively few pigments, with concentrations varying among different herbs (Figure 2C). Lycopenes were most abundant in *A. cepa* (35.8 ± 1.8 mg/100 g). Anthocyanins were minimally present, with a maximum content of 3.89 ± 0.50 mg/100 g in *Petroselinum crispum*. Regarding β-carotenes, *Petroselinum crispum*, *O. basilicum*, and *A. graveolens* had the highest levels, with 33.1 ± 1.93 ; 32.6 ± 1.63 ; and 31.1 ± 1.55 mg/100 g, respectively. Chlorophyll was much more prevalent in *Petroselinum crispum*, *Anethum graveolens*, and *O. basilicum*, with respective contents of 28.165 ± 0.203 , 27.738 ± 0.738 , and 27.170 ± 0.216 mg/100 g.

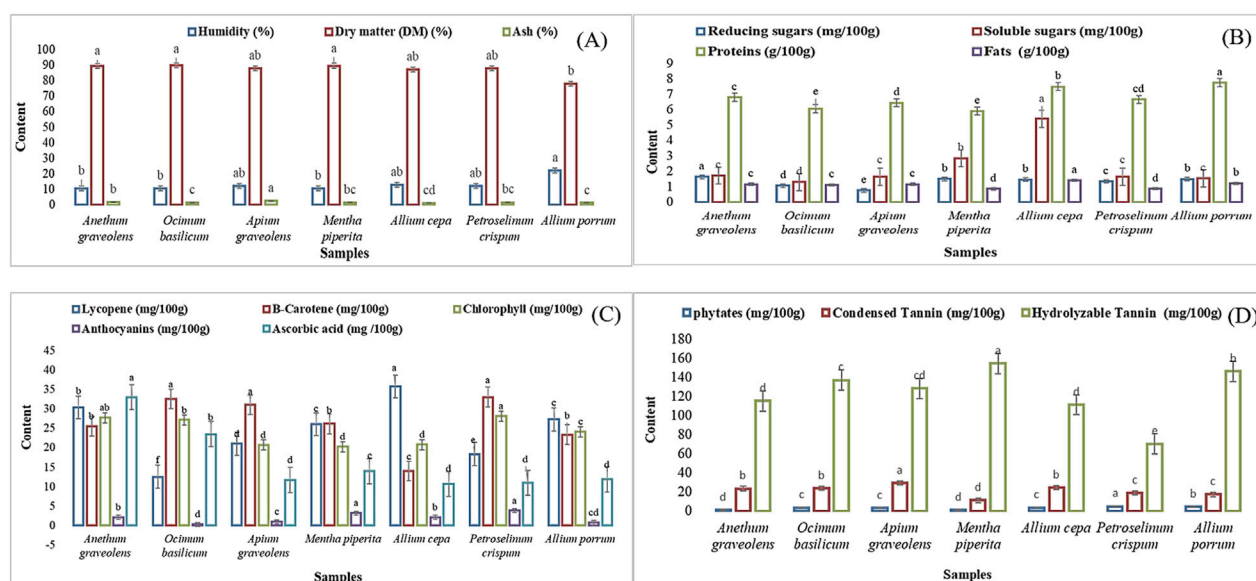


FIGURE 2
Nutritional and bioactive profile of the culinary herbs studied. (A) Basic composition parameters; (B) Macronutrients; (C) Pigment compounds; (D) Antinutritional compounds. Results are expressed as mean $\pm$ standard deviation, based on three determinations. For each parameter, bars with different letters indicate significant differences at the 5% level ($p < 0.05$).

3.4 Ascorbic acids content

Analysis of ascorbic acid (vitamin C) in various spices and herbs (Figure 2C) revealed significant differences among the species *Anethum graveolens*, *O. basilicum*, and *M. piperita*. The highest levels were detected in *Anethum graveolens* and *O. basilicum*, with 33.02 ± 0.36 mg/100 g and 23.53 ± 0.93 mg/100 g, respectively. At the same time, the lowest values were found in *A. porrum*, *A. cepa*, *A. graveolens*, and *Petroselinum crispum*. No significant differences were observed among these last species.

3.5 Antinutritional factors content

The antinutrients determined were tannins and phytates. The results are recorded in Figure 2D. The quantitative analysis of these compounds in spices and culinary herbs revealed significant differences between species. Hydrolyzable tannins were more prevalent than condensed tannins and phytates. The lowest hydrolyzable tannin content (70.47 ± 1.05 mg/100 g DM) was found in *Petroselinum crispum*. Condensed tannins were particularly low in *M. piperita* (11.46 ± 0.59 mg/100 g DM). Regarding phytates, they were present in small amounts in spices, with contents ranging from 1.198 ± 0.041 mg/100 g DM to 5.08 ± 0.108 mg/100 g DM, respectively in *M. piperita* and *Petroselinum crispum*.

3.6 Amino acid content

The amino acid profile analysis was conducted on all the spices studied. A total of 18 distinct peaks were observed on the chromatogram, as they share the same retention time. It is

important to note that asparagine and aspartic acid, as well as glutamine and glutamic acid, show up as a single peak. Tryptophan is destroyed during hydrolysis by hydrochloric acid. The most abundant amino acids were proline, followed by the glutamine + glutamic acid and asparagine + aspartic acid pairs. The proline content was 3.60 g/100 g in *A. porrum*, 2.95 in *P. crispum* and 2.88 in *A. graveolens*. The glutamine + glutamic acid pair was 3.49 g/100 g in *P. crispum*, and 3.33 in *A. porrum*; the asparagine + aspartic acid pair was 2.62 g/100 g in *A. porrum*, and lysine 2.45 g/100 g in *A. cepa* (Table 1). The essential amino acid content ranged from 2.43 to 6.02 g/100 g. The highest contents were found in *A. cepa* (5.73) and *P. crispum* (5.47). Lysine was the essential amino acid with the highest amount. The best contents were found in *A. cepa* (2.45). Except for *A. graveolens* and *A. cepa*, which did not contain methionine, all other spices possessed not only all eight essential amino acids but also histidine and arginine.

3.7 Mineral content

The trace elements quantified in this study included magnesium (Mg), calcium (Ca), iron (Fe), zinc (Zn), and sodium (Na) (Table 2). Culinary herbs were found to be particularly rich in calcium (Ca), with levels ranging from 32.82 mg/100 g to 220.36 mg/100 g. The highest levels were observed in *A. graveolens* and *O. basilicum*, with 220.36 mg/100 g and 106.75 mg/100 g, respectively. Sodium was also detected at significant levels, especially in *A. graveolens* (69.23 mg/100 g) and *Anethum graveolens* (58.32 mg/100 g). Magnesium was present at high levels, reaching 49.42 mg/100 g and 53.59 mg/100 g for *M. piperita* and *O. basilicum*, respectively. For iron, the highest concentrations were found in

TABLE 1 Amino acid profile of spices and culinary herbs studied.

Amino acid composition (%)	Samples						
	<i>An. graveolens</i>	<i>A. graveolens</i>	<i>A. cepa</i>	<i>A. porrum</i>	<i>M. piperita</i>	<i>P. crispum</i>	<i>O. basilicum</i>
Histidine (H)	ND	0	0.27	0.47	0.3	0.47	0.35
Isoleucine (I)	ND	0.26	0.39	0.55	0.39	0.69	0.44
Leucine (L)	ND	0.36	0.57	0.81	0.74	1.13	0.75
Lysine (K)	ND	0.33	2.45	0.66	1.6	0.78	0.54
Methionine (M)	ND	0	0	0.18	0.14	0.25	0.16
Phenylalanine (F)	ND	0.35	1.36	0.66	0.58	0.81	0.55
Threonine (T)	ND	0.35	0.42	0.63	0.47	0.86	0.57
Valine (V)	ND	0.47	0.54	0.77	0.64	0.95	0.63
Alanine (A)	ND	0.32	0.52	1.05	0.61	1	0.73
Arginine (R)	ND	0.36	0.62	1.57	0.65	1.06	0.84
Asparagine(N)+ aspartic acid (D)	ND	1.81	1.06	2.62	1.77	2.37	1.58
Cysteine (C)	ND	0.14	0	0.12	0	0.22	0.17
Glutamine (Q) + glutamic acid (E)	ND	1.38	3	3.33	1.74	3.49	1.99
Glycine (G)	ND	0.42	0.58	0.79	0.77	1.09	0.76
Proline (P)	ND	2.88	2.67	3.6	2.17	2.95	1.71
Serine (S)	ND	0.47	0.68	0.9	0.7	0.99	0.68
Tyrosine (Y)	ND	0.31	0.28	0.39	0.34	0.55	0.36
Total (66,52%)		10.28%	15.48%	19.19%	13.69%	19.73%	12,88%

Anethum graveolens (26.4 mg/100 g), *A. graveolens* (26.75 mg/100 g), and *A. cepa* (26.2 mg/100 g). Zinc was the mineral with the lowest levels, not exceeding 1 mg/100 g.

3.8 Estimation of the relative bioavailability of minerals

To predict mineral bioavailability, the molar ratios of phytate to the various minerals, Phy:Zn, Phy:Fe, Phy:Ca, and Phy:Mg, as well as the ratio of the phytate and Ca product to Zn (Phy:Ca):Zn, were determined and recorded in Table 2. The Phy:Fe ratios ranged from 0.0047 to 0.222, values well below the critical threshold of 1. Similarly, the Phy:Zn ratio did not exceed 0.0957 in the different samples, remaining below the critical value of 15. For calcium, the highest ratio observed was 0.008, well below the critical threshold of 0.24. For Mg, the ratio was also well below the critical threshold of 0.24. The determined (Phy:Ca):Zn ratios ranged from 199.89 to 2,401.04 depending on the sample. The highest ratio was found in *A. graveolens*. Except for *M. piperita*, the others had ratios well above the recommended limit of 200.

3.9 Pesticide

The results of the pesticide analysis are shown in the following Table 3. A total of seven samples were analyzed for the presence of

50 pesticides by gas chromatography. Pesticide residues including aldrin (0.02 mg/kg) and carbofuran (4.64 mg/kg) were detected in *A. cepa* and *O. basilicum* respectively at concentrations above the maximum limit of 0.01 mg/kg. Traces of malathion and imidacloprid were also detected in the samples of *A. graveolens* and *Anethum graveolens*.

3.10 Principal component analysis (PCA) and hierarchical ascendant classification of the studied spices and culinary herbs

Principal component analysis (PCA) of minerals and macronutrients showed a 67.68% inertness around the first two axes, F1 and F2. The results revealed a significant clustering of the parameters (i) Na, Ca, Zn and (ii) proteins, lipids, soluble sugars, and reducing sugars, around axis F1. Axis F2 contrasts iron and Mg (Figure 3A). Positive correlations were observed between Fe, Na, Ca, and Zn, associated with *Anethum graveolens* and *A. graveolens*. However, they were inversely associated with Mg. *A. porrum* and *A. cepa* were strongly associated with proteins, sugars, and lipids, as well as with low zinc content. Iron was negatively correlated with magnesium, which was itself associated with *O. basilicum*. The species *P. crispum* and *M. piperita*, located in the lower quadrant of the factorial plane, exhibit an intermediate profile, without a marked association with any particular element.

TABLE 2 Mineral content and molar ratio of spices and culinary herbs studied.

Samples	Mineral content (mg/100 g)					
	Zn	Ca	Fer	Mg	Na	Ca/Zn
<i>An.graveolens</i>	0.826	79.825	26.4	34.398	58.323	157.64
<i>A.graveolens</i>	0.78	220.363	26.75	29.753	69.235	460.85
<i>A. cepa</i>	0.523	43.55	26.2	41.318	19.238	135.83
<i>A. porrum</i>	0.482	32.825	2.312	36.503	49.993	111.09
<i>M. piperita</i>	0.882	59.45	4.3	49.423	23.4	109.95
<i>P. crispum</i>	0.819	70.075	1.931	41.878	24.533	139.57
<i>O. basilicum</i>	0.509	106.75	2.27	53.59	20.093	342.11

Samples	Molar ratio					
	Phytate/Zn	Phytate/Ca	Phytate/Fer	Phytate/Mg	Phytate/Na	(Phytate x Ca)/Zn
<i>An.graveolens</i>	0.1790	0.001135	0.004774	0.0015986	0.0008920	355.80
<i>A.graveolens</i>	0.4364	0.000947	0.01087	0.0042546	0.0017298	2,401.04
<i>A. cepa</i>	0.7081	0.005213	0.012064	0.003333	0.0067725	768.81
<i>A. porrum</i>	0.9570	0.008615	0.170409	0.0046989	0.0032460	783.74
<i>M. piperita</i>	0.1345	0.001223	0.023610	0.0008927	0.0017840	199.89
<i>P. crispum</i>	0.614	0.004402	0.222570	0.0044678	0.0072155	1,074.14
<i>O. basilicum</i>	0.7138	0.002086	0.136783	0.0025209	0.0063612	1902.14
Critical value	<15	<0.24	<1	0.24	-	<200

TABLE 3 Pesticides in spices and culinary herbs studied.

Samples	Compounds	Concentration (mg/kg)	Maximum residue limit (MRL) (mg/kg)
<i>Allium cepa</i>	Aldrine	0,02	0,01
<i>Ocimum basilicum</i>	Carbofuran	4,64	-
<i>Apium graveolens</i>	Malathion	Trace	0,5
<i>Anethum graveolens</i>	Imidachlopride	Trace	0,5

The hierarchical ascending classification (HAC), developed based on the composition of bioactive compounds and antinutritional factors, presented in Figure 3B, shows significant variation between the different species. The hierarchical clustering presents three main groups reflecting distinct metabolic predominances.

Group I, with a favorable nutritional profile, includes *Anethum graveolens*, *M. piperita*, and *O. basilicum*. It is distinguished by a clear predominance of phenolic and pigmentary compounds, with antioxidant activity, and low levels of antinutritional factors (phytate and condensed tannins).

Group II, with an intermediate profile, including *Petroselinum crispum* and *A. cepa*, is characterized by a notable pigmentary richness but with intermediate levels of antinutritional factors.

Group III includes *A. graveolens* and *A. porrum*. These species exhibit a significant accumulation of phytate or condensed

tannin, while their phenolic and antioxidant content is relatively low compared to that of Group I species.

4 Discussion

The study on seven culinary herbs commonly used in Burkinabe cuisine allowed us to evaluate their nutritional potential, essential mineral content, and certain antinutritional factors. The moisture content of all our samples was relatively high, likely due to the leaves' ability to retain water, given their large surface area and thin cell walls. Although moisture levels varied among species, they remained relatively high overall, which has implications for storage stability and susceptibility to microbial growth. The lower values for basil, mint, and dill suggest these herbs may be less prone to rapid spoilage than others, making them more suitable for fresh market distribution (Alegbeleye et al., 2022).

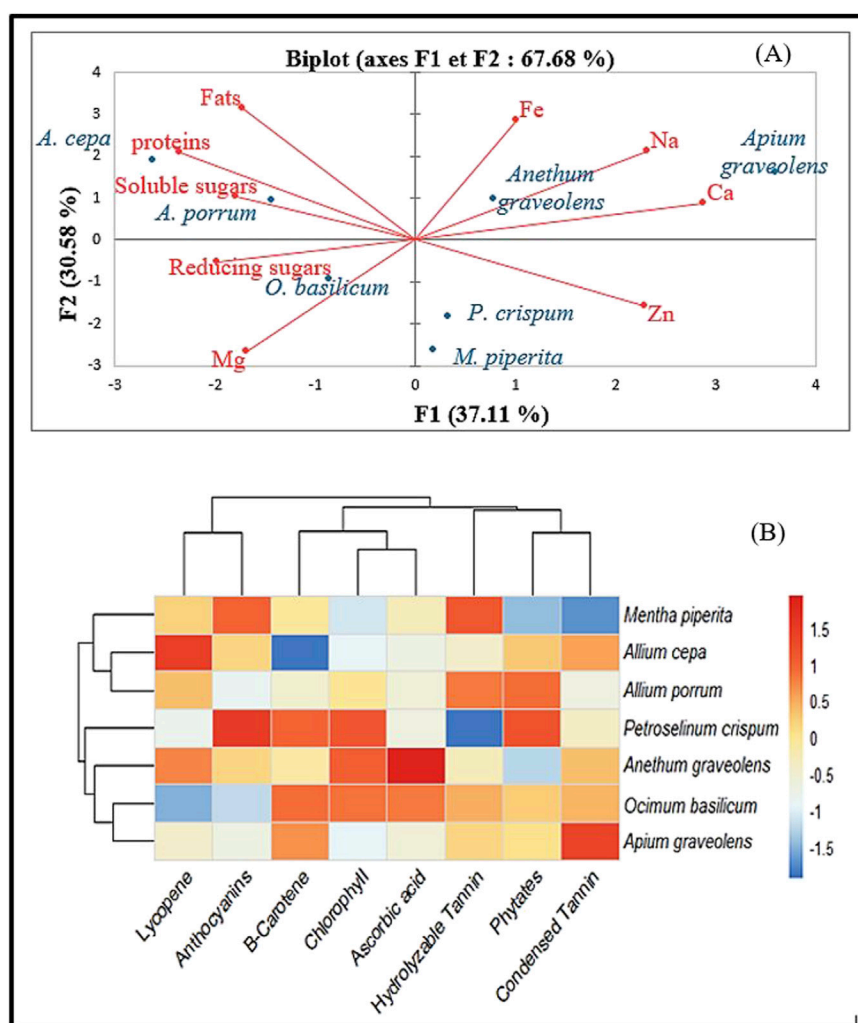


FIGURE 3
Principal component analysis between parameters and spices herbals studied (A) and Heat map and Hierarchical classification of spices herbals (B).

Ash content indicates the total amount of mineral matter in the sample. Significant differences were observed among the various samples. The variation in ash content highlights differences in mineral density among species. *Apium graveolens* and *Anethum graveolens*, with higher ash values, could serve as important dietary sources of essential minerals, particularly in regions where mineral deficiencies are common (Tola et al., 2025).

Allium cepa leaves showed the highest fat content, which, although modest compared to staple foods, may contribute to the intake of fat-soluble vitamins. This suggests that incorporating onion leaves into diets could enhance micronutrient absorption. Lipids serve as an essential energy source and participate in various biological functions, including the synthesis of reproductive hormones and the transport of fat-soluble vitamins (A, D, E, and K) (Kaboré et al., 2022). However, excessive fat intake can lead to overnutrition and increase the risk of chronic diseases like obesity and diabetes.

The soluble sugar content varied significantly among the species, indicating that these studied plants have distinct carbohydrate

profiles. The highest soluble sugar content observed in the leaves of *A. cepa* suggests that this species could contribute energy and contribute to a milder or sweeter taste in preparations. These observations are consistent with the work of Báez et al. (2023), who showed that incorporating onions into certain food preparations can significantly increase their energy value. Furthermore, the high reducing sugar content observed in *Anethum graveolens* could have sensory significance. These sugars can contribute to flavor, but also participate in non-enzymatic browning reactions during drying or cooking, thus influencing the flavor, color, and acceptability of the final product. However, they are not generally a major source of carbohydrates due to the small quantities consumed. Their value lies in their complementary contribution to nutritional and sensory quality.

Proteins are essential macronutrients involved in growth, tissue renewal, and the proper development of living organisms. Their content in the analyzed aromatic herbs varied considerably among species, indicating distinct nutritional

profiles. The highest content observed in *A. porrum* suggests that this species could contribute more to the nutritional enrichment of food preparations. These results are consistent with the levels reported by Tankoano et al. (2024) for *A. cepa* in Burkina Faso (7.930 ± 0.030 g/100 g). However, these levels remain moderate compared to major dietary protein sources such as legumes, seeds, and processed foods. Their regular consumption as culinary ingredients can complement overall protein intake, particularly in diets dominated by cereals or tubers (Scarcella et al., 2022).

The amino acid profile of a food indicates the quality of its proteins. Both essential and non-essential amino acids can be found in spices and culinary herbs. Yuasa et al. (2022) showed that spices are rich in proline, glutamine, aspartic acid, asparagine, lysine, leucine, isoleucine, valine, and serine. In the leaves studied, proline and the pair Glutamine (Q) + glutamic acid (E) were the predominant amino acids. The essential amino acid content was predominant in *A. cepa* (5.73%). Lysine and leucine were the predominant essential amino acids in most of the plants studied. This is consistent with those reported by Oboh et al. (2023) who observed similar trends in pumpkin leaves. They play an important role in muscle growth and protein synthesis. They are essential to produce enzymes and hormones that regulate various bodily functions. Adequate consumption of essential amino acids promotes rapid recovery and increased performance during physical activities. They also play a role in the structure, metabolism, and physiology of living cells. Cysteine and methionine were the least represented in leaves. These results are similar to those reported by Oboh et al., 2023.

A significant variation in the levels of bioactive compounds was observed among the studied species, indicating that the analyzed plants do not contribute equally to the overall antioxidant profile. The high levels of β -carotene observed in *Petroselinum crispum*, *O. basilicum*, and *A. graveolens* suggest that these species may have greater nutritional value as a source of provitamin A. β -carotene plays a crucial role in maintaining good vision, supporting the immune system, and preventing infections. Its presence in these species represents a valuable contribution, particularly in diets low in vegetables rich in this vitamin. The high ascorbic acid content observed in *Anethum graveolens* further enhances its nutritional value, as it can contribute to a regular intake of vitamin C. However, this content may decrease during washing and drying due to its water-soluble nature. Conversely, the low anthocyanin content observed across all samples indicates that this compound is probably not the primary contributor to the antioxidant profile of these herbs. This result is consistent with the predominantly green nature of the analyzed plants, whose pigmentation is generally dominated by chlorophylls and certain carotenoids. These pigments could, however, play a complementary role in reducing oxidative stress (Di Venere et al., 2016). Chlorophyll, an essential bioactive pigment, was particularly abundant in several of the herbs studied, notably *Petroselinum crispum*, *Anethum graveolens*, and *O. basilicum*. This abundance can be explained by the high proportion of green leaf tissue in these species. Known for its antioxidant and detoxifying properties, chlorophyll enhances the functional potential of these plants, highlighting their value as health-promoting foods whose benefits extend beyond their

simple nutritional value (Cvitković et al., 2021). Furthermore, lycopene, another bioactive compound, was abundant in all seven plants studied, particularly in *A. cepa*, with a concentration higher than that reported by Tomori et al. (2023) in *Ocimum gratissimum*. This compound plays a crucial role in preventing various chronic diseases, including certain cancers and cardiovascular diseases (Arballo et al., 2021). Moreover, it has been associated with a reduced risk of diabetes, liver disorders, cardiac complications, and diseases related to oxidative stress (Imran et al., 2020). The most interesting species vary according to the type of antioxidant compounds they contain. This diversity could contribute to a more varied intake of bioactive compounds.

Mineral content showed notable variability among the species, highlighting once again the nutritional diversity of the spices studied. These minerals are essential for the proper development and functioning of living organisms. Calcium was detected in appreciable quantities in all seven samples, with the highest levels observed in *A. graveolens* and *Petroselinum crispum*. These results suggest that these two species could contribute, in a complementary way, to dietary calcium intake. This mineral plays a role in bone and muscle formation, as well as in blood clotting. A high intake is strongly recommended, especially for children. However, their actual contribution to meeting requirements will depend on their bioavailability, which can be influenced by antinutritional compounds such as phytates and oxalates. The levels obtained in this study remain lower than those reported by Abdi et al. (2022) and Nouioura et al. (2024) for these two plants, respectively. Sodium was very abundant in the leaves of *A. graveolens* was found to have higher levels than those reported by Islomova et al. (2023). Its high content in *A. graveolens* is of technological and sensory interest, particularly in enhancing the flavor of culinary preparations. However, excessive sodium intake is associated with an increased risk of hypertension. Magnesium content was significant in all samples, with the highest value observed in *O. basilicum*. Magnesium plays a role in protein synthesis, cellular metabolism, and maintaining osmotic pressure. Its significant content in culinary herbs could contribute to magnesium intake, especially in regions with limited biodiversity. Regarding iron, *Anethum graveolens*, *A. graveolens*, and *A. cepa* proved to be the most interesting species. Our levels remain lower than those reported by Islomova et al. (2023). However, they are higher than those reported by Abdi et al. (2022). These results indicate that these species can contribute to iron intake. However, the bioavailability of plant-based iron generally remains low. This essential metal is involved in hemoglobin formation and oxygen transport. Iron deficiency can lead to anemia and growth retardation. Zinc was the least abundant metal in the samples studied. The highest concentrations were observed in *M. piperita*, *Anethum graveolens*, and *P. crispum*. Although their content is relatively lower than that reported by Afshiya and Anil (2024) for *M. piperita*, their presence remains valuable as part of a varied diet. These plants can contribute significantly to micronutrient intake when consumed regularly.

Antinutritional factors interact with nutrients, reducing their bioavailability, which is a significant concern (Di et al., 2024). Their high concentration in foods is therefore undesirable. The phytate content of our samples was consistent with data reported by Ogunka-Nnoka and Mepba (2008) on spices in Nigeria. Unlike Borquaye et al. (2017), the phytate content of our spices was very

low. The maximum content was well below the critical range of 1%–6%, reported by Pires et al (2023), which may decrease the bioavailability of some minerals. Indeed, phytates chelate and form non-absorbable mineral complexes with phosphorus, zinc, iron, calcium, and magnesium, thereby reducing their bioavailability (Schafleitner et al., 2022). This phenomenon is exacerbated by regular consumption of phytate-rich foods over a long period. Furthermore, they deplete the utilization of proteins and lipids in the body beyond a minimum lethal dose of 5 g for an adult (Morales et al., 2011). However, in some cases, phytates may have beneficial health effects by acting as antioxidants and antitumor agents (Pires et al., 2023). The condensed tannin contents of our samples were higher than 0.019 ± 0 mgCE/g found by Brinsi et al. (2024) with *M. piperita* and lower than the content of 25.93 mg/100 g found with *Mussaenda arcuata* by Rumicha et al., 2025. Compared to the content of 329.9 mg/100 g reported by Yimer et al., 2023 on *Cleome gynandra*, the contents of our samples are too low to be of concern. Tannins are astringent, thus reducing the palatability of foods. They can bind to proteins, polysaccharides, and iron. Their binding to proteins can modify protein activity or precipitate them, making them inaccessible to digestive enzymes (Ozogul et al., 2025). These low phytate and tannin contents suggest that these culinary herbs can be consumed fresh without any processing intended to eliminate or reduce these antinutritional factors.

Phytate is known to chelate minerals and can contribute to deficiencies in iron, zinc, and calcium. Phytate-to-mineral molar ratios are generally considered good models for estimating the fraction of minerals in a food that are assimilable by the body. The calculated ratios of phytate to iron, calcium, and magnesium in the studied spices and herbs were all below the respective critical thresholds of 1 and 0.24 reported by Abdulwaliyu et al. (2019). This result indicates that the presence of phytate in various culinary herbs will not negatively affect iron and calcium absorption. In contrast to our findings, Borquaye et al. (2017) reported ratios exceeding the critical values for spices from Ghana. The phytate:Zn ratio was also below the limit recommended by Morris and Ellis (1989), suggesting that zinc availability is not affected by phytate alone. However, the combined effect of phytate and calcium on zinc bioavailability, measured by the molar ratio (Phytate:Ca):Zn, was very high in most samples and exceeded the limit of 200 recommended by Morris and Ellis (1989). This result indicates low zinc availability in these culinary herbs, likely due to the formation of an insoluble phytate-Ca-Zn complex. Although the phytate content is relatively low in these herbs, the very high calcium content contributed to the increased ratio, even if its inhibitory effect alone remains limited.

A contamination level exceeding the maximum residue limit was observed for aldrin and carbofuran in samples of *A. cepa* and *O. basilicum*, respectively. These contamination levels are consistent with those reported by Reinholds et al. (2017), who also found contamination levels exceeding the MRL. These results could be explained by persistent non-compliance with the recommended dose and harvest time, reflecting pest pressure that pushes producers to intensify treatment. However, the results obtained with Aldrin are lower than the 0.153 mg/kg reported by Sahyoun, (2022) on *A. cepa*. In addition, the diversity of pesticides detected in our samples was less marked than that of Reinholds et al. (2017), who listed more than 24 different types of pesticides in spices and

culinary herbs. This difference could be attributed to variability in agricultural practices and pesticide use. Carbofuran, often used in post-harvest protection, has also been reported in previous studies on vegetables (Lv et al., 2022). Its use remains a significant health concern given its toxicity (Lv et al., 2022). Aldrin, an organochlorine banned in several countries, has been shown to be estrogenic, carcinogenic, and resistant to environmental degradation (Sahyoun, 2022). Organochlorine pesticides are characterized by half-lives estimated at approximately 10–30 years in tissues, which increases their accumulation (Sparling, 2016).

Principal component analysis (PCA) revealed significant biochemical heterogeneity among the studied culinary herbs. The distribution of species into distinct groups suggests the existence of distinct metabolic strategies. Four distinct groups can therefore be identified. The first group consists of *A. cepa* and *A. porrum*, which are correlated with total macromolecules. This indicates their significant contribution of primary metabolites necessary for the organism's functioning. This corroborates the findings of previous studies in Burkina Faso that showed onions can contain over 80% dry matter, as well as $91.62\% \pm 0.55\%$ carbohydrates and $7.93\% \pm 0.03\%$ protein. This highlights their nutritional density and importance in the diet (Tankoano et al., 2024). The second group consists of *O. basilicum*, which is associated with reducing sugars and magnesium. Other studies have demonstrated the high magnesium content of *O. basilicum*, with levels ranging from 89 to 199.7 mg/100 g D.M. However, it should be noted that reducing sugar content depends on the harvest period, the plant's physiological stage, cultivation techniques and soil and climate parameters. These first two groups are linked, with correlations varying depending on the parameters (Dinu et al., 2025). Similarly, groups 3 and 4 are also linked. These two groups consist of mineral-rich plants that can prevent hidden hunger in a context where dietary habits are increasingly shifting towards less nutritious, energy-dense foods. While *A. graveolens* and *Anethum graveolens* are rich in calcium, iron and sodium, *P. crispum* and *M. piperita* are rich in zinc. These observations confirm that vegetables are a true source of minerals (Tibe and Mathapa, 2026). The hierarchical classification reveals that *Anethum graveolens* stands out for its high level of ascorbic acid and pigment content, and its ability to promote the synthesis of compounds involved in photosynthesis and oxidative defence mechanisms. This species has a potentially more favorable nutritional profile due to its high antioxidant pigment and ascorbic acid content, as well as its low content of factors that limit mineral bioavailability. In contrast, *P. crispum* is potentially rich in phenolic compounds; however, its high phytate content could reduce the bioavailability of certain nutrients if consumed very regularly. To fully benefit from its nutrients, processing may be necessary to reduce the concentration of antinutritional compounds. *Ocimum basilicum* appears to be low in minerals but relatively rich in compounds with antioxidant activity and low in antinutritional factors. *Anethum graveolens* has a more balanced profile. Its high content of macronutrients and minerals, combined with an abundance of potential antioxidants and low levels of antinutritional factors, particularly phytate, enhances its nutritional value. *Allium cepa* is reportedly the richest source of lycopene. These observations suggest that consuming these plants can help to combat malnutrition and prevent oxidative stress (Lugumira et al., 2025).

5 Conclusion

This study highlights a marked nutritional differentiation among aromatic herbs commonly used in Burkina Faso. *A. porrum* and *A. cepa* are the richest in macronutrients, confirming their contribution to energy and protein in the diet. *Anethum graveolens* and *A. graveolens* appear as a potential source of minerals, particularly iron and calcium, thereby reinforcing their potential to prevent nutritional deficiencies. *Anethum graveolens* exhibited the most balanced profile, combining a low content of antinutritional factors with a high abundance of potential antioxidants, notably chlorophyll, β -carotene, and anthocyanins. *M. piperita* appears as a potential source of phenolic compounds, bioavailable zinc, and lysine. *Ocimum basilicum*, despite its favorable phytochemical profile for nutrition, is marked by the presence of carbofuran residues exceeding the maximum permitted limit, raising food safety concerns. This study highlights the nutritional value of these culinary herbs and the need for further health risk assessments to better promote them.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

BK: Methodology, Investigation, Writing – original draft. MD: Validation, Data curation, Conceptualization, Formal Analysis, Writing – review and editing, Supervision, Investigation. TO: Writing – original draft, Methodology. MS: Writing – original draft, Formal Analysis, Methodology. HS: Methodology, Formal Analysis, Data curation, Writing – original draft. KaK: Formal Analysis, Investigation, Writing – original draft. DB: Writing – original draft, Software, Formal Analysis. SG: Writing – review and editing, Data curation. ID: Writing – review and editing, Supervision. MG: Investigation,

Writing – review and editing. KiK: Validation, Writing – review and editing. MD: Resources, Funding acquisition, Writing – review and editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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