frontiers | Frontiers in Food Science and Technology

TYPE Original Research
PUBLISHED 22 August 2025
DOI 10.3389/frfst.2025.1636295

OPEN ACCESS

EDITED BY
Sapna Langyan,
Indian Council of Agricultural Research (ICAR), India

REVIEWED BY
Abhay Tiwari,
Sharda University, India
Koffi Kibalou Palanga,
Chinese Academy of Agricultural Sciences, China
Damba Yahaya,
University for Development Studies, Ghana
Ashoka S,
College of Agriculture, India

*CORRESPONDENCE
Edwige Bahanla Oboulbiga,
obouled@yahoo.fr

RECEIVED 27 May 2025
ACCEPTED 11 July 2025
PUBLISHED 22 August 2025

CITATION
Oboulbiga EB, Semdé Z, Tapsoba FW-B, Youl S, Nikiéma F, Dibala CI, Hama-Ba F and Dicko MH (2025) Comparative study of the physicochemical and nutritional characteristics of the grains of two varieties of sesame cultivated in two climatic zones of Burkina Faso. *Front. Food Sci. Technol.* 5:1636295. doi: 10.3389/frfst.2025.1636295

Comparative study of the physicochemical and nutritional characteristics of the grains of two varieties of sesame cultivated in two climatic zones of Burkina Faso

Edwige Bahanla Oboulbiga[1]*, Zénabou Semdé[1], Fidèle Wend-Bénédo Tapsoba[1], Siébou Youl[2], Fulbert Nikiéma[3], Crépin Ibingou Dibala[2], Fatoumata Hama-Ba[1] and Mamoudou Hama Dicko[2]

[1]Food Technology Department (DTA), Institute of Research in Applied Sciences and Technologies (IRSAT), National Center for Scientific and Technological Research (CNRST), Ouagadougou, Burkina Faso, [2]Laboratory of Biochemistry, Biotechnology, Food Technology and Nutrition (LABIOTAN), Department of Biochemistry and Microbiology, Joseph KI ZERBO University, Ouagadougou, Burkina Faso, [3]National Agency for Environmental, Food, Occupational and Health Product Safety (ANSSEAT), Ouagadougou, Burkina Faso

Introduction: In Burkina Faso, sesame is one of the most widely grown oil and rend crops. Several varieties are grown in different regions, but little is known about their nutritional characteristics. The objective of this study was to evaluate the impact of the production area on the nutritional characteristics of two sesame varieties grown in Burkina Faso.

Methods: The biological material consisted of sesame varieties *S42* and *Humera* from two production areas of Burkina Faso. The physicochemical characteristics, macronutrients, and minerals of whole and hulled grains were determined according to standard methods. The study showed a significant difference ($p < 0.05$) between the grain samples of the two sesame varieties from the two areas for the weight of 1,000 grains, moisture, ash, protein, fat, and carbohydrate contents, and energy values.

Results: The color parameters (L*, a*, b*) of the samples did not show any significant difference. The mineral contents of the seeds of the two sesame varieties varied from 95.51 ± 7.07 to 1,057.01 ± 7.07 mg/100 g for Calcium, 169.32 ± 7.07 to 364.56 ± 7.07 mg/100 g for Potassium, 142.52 ± 7.14 to 261.58 ± 1.41 mg/100 g for Magnesium, 2.46 ± 7.07 to 4.54 ± 7.07 mg/100 g for Zinc, 3.48 ± 7.07 to 9.65 ± 7.07 mg/100 g for Iron with a significant difference ($p < 0.05$). There was a significant difference ($p < 0.05$) between the biochemical composition of whole and hulled sesame grains, with a decrease in ash, protein, and mineral contents and an increase in total sugars and fats.

Conclusion: This study showed that the production area and hulling have an impact on the physicochemical and nutritional characteristics of the grains of sesame varieties *S42* and *Humera*. In view of their nutritional composition, these two sesame varieties constitute a good source of nutrients. The nutritional potential of sesame will lead to increased consumption of whole or processed sesame, as well as an increase in its production in Burkina Faso.

KEYWORDS

climatic zones of Burkina Faso, hulling, macronutrients, minerals, physicochemical characteristics, sesame seeds

1 Introduction

In Burkina Faso, the agricultural sector occupies a predominant place in the socio-economic life of the population. It employs more than 85% of the active population and contributes to 40% of the gross domestic product (FAO, 2015). Indeed, even if cereal production has increased over the years, it remains insufficient because of the population a quick growth of the country has experienced. Thus, agricultural production is unable to cover the food needs of this population. This situation is often explained by unfavorable climatic conditions, the natural poverty of the soils, and the poor management of their fertility.

Since 2009, the Government of Burkina Faso, through the Ministry of Agriculture, has been developing a strategy to diversify agricultural sectors, to sustainably improve its contribution to food security and poverty reduction (Sanfo, 2022). Sesame (*Sésamum Indicum*. L) is part of this diversification of agricultural production. The cultivation of sesame (*Sesamum Indicum*. L) is an alternative way of improving people's diet. It adapts well to the climatic conditions (warm temperatures, rainfall) of Burkina Faso, guaranteeing good development and optimal production yields (Nakelse et al., 2025).

Sesame is an annual plant of the Pedaliaceae family, considered one of the oldest oilseed crops cultivated in the world (cultivation in Mesopotamia for over 4,000 years) (Ashri, 1998). This seed is variable in color: white, yellow, brown, and black. In Burkina Faso, sesame has been cultivated since the early 20th century and was part of crop rotations before the development of industrial cotton cultivation. In recent years, this crop has experienced significant fluctuations in production due to its heavy dependence on a small number of actors. According to the Food and Agriculture Organization (FAO) (FAOSTAT, 2024) show world sesame seed production reached a record figure of 6,741,479 tons in 2022. Africa's share of sesame production was 45.4%. In Burkina Faso, sesame seed production was estimated at 208,794 tons in 2022, a decrease of more than 30% compared to the previous campaign, given the security crisis in the country (FAOSTAT, 2024). In Burkina Faso, sesame is the second most important agricultural export after cotton, and a source of income for producers, exporters, and processors in the sector (Ouedraogo, 2022). Sesame seeds are used in the manufacture of several products, including kibbles, sesame oil, sesame paste, and enriched foods (bread, biscuits, flour, *etc.*).

Whole seeds contain a high fat content of more than 40% and protein (Elleuch et al., 2007; Hoyos, 2024; Ro et al., 2021; Sene et al., 2018a; Wei et al., 2022). They are rich in ash and minerals (Mg, K, Ca, Fe, Zn) and vitamins (Vit E, K, B9, B6, B3, B2) (Elleuch et al., 2007; Sene et al., 2018b). Previous studies have shown that the fatty acid profile of sesame is rich in oleic acid (41.68%) and linoleic acid (38.29%) (Hoyos, 2024; Borchani et al., 2010; Mostashari and Mousavi Khaneghah, 2024; Oboulbiga et al., 2023). However, the high oil and fatty acid content of sesame seeds can be influenced by genetic and environmental factors (Carlsson et al., 2008). It is also rich in bioactive compounds such as lignans (sesamin, sesamol, sesamolin), tocopherols and phytosterols. These bioactive compounds can help prevent certain cardiovascular, metabolic and coronary diseases (Oboulbiga et al., 2023). The w-3 and w-6 fatty acids in sesame seed oil are precursors of eicosanoids which regulate the immune system and inflammatory functions (Oboulbiga et al., 2023). Similarly, sesame's high calorie and micronutrient content can help combat undernutrition, especially in children and women of childbearing age.

Given the food and nutritional situation in Burkina Faso, sesame, although perceived as a cash crop, could also contribute to achieving the much sought-after nutritional security in the country if the nutritional values of the said crop are known by the entire population. In this way, the study will contribute to achieving the HUNGER ZERO objective of the United Nations (UN) Sustainable Development Goals (SDGs). The general objective of this study is to compare the physicochemical and nutritional properties of whole and hulled grains of two varieties of sesame from two regions of Burkina Faso.

2 Materials and methods

2.1 Plant material and sample collection

The study focused on two specific regions of Burkina Faso (Cende and Hauts Bassins). These regions are home to the research stations of the Institute for Environmental and Agricultural Research (INERA) located in Kamboinsin (Ouagadougou) and Farakoba (Bobo-Dioulasso). To visually represent the geographical distribution of these areas, the software QGIS was used to create a map representation (Figures 1, 2). The plant material consisted of seeds of two sesame varieties (*S42* and *Humera*) from the two Research Stations of the Institute for Environmental and Agricultural Research (INERA) located in Kamboinsin (Ouagadougou) and Farakoba (Bobo-Dioulasso). For each sesame variety and zone, three grain samples were taken. A basic seed sample of each sesame variety was also collected at INERA Kamboisin in Ouagadougou. The same basic seed of both sesame varieties was used in both zones for propagation. Table 1 presents information on the two sesame varieties.

2.2 Sample pretreatment

Sesame seeds of both varieties were dehulled using a wooden mortar. Whole seeds and dehulled seeds were ground using a

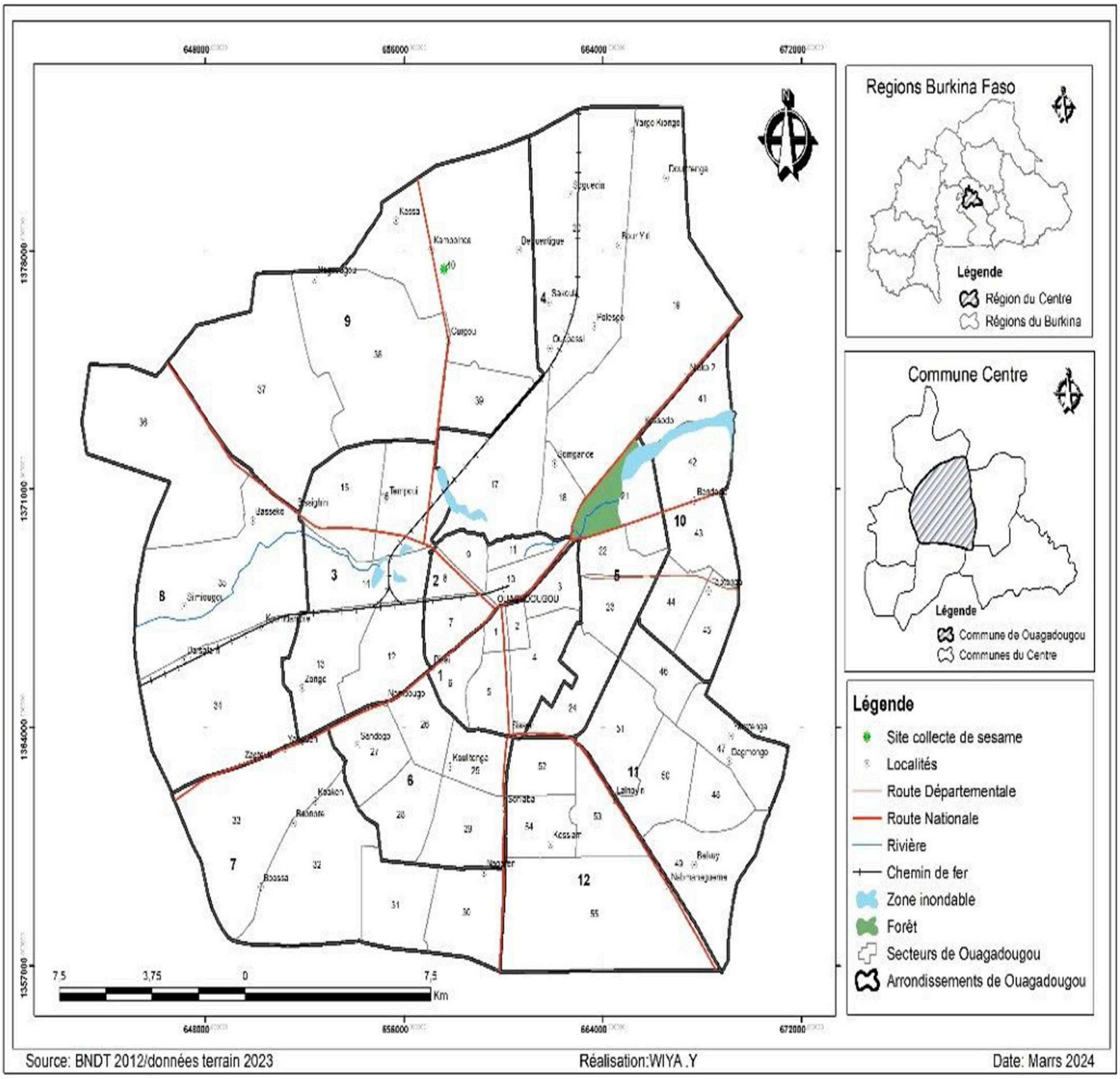

FIGURE 1
Collection site for sesame varieties from INERA Kamboinsin (Ouagadougou).

stainless-steel electric grinder SEAAN type and stored in the freezer Boreal at −20°C for analysis. The initial ion moisture was between 2,70 et 4,70%. The physicochemical analyses were carried out in triplicate.

2.3 Determination of physicochemical parameters

2.3.1 Determination of the weight of 1000-grains, acidity, and color parameters

The mass of 1000-grains was determined according to the standard. This process involves taking a sample quantity, separating the whole grains, weighing them to the nearest 0.01 g, and counting them. The mass of the whole grains is divided by their number and expressed per 1000-grains. The mass of 1000-grains (m), in grams, is given by the following equation:

$$m = \frac{m_t}{\mathrm{N}} \times 100$$

m_t: mass, in grams, of whole grains in the test sample.

N: number of whole grains contained in the test sample.

The acid value and acidity of sesame seeds were determined according to the standard (ISO 660, 2020).

The color of the different sesame samples was measured using a colorimeter (PCE-CSM 1, PCE instruments, Im Langel 4, D-59872 Meschede, Deutschland) based on the color system of the International Commission on Illumination (CIE): L*, a*, b*. Measurements of the parameters L*, a*, and b* were carried out three times for each sample by placing the objective of the

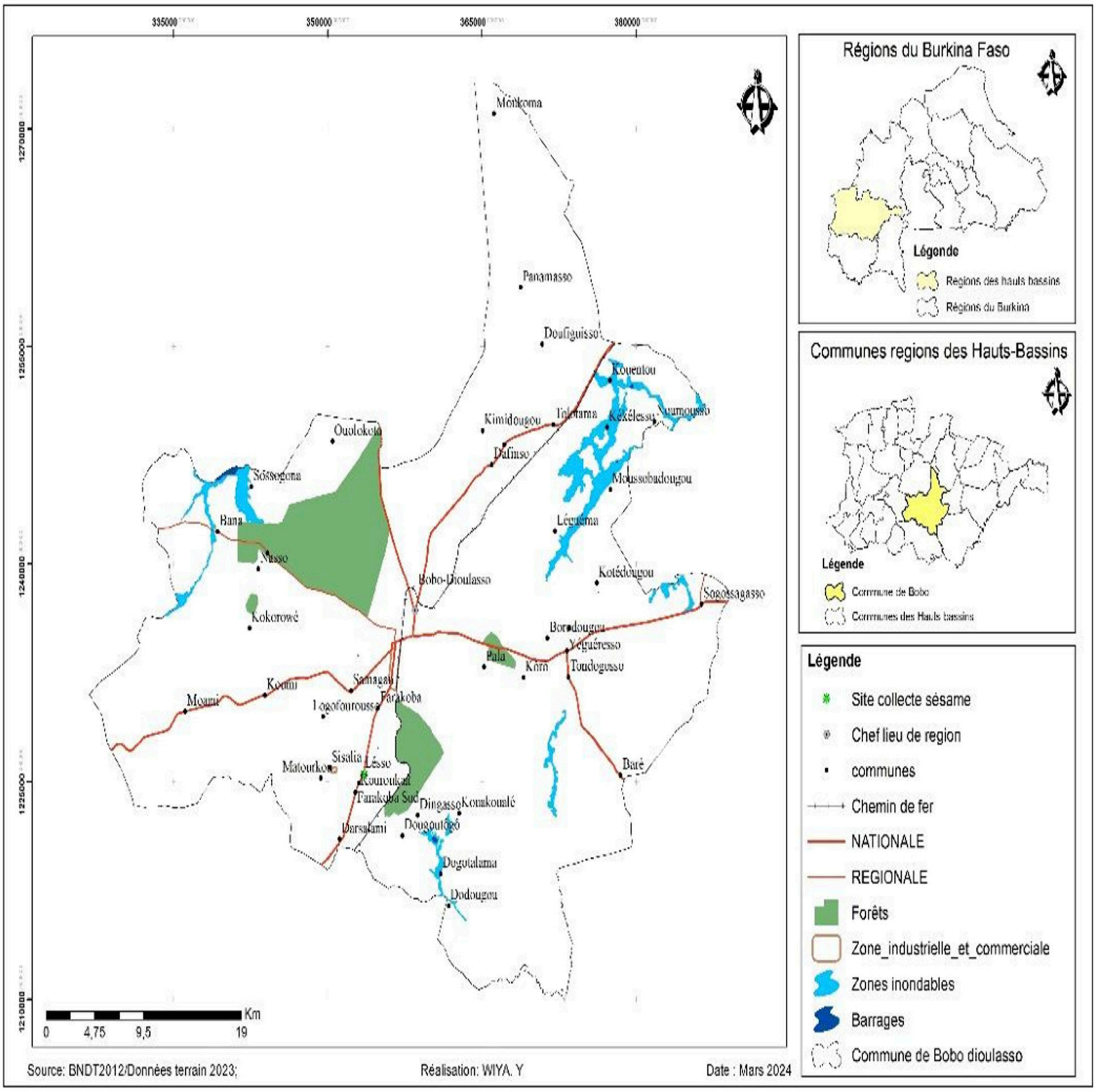

FIGURE 2
Sesame variety collection site at INERA Farakoba (Ouagadougou).

colorimeter on a homogeneous surface of the sesame seeds. The values indicated are L* lightness–darkness, a* redness-greenness, and b* yellowness–blueness of sesame samples. The value of the parameters C* is calculated as follows: $C* = \sqrt{(a*2 + b*2)}$. The C* index represents the saturation of the color.

2.3.2 Determination of proximate composition of sesame varieties

The moisture of the samples was determined by weighing before and after being placed in an oven at 103°C ± 2°C according to the standard (ISO 665, 2020). For this purpose, 5 g of sample were weighed into a gondola whose empty weight had been determined. The carriers were placed in an oven at 105°C overnight (approx. 12 h). They were then removed from the oven and placed in a desiccator for cooling for approximately 30 min, then reweighed. Each sample was weighed in triplicate, and the average was calculated.

The ash content of sesame seeds was determined by incineration according to the standard (ISO 2171, 2007). Five g samples was in an empty weight crucible and then placed in a furnace at 550°C for 12 h. The calcined samples were removed from the furnace and placed in a desiccator for cooling and then weighed.

The fat content of the samples was determined by Soxhlet extraction according to the standard (ISO 659, 2009) using hexane as solvent. To do this, 5 g of sample was weighed into a cartridge, covered with cotton wool, and placed in a Soxhlet.

TABLE 1 Information on sesame varieties.

Name of the variety	Production site	Shape	Code
S42	INERA Kamboinsin (Ouagadougou)	Whole seeds	*S42*KW
	INERA Farakoba (Bobo Dioulasso)	Whole seeds	*S42*FW
	INERA Kamboinsin (Ouagadougou)	Hulled	*S42*KH
	INERA Kamboinsin (Ouagadougou)	Base	*S42*KB
Humera	INERA Kamboinsin (Ouagadougou)	Whole seeds	HKW
	INERA Farakoba (Bobo Dioulasso)	Whole seeds	HFW
	INERA Kamboinsin (Ouagadougou)	Hulled	HKH
	INERA Kamboinsin (Ouagadougou)	Base	HKKB

The Soxhlet was mounted in a flask of known weight, and the cartridge was immersed in approximately 200 mL of hexane. Extraction was performed by boiling on a hot plate for 4 h. The solvent was then evaporated by distillation using a rotary evaporator. The flask containing the fat was then dried in an oven for 1 h to ensure complete evaporation of the hexane. It was then cooled in a desiccator, weighed again, and the final weight recorded.

Total sugars of sesame seeds were determined by the orcinol method described by Montreuil et spik (Montreuil and Spik, 1969). In a beaker, 0.2 g of ground sample was taken. 5 mL of distilled water was then added, and the mixture was stirred magnetically for 10 min. The mixture was then transferred to a 100 mL volumetric flask and homogenized after completing the volume. Next, 1 mL of homogenate was taken into a test tube, to which 2 mL of orcinol reagent and 7 mL of sulfuric acid (60%) were added. The contents of the tube were vortexed and placed in a boiling water bath for 20 min, then placed in the dark for 45 min, followed by 10 min at room temperature. After homogenization, absorbance was measured using a spectrophotometer (UNI 002_EN Spectrophotometer I 200), at 510 nm. A calibration range based on D-glucose solutions from between 0 and 1 mg/mL was used to estimate the total sugar concentration of the samples. The results are expressed in g D-glucose equivalent per 100 g dry matter.

The protein content of sesame seeds was determined by the determination of total nitrogen using the Kjeldahl method (ISO, 1871, 2009). The protein content was calculated by multiplying the nitrogen content by a conversion factor (6.25). A 0.2 g sample was weighed and placed in a Kjeldahl mineralization tube or mat. To which a pellet of Kjeltabs catalyst and 10 mL of concentrated sulfuric acid were added. The prepared samples were mineralized on a heating block at progressive temperatures of 90, 120, and 400°C for 4 h, until the solution was completely decolorized. Solution. The resulting mineralized solution was diluted with 50 mL of distilled water and neutralized with concentrated sodium hydroxide (10 N) and then distilled using a distillation apparatus (Gerhardt). The distillate (150 mL) was collected in a beaker containing 5 mL of Tashiro color indicator, composed of bromocresol green, methyl red, and boric acid. The mixture was titrated with 0.1 N sulfuric acid until the indicator turned from green to pink.

The theoretical energy value of sesame seeds was calculated using Atwater coefficients. (FAO, 2003). Energy value (Kj/100 g) = (% protein) × 4 + (% carbohydrate) × 4 + (% fat) × 9.

2.3.3 Determination of minerals

The calcium (Ca), magnesium (Mg), potassium (K), iron (Fe), and zinc (Zn) of sesame seeds were determined by flame atomic absorption spectrometry (PerkinElmer PinAAcle 900H) according to the method described by Jorhem et al. (2000). For mineralization and acid digestion of the mineralized material, a test portion of 2 g of the sample was placed in crucibles and then mineralized by dry process in a muffle furnace and allowed to cool. After cooling, nitric acid (10%) was added to the crucibles and filtered using filter paper into 50 mL flasks. The solution thus obtained was well stored at room temperature until injection. The standard solutions were prepared by diluting the commercial solution in 10% nitric acid (20 mL of HNO_3 (76%) in a 1,000 mL graduated flask and topping up with ultrapure water to the mark).

2.4 Statistical analyses

Data were entered using an Excel 2019 spreadsheet. Analysis of variance (ANOVA) was performed using XLSAT software version 2021. Means were compared using Tukey's test at the 5% probability level. Principal component analyses (PCA), Hierarchical Ascending Classification, and Heatmaps were carried out using the open-source statistical program R (version 3.6.2) to assess the overall variability.

The results are expressed as mean values ± standard deviation and presented in tables.

3 Results

3.1 Weight of 1000-grain, acidity, and color parameters

The 1000-grain weight of the two sesame varieties is presented in Table 2. The 1000-grain weight ranged from 1.24 g to 1.33 g. The INERA Kamboinsin varieties had the highest 1000-grain weights. The results showed no significant difference between the 1000-grain weights of the varieties from

10.3389/frfst.2025.1636295

TABLE 2 Thousand-grain weight and acid values of the two sesame varieties.

Origin	Varieties	Weight of 1,000 grains (g)	Acid (mg/KOH)
Ouagadougou	*S42*KW	1.33 ± 0.14^{a}	5.43 ± 0.34^{a}
	HKW	1.29 ± 0.16^{abcd}	3.79 ± 0.37^{cd}
Bobo Dioulasso	*S42*FW	1.29 ± 0.85^{abcd}	3.16 ± 0.60^{bcd}
	HFW	$1.28 \pm 0.75_{de}$	5.36 ± 0.12^{a}
Base	*S42*KB	1.24 ± 0.15^{cde}	3.87 ± 0.34^{cd}
	HKB	1.29 ± 0.35^{abcd}	4.47 ± 0.25^{abc}
Hulled	*S42*KH	–	4.04 ± 0.21^{abcd}
	HKH	–	0.17_{ab}
P value		0.000	0.000

Values assigned the same letter in the same column are not significantly different at the probability threshold P < 0.05. S42KW, Whole S42 Kamboisin Sesame Seed; HKW, Whole Humera Kamboisin Sesame Seed, S42FW, Whole S42 Farakoba Sesame Seed; HFW, Whole Humera Farakoba Sesame Seed; S42KB, S42 Kamboisin Base Sesame Seed; HKB, Humera Kamboisin Base Sesame Seed; S42KH, Hulled S42 Kamboisin Sesame Seed; HKH, Hulled Humera Farakoba Sesame Seed

TABLE 3 Color parameters (L*a*b*) of the grains of the two sesame varieties.

Origin varieties		L *	a *	b*	C *
Ouagadougou	*S42*KE	51.38^{a}	8.26^{a}	24.02^{a}	25.40^{a}
	HKW	50.30^{a}	9.28^{a}	24.18^{a}	25.91^{a}
Bobo Dioulasso	*S42*FW	49.69^{a}	8.13^{a}	23.80^{a}	25.15^{a}
	HFW	50.39^{a}	9.27^{a}	24.06^{a}	25.78^{a}
Base	*S42*KB	53.56^{a}	9.12^{a}	25.76^{a}	27.32^{a}
	HKB	51.85^{a}	10.01^{a}	24.94^{a}	26.90^{a}
Hulled	*S42*KH	54.6^{a}	7.73^{a}	24.31^{a}	25.51^{a}
P-value		0.000	0.000	0.000	0.000

Values assigned the same letter in the same column are not significantly different at the probability threshold P < 0.05. S42KW, Whole S42 Kamboisin Sesame Seed; HKW, Whole Humera Kamboisin Sesame Seed, S42FW, Whole S42 Farakoba Sesame Seed; HFW, Whole Humera Farakoba Sesame Seed; S42KB, S42 Kamboisin Base Sesame Seed; HKB, Humera Kamboisin Base Sesame Seed; S42KH, Hulled S42 Kamboisin Sesame Seed; HKH, Hulled Humera Farakoba Sesame Seed.

the two locations. On the other hand, there was a significant difference between the 1000-grain weight of the INERA Kamboinsin *S42* variety and that of the basic *S42* seed.

Acidity contents of the whole, base and dehulled sesame seeds of the two varieties are presented in Table 2. The acid value ranged from 3.87 ± 0.34 (*S42*KB) to 5.43 ± 0.34 mg/KOH (*S42*KW). The results showed a statistically significant difference between the acid values of the two varieties from the two sources, as well as between those of the whole and dehulled sesame seeds.

The color parameters (L*, a*, b*) of the grains of the two sesame varieties are presented in Table 3. The luminance (L*) ranged from 50.30 (HKW) to 54.66 (*S42*KH); the color parameter a* from 7.73 (S42KH) to 10.01 (HKB); the color parameter b* from 23.80 (*S42*FW) to 25.76 (S42KB); and the color parameter dc* from 25.15 (*S42*FW) to 27.32 (*S42*KB). The results showed no significant difference between the color of the grains of sesame varieties from INERA Farakoba, that of the sesame grains of varieties from INERA Kamboinsin, that of the basic sesame grains, and that of the decorticated sesame grains. It is the same observation with the photo of sesame varieties from the two production areas (Figure 3).

3.2 Proximate composition of sesame varieties

Table 4 presents the macronutrient composition of the grains of the two sesame varieties. The water content of the grains of both whole, base and dehulled varieties is between 2.70% ± 0.07% (HFW) and 4.70% ± 0.05% (HKW). Statistical analyses showed that there is a significant difference between the water content of the grains of the Humera variety of INERA Kambonsin and that of the grains of the Humera variety of INERA Farakoba.

The ash content of the grains of the two varieties of whole sesame, base and dehulled, was between 2.40% ± 0.07% (HKB) and 7.00% ± 0.25% (HFW). Statistical analyses showed that there is a significant difference between the ash contents of the two sesame varieties.

The protein content of the whole, base and dehulled sesame seeds of the two varieties varied from 13.73% ± 7.07% (HKB) to 18.66% ± 7.07% (HKW). Statistical analyses showed that there is a significant difference between the protein contents of the seeds of the two sesame varieties.

The fat content of the whole, base and dehulled sesame seeds of the two varieties ranged from 42.16% ± 1.40% (*S42*KB) to 73.86% ± 7.007% (*S42*KD). Statistical analyses showed that there is a significant difference

 10.3389/frfst.2025.1636295

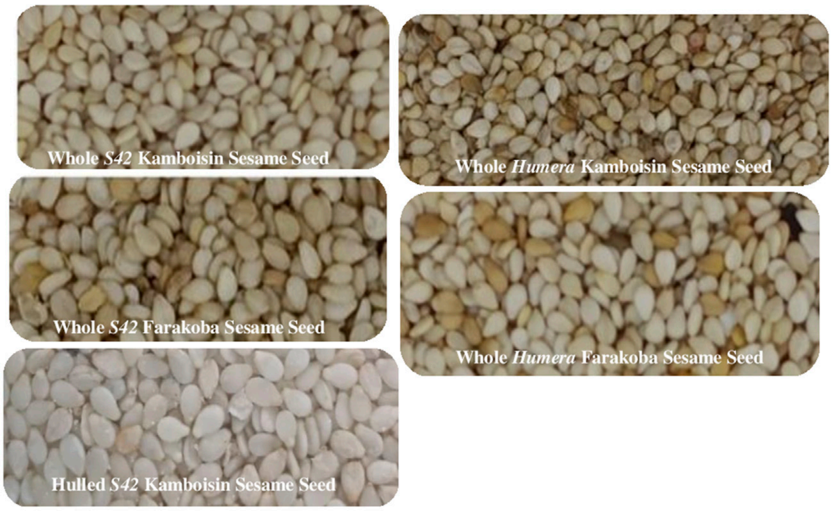

FIGURE 3
Photo of the grains of the two sesame varieties.

TABLE 4 Macronutrient composition and energy value of sesame seeds per 100 g of dry matter.

Origin varieties		Ash (%)	Moisture (%)	Proteins (%)	Fats (%)	Carbohydrates (%)	Energy value (KJ/100 g)
Ouagadougou	*S42*KW	4.80 ± 0.08^{c}	3.00 ± 0.05^{bcde}	18.56 ± 7.07^{f}	54.50 ± 7.07^{g}	6.40 ± 3.18^{abc}	2,467.58 ± 7.07^{cd}
	HKW	4.70 ± 0.08^{e}	4.70 ± 0.05^{a}	18.66 ± 7.07^{e}	47.09 ± 7.07^{o}	7.07 ± 1.03^{abc}	2,202.47 ± 7.07^{d}
Bobo Dioulasso	*S42*FW	4.60 ± 014^{ef}	3.60 ± 0.09^{bcd}	16.45 ± 7.07^{i}	52.82 ± 0.00^{h}	6.54 ± 1.29^{abc}	2,371.03 ± 7.07^{c}
	HFW	7.00 ± 0.25^{a}	2.70 ± 0.07^{de}	15.57 ± 0.00^{L}	46.76 ± 1.41^{P}	5.018 ± 5.12^{bc}	2,102.89 ± 7.07^{e}
Base	*S42*KB	4.50 ± 0.05^{h}	3.90 ± 0.08^{ab}	15.27 ± 7.00^{m}	42.16 ± 1.40^{r}	6.15 ± 3.88^{abc}	1945.58 ± 1.48^{f}
	HKB	2.40 ± 0.07^{q}	3.70 ± 0.09^{abcd}	13.73 ± 7.00^{r}	54.67 ± 7.07^{f}	7.76 ± 7.64^{abc}	2,415.74 ± 7.07^{g}
Hulled	S42KH	3.10 ± 0.03^{bcde}	3.40 ± 0.04^{bcd}	15.20 ± 7.07^{n}	73.86 ± 7.07^{b}	4.56 ± 2.67^{bc}	3,109.18 ± 0.00^{a}
	HKH	3.30 ± 0.03^{m}	3.40 ± 0.04^{bcd}	13.79 ± 1.41^{q}	63.02 ± 1.00^{d}	6.35 ± 1.00^{abc}	2,707.29 ± 7.14^{b}
P-value		<0.0001	<0.0001	<0.0001	<0.0001	<0.005	<0.0001

Values assigned the same letter in the same column are not significantly different at the probability threshold P < 0.05. S42KW, Whole S42 Kamboisin Sesame Seed; HKW, Whole Humera Kamboisin Sesame Seed, S42FW, Whole S42 Farakoba Sesame Seed; HFW, Whole Humera Farakoba Sesame Seed; S42KB, S42 Kamboisin Base Sesame Seed; HKB, Humera Kamboisin Base Sesame Seed; S42KH, Hulled S42 Kamboisin Sesame Seed; HKH, Hulled Humera Farakoba Sesame Seed

between the fat contents of the two sesame seeds. The carbohydrate content of whole, base, and dehulled sesame kernels from both origins ranged from 4.56% ± 2.67% (*S42*KH) to 7.76% ± 7.64% (HKH). Dehulled kernels had the highest carbohydrate contents, but statistical analyses did not show any significant difference.

The energy values of sesame seeds ranged from 1945.58 ± 1.48 (*S42*KB) to 3,109.18 ± 0.00 KJ/100 g/MS (*S42*KH). Dehulled sesame seeds had the highest energy values. Statistical analyses showed that there is a significant difference between the sesame seed samples.

3.3 Mineral content

The mineral contents of the grains of the two sesame varieties are presented in Table 5. The calcium (Ca) content ranged from 95.51 ± 7.07 mg/100 g (*S42*KH) to 1,057.01 ± 7.07 mg/100 g (HKW), potassium (K) content ranged from 169.32 ± 7.07 mg/100 g (*S42*KD) to 364.56 ± 7.07 mg/100 g (*S42*FW), magnesium (Mg) content ranged from 142.52 ± 7.14 mg/100 g (*S42*KW) to 261.58 ± 1.41 mg/100 g (HKW), Zinc (Zn) content ranged from 2.46 ± 7.07 mg/100 g (HKB) to 4.54 ± 7.07 mg/100 g (*S42*KB), the iron (Fe) content ranged from 3.48 ± 7.07 mg/100 g (*S42*KW) to 9.65 ± 7.07 mg/100 g (HKB).

3.4 Principal component analysis (PCA)-biplot, cluster dendrogram, and heatmap of the two sesame varieties based on physicochemical and nutritional characteristics

The Principal Component Analysis (PCA) of the physicochemical and nutritional characteristics is illustrated in Figure 4. This representation follows two axes, Dim 1 (39,90%) and Dim 2 (25.80%), which are made up of 65.70% of the reliable results. The

TABLE 5 Mineral content of sesame seeds.

Origin varieties	Varieties	Ca (mg/100 g)	K (mg/100 g)	Mg (mg/100 g)	Zn (mg/100 g)	Fe (mg/100)
Ouagadougou	S42KW	$426,010 \pm 1.36^{L}$	186.29 ± 7.07^{q}	146.56 ± 7.07^{r}	4.38 ± 7.07^{d}	3.48 ± 7.07^{o}
	HKW	$1,057, 01 \pm 7.07^{a}$	335.92 ± 7.07^{d}	261.58 ± 1.41^{b}	4.42 ± 7.07^{c}	6.41 ± 7.07^{d}
Bobo Dioulasso	S42FW	536.16 ± 7.07^{g}	364.56 ± 7.07^{c}	161.80 ± 7.07^{p}	2.79 ± 7.07^{L}	7.16 ± 7.07^{c}
	HFW	945.25 ± 2.83^{b}	335.91 ± 0.00^{d}	240.25 ± 7.07^{c}	4.28 ± 5.66^{f}	5.95 ± 1.77^{e}
Base	S42KB	792.77 ± 7.07^{c}	265.98 ± 7.07^{d}	180.35 ± 7.07^{k}	4.54 ± 7.07^{b}	5.38 ± 7.07^{f}
	HKB	569.54 ± 7.07^{e}	198.96 ± 1.34^{p}	153.48 ± 4.65^{q}	2.46 ± 7.07^{m}	9.65 ± 7.07^{b}
Hulled	S42KH	95.51 ± 7.07^{q}	169.32 ± 7.07^{r}	142.52 ± 7.14^{s}	4.42 ± 7.07^{c}	4.93 ± 2.83^{h}
	HKH	$92,570 \pm 7.07^{r}$	253.72 ± 7.07^{k}	188.57 ± 7.07^{y}	4.38 ± 7.07^{d}	3.67 ± 0.00^{lm}
P-value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Values assigned the same letter in the same column are not significantly different at the probability threshold $P < 0.05$. S42KW, Whole S42 Kamboisin Sesame Seed; HKW, Whole Humera Kamboisin Sesame Seed, S42FW, Whole S42 Farakoba Sesame Seed; HFW, Whole Humera Farakoba Sesame Seed; S42KB, S42 Kamboisin Base Sesame Seed; HKB, Humera Kamboisin Base Sesame Seed; S42KH, Hulled S42 Kamboisin Sesame Seed; HKH, Hulled Humera Farakoba Sesame Seed

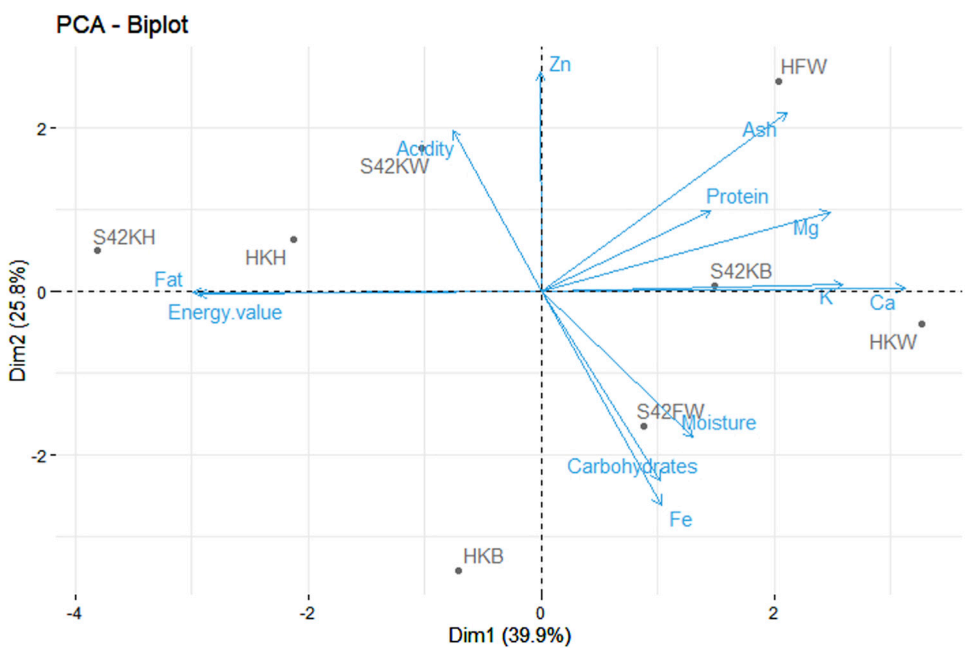

FIGURE 4
Principal component analysis (PCA).

PCA shows three groups. Group 1 is composed of the samples Whole *S42* Kamboisin, Hulled *S42*, Hulled *Humera,* and has a high Energy value (2,707.29 kcal/g DM), Fat (63.02% DM) and Zn (4.38) content. These average acidity index contents are comparable to those of group 3. Group 2 is composed of sesame samples: Whole *Humera* Kamboisin, Whole *Humera* Farakoba and Basic *S42.* They are characterized by high contents of acidity, ash, protein, Ca, K, Mg and Zn. The average contents of Zn are comparable to those of Group 1. Group 3 consists of Whole *S42* Farakoba, Basic *Humera* samples characterized by high moisture, carbohydrate, Fe value contents, with very low Mg, Ca, Zn, and P contents, lower than those of group 2.

The dendrogram carried out on the sesame samples focused on the variables' acidity, acid index, water content, ash, lipids, proteins, carbohydrates, and energy value. The results of the Dendrogram revealed a structuring of the variability of the samples of sesame varieties into three distinct groups (Figure 5). The decomposition of the variance shows that the inter-group variability corresponds to 71.87% against 28.13% for the intra-class variability.

The heatmap illustrates physicochemical characteristics (Figure 6). The color intensity of each variety is directly proportional to the physicochemical and nutritional content measured in samples of varieties from the production zones. The color gradient goes from blue, indicating the lowest content, to red, indicating the highest content. The samples, depending on their shape or production zone, showed a high content of variable nutrients. For example, the husked S42 Kamboissin variety (S42KH) had high lipid content and energy

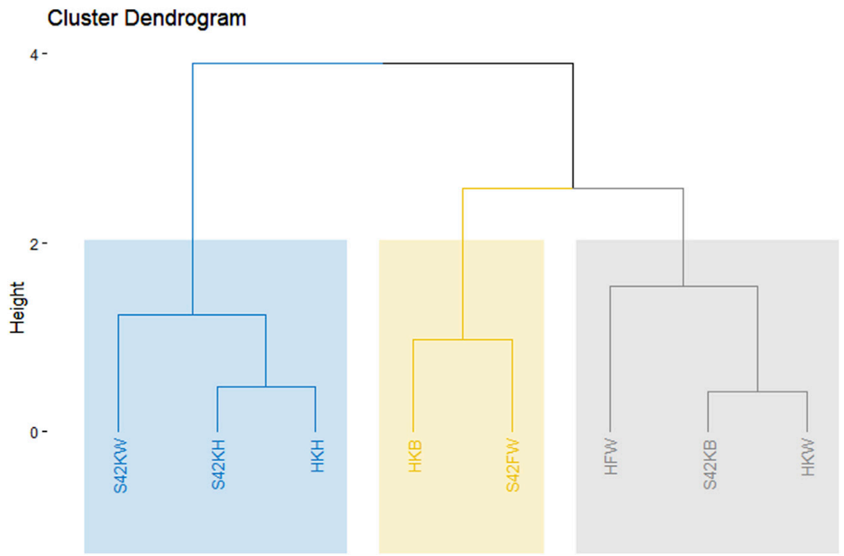

FIGURE 5
Hierarchical ascending classification of the two sesame varieties based on physicochemical and nutritional characteristics.

values. The whole *Humera* Kamboisin variety (HKW) had high lipid contents and high energy values, as well as high moisture, protein, calcium and magnesium contents.

4 Discussion

4.1 Weight of 1000-grains, acidity and color parameters

The variation in the weight of 1,000 grains recorded in this study could be explained by agronomic and environmental conditions that can influence the weight of sesame seeds. Plant treatments or climatic conditions modify the mass of 1,000 grains (Garcia, 2015). The weight of 1000-grain is less than that found by Khyber and Ali. (2014), El Naim et al. (2012) and Raikwar. (2016) which were respectively 2.79–3.64 g, 3.29 g, 3.1–3.9 g, 3.26–4.18 g. This difference could be explained by the cultural conditions (Khyber and Ali, 2014). The 1000-grain weight is a good indicator of the yield and the problems encountered by the plant during its development, such as drought. On the technological level, it represents one of the indicators of technological performance in primary processing industries. The 1,000-grain weight is generally difficult to control because it is strongly linked to the effects of the environment at the time of grain formation and filling. A lack of water after flowering, combined with high temperatures, leads to a decrease in the 1000-grain weight by altering the speed and/or duration of filling (Benbelkacem and Kellou, 2000). Mohammed et al. (2018) in Saudi Arabia found acidity between 0.19 and 2.00 mg/KOH in several sesame varieties. The acidity value found in these varieties indicates that sesame has not been stored for a long time or has not undergone an oxidation reaction, and can be used for human consumption. A high acidity value can be an indicator of rancidity, oxidation, and a high degree of biological activity and deterioration of non-fatty materials such as carbohydrates and proteins (Mohammed et al., 2018). The luminance L* is high for both varieties (*S42* and *Humera*) of sesame and tends towards white color. The L* values are similar to those obtained by Cui et al. (2021) with values ranging from 10.53 to 63.40. All the values of parameter a* obtained are positive. According to Granato and Masson. (2010). The color parameter a* takes positive values for reddish colors and negative values for greenish colors. Hence, the color of sesame seeds tends towards a reddish color rather than a greenish color. For the parameter b*, it takes positive values for yellowish colors and negative values for bluish colors (Granato and Masson, 2010). All the values found for the color parameter b* are positive as well. Hence, the color of the seeds of both sesame varieties tends towards yellowish. The *S42* and *Humera* varieties of INERA Kambosin are whiter, redder, and yellower than those of INERA Farakoba because they have higher L*a*b* values. Between the varieties, the S42 is whiter, redder, and yellower than the *Humera* because they have higher L*a*b* values. Between the hulled varieties, the hulled seeds are whiter and redder than the unhulled seeds because they have higher L* values. It is the same observation with the photo of sesame varieties from the two production areas. The C* index indicates the brightness and dullness. The C* values of both varieties are high, which shows that their colors are vivid (bright).

4.2 Proximate composition of sesame varieties

The water contents are similar to those obtained (4.18%–4.58%) by Makinde and Akinoso (Makinde and Akinoso, 2013) with two varieties of whole and hulled sesame, and to those found (4.71%) by (Elleuch et al., 2007). Also, Zebib et al. (2015) reported water contents of Ethiopian sesame varieties ranging from 3.17% to 3.40%. However, they are higher than those obtained by (Yewande Bamigboye et al., 2010) with values of 5.2%–6.4%.

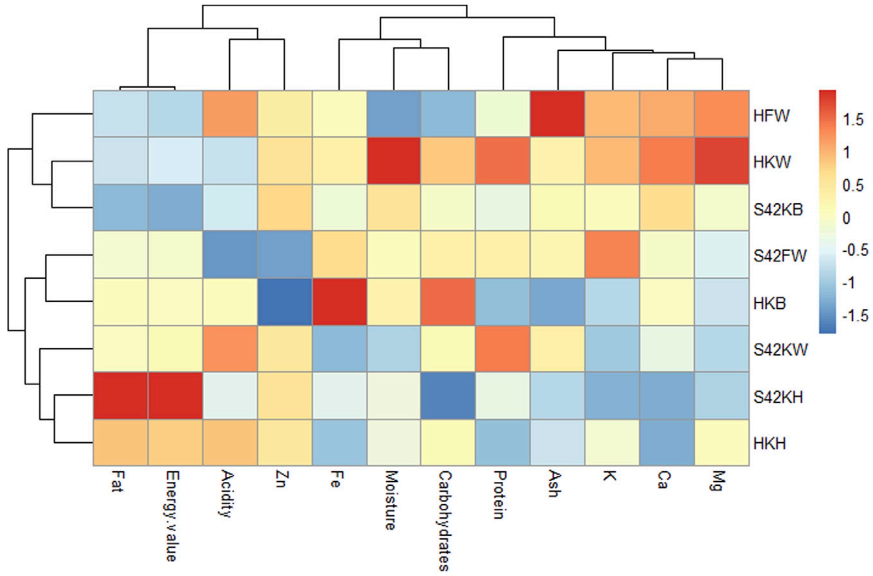

FIGURE 6
Heatmap of samples of the two sesame varieties.

The ash contents obtained are similar to those found (4.68% and 3.72%–6.16%) in Elleuch et al. (2007) and Makinde and Akinoso. (2013) two varieties of whole and hulled sesame. The variation in ash content between the two varieties and within the same varieties could be due to environmental and genetic conditions. Hullin, g of sesame seeds resulted in a decrease in ash content. Makinde and Akinoso. (2013) also reported a decrease in ash content after hulling of the grains. Hulling of sesame grains results in a decrease in ash content and consequently a decrease in minerals. Minerals are therefore mainly concentrated in the seed germ (Makinde and Akinoso, 2013). The protein contents obtained are lower than those of 21.94% to 26.79% found by Makinde and Akinoso. (2013) in whole and hulled sesame varieties and 22.59% to 29.37% (Sene et al., 2018a) in whole sesame varieties. Hulling sesame seeds results in a decrease in protein content. These results are similar to those obtained by Yewande Bamigboye et al. (2010) who also found a decrease in the protein content of sesame seeds after hulling. Makinde and Akinoso. (2013) found an increase in the protein content of the seeds after hulling. This difference could be explained by the environmental conditions and the dehulling of the seeds. The fat contents obtained are similar to those reported (46.09%–49.91% and 48.65%–52.45% respectively) by Makinde and Akinoso. (2013) and Sene et al. (2018a) in whole and hulled sesame varieties. In contrast to protein, fat content was higher in hulled sesame seeds than in whole seeds (Makinde and Akinoso, 2013). Sesame fat plays an essential role in human nutrition by contributing to energy intake. It is a source of essential fatty acids, particularly linoleic acid, a precursor of omega-6, and alpha linoleic acid, a precursor of omega-3, and participates in the supply and transport of fat-soluble vitamins including E, D and pro-A. Sesame fat also contains bioactive compounds such as lignans (sesamin, sesamol, sesamolin), tocopherols and phytosterols (Oboulbiga et al., 2023; Nzikou et al., 2010; Nzikou et al., 2009; Adewuyi and Pereira, 2017). These bioactive compounds may help prevent certain cardiovascular, metabolic and coronary diseases (Oboulbiga et al., 2023; Prasad et al., 2012; Deme et al., 2018; Jacklin et al., 2003; Selvarajan et al., 2015). The w-3 and w-6 fatty acids in sesame fat are precursors of eicosanoids that regulate the immune system and inflammatory functions (Deme et al., 2018; Selvarajan et al., 2015; Wu et al., 2019). The essential fatty acids contained in this oil are essential for cell construction and highly recommended during the first trimester of pregnancy (Oboulbiga et al., 2023). The carbohydrate contents obtained were lower than those found (12.36%–16.95%). Makinde and Akinoso. (2013) in two varieties of whole and dehulled sesame. Differences in carbohydrate composition may exist between different varieties of sesame kernels and between sesame varieties grown in different countries (Oboulbiga et al., 2023).

4.3 Mineral contents

Within the same variety, statistical analyses showed that there is a significant difference between the mineral content of the samples. For both varieties, the results showed that the Ca, K, and Mg content was lower in hulled sesame seeds. Ca is the most abundant mineral, followed by K, Mg, Fe and Zn. This abundance of Ca, K, and Mg has already been reported by several authors (Elleuch et al., 2007; Sene et al., 2018a; Deme et al., 2018). The Ca, Mg, and Zn contents are similar, and the Fe content is lower than those obtained (630.42, 390.59, 6.54% and 10.50% respectively) than those of Sene et al. (2018a) in several varieties of sesame from Senegal. The Ca, K, Mg, Fe, and Zn contents are lower than those obtained. Elleuch et al. (2007) in sesame seeds from Belgium with values of 1.03, 525.90, 349.90, 11.39, and 8.87 mg/100 g. The K, Mg, and Fe contents are lower than those of Wei et al. (2022) with respective values of 468 mg/100 g, 324 mg/100 g, and 14.6 mg/100 g. This variation in macronutrient contents could be due to environmental and genetic factors as well as analytical methods (Makinde and Akinoso, 2013). For both varieties, the results showed that the Ca, K, and Mg content was lower in hulled sesame seeds. Makinde and Akinoso. (2013) also reported that the Ca, P, Mg, Fe, and Zn contents decreased after hulling the seeds. This could be explained by the fact that the sesame germ contains a significant portion of minerals, and removing it leads to a decrease in this. The seeds of sesame varieties *S42* and *Humera* contain high amounts of Ca, K, Mg, Fe, and Zn; they are therefore a good source of minerals and could contribute to the fight against malnutrition. Minerals are essential for the proper functioning of the body; they are necessary for the normal functioning of cells. Enrichment of children's complementary foods, such as biscuits, flours with sesame, could be a good strategy to combat malnutrition. Indeed, in developing countries such as Burkina Faso, enrichment/fortification of infant foods with Fe and Zn is a priority.

5 Conclusion

This study showed that the production area impacts the physicochemical and nutritional characteristics of sesame seeds of the *S42* and *Humera* varieties. The seeds of these two varieties are a good source of protein, minerals, and fat. Hulling affects the ash, protein, and mineral content of sesame seeds. Given their biochemical composition and richness in minerals, seeds of the *S42* and *Humera* varieties could contribute to achieving nutritional security and combating malnutrition in Burkina Faso. Whole *S42* Kamboisin can be used for oil production due to its rich oil content.

The results of this study on sesame in Burkina Faso can guide local initiatives in nutrition, agriculture and plant breeding. These data can help target nutritional programmes according to the specific needs of the population, guide agricultural policies to encourage sesame production and improve yields, and finally, guide breeders in the choice of two varieties.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

EO: Data curation, Methodology, Conceptualization, Investigation, Writing – review and editing, Funding acquisition, Writing – original draft, Formal Analysis. ZS: Methodology, Data curation, Writing – review and editing, Writing – original draft, Formal Analysis. F-BT: Writing – review and editing, Writing – original draft, Visualization, Validation, Methodology. SY: Writing – original draft, Methodology, Conceptualization, Writing – review and editing. FN: Methodology, Writing – original draft, Formal Analysis. CDI: Visualization, Writing – review and editing, Validation. FH-B: Writing – review and editing, Validation, Supervision. MD: Visualization, Supervision, Validation, Writing – review and editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. The research presented in this article was conducted as part of the Burkina Faso FONRID Project No. 0030 FONRID/APP7/NCP/PC/2020.

Acknowledgments

The authors thank the Department of Food Technology (DTA) of the Institute for Research in Applied Sciences and Technologies (IRSAT) and the National Fund for Research and Innovation for Development (FONRID) for funding this study. They also thank the Laboratory of Biochemistry, Biotechnology, Food Technology and Nutrition (LABIOTAN) through ISP/IPICS project no. 172 600 000 for its contribution to this study.

Conflict of interest

The authors declare that the research 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) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Adewuyi, A., and Pereira, F. V. (2017). Fatty alkyl tosylate from *Sesamum indicum* seed oil: a potential resource for the oleochemical industry. *Riv. Ita Sostanze grasse* 94 (3), 161–167.

Ashri, A. (1998). Sesame breeding. *Plant Breed. Rev.* 16, 179–228. doi:10.1002/9780470650110.ch5

Benbelkacem, A., and Kellou, K. (2000). *Evaluation du progrès génétique chez quelques variétés de blé dur (*Triticum turgidum *L. var. durum) cultivées en Algérie*. p. 105–120.

Borchani, C., Besbes, S., Blecker, C., and Attia, H. (2010). Chemical characteristics and oxidative stability of sesame seed, sesame paste, and olive oils. *J. Agric. Sci. Technol.*, 176.

Carlsson, A. S., Chanana, N. P., Gudu, S., Suh, M. C., and Were, B. A. I. (2008). Sesame. In: H. Kole, editor. *Compendium of transgenic crop plants*. Hoboken, New Jersey: Wiley.

Cui, C., Liu, Y., Liu, Y., Cui, X., Sun, Z., Du, Z., et al. (2021). Genome-wide association study of seed coat color in sesame (*Sesamum indicum* L.). *PLoS One* 1, e0251526. doi:10.1371/journal.pone.0251526

Deme, P., Narasimhulu, C. A., and Parthasarathy, S. (2018). Identification and evaluation of anti-inflammatory properties of aqueous components extracted from sesame (*Sesamum indicum*) oil. *J. Chromatogr. B Anal. Technol. Biomed. Life Sci.* 1087–1088, 61–69. doi:10.1016/j.jchromb.2018.04.029

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C., and Attia, H. (2007). Quality characteristics of sesame seeds and by-products. *Food Chem.* 103 (2), 641–650. doi:10.1016/j.foodchem.2006.09.008

El Naim, A. M., El dey, E. M., Jabereldar, A. A., Ahmed, S. E., and Ahmed, A. A. (2012). Determination of suitable variety and seed rate of sesame (*Sesamum indicum* L) in sandy dunes of kordofan, Sudan. *Int. J. Agr. For.* 2 (4), 175–179. doi:10.5923/j.ijaf.20120204.08

FAO (2003). Food energy-methods of analysis and conversion factors. In: *FAO food and nutrition*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2015). *Evaluation du Programme de la FAO au Burkina Faso*. Rome: Food and Agriculture Organization of the United Nations.

FAOSTAT (2024). *Cultures et produits animaux*. Rome: Food and Agriculture Organization of the United Nations. Available online at: https://www.fao.org/faostat/fr/#data/QCL.

Garcia, L. (2015). *Impact du changement climatique sur les rendements du mil et de l'arachide au Sénégal: Approche par expérimentation virtuelle*. Dakar, Senegal: Université de Dakar.

Granato, D., and Masson, M. L. (2010). Instrumental color and sensory acceptance of soy-based emulsions: a response surface approach. *Food Sci. Technol.* 30, 1090–1096. doi:10.1590/S0101-20612010000400039

Hoyos, B. E. (2024). *Biochemical characterization of the northern Australian-grown Black sesame as a source of bioactive compounds*. Canberra, Australia: University Australia

ISO 2171 (2007). *Céréales, légumineuses et produits dérivés - dosage du taux de cendres par incinération*. Geneva, Switzerland: International Organization for Standardization.

ISO 1871 (2009). *Produits alimentaires et aliments des animaux - lignes directrices générales pour le dosage de l'azote selon la méthode de Kjeldahl*. Geneva, Switzerland: International Organization for Standardization.

ISO 659 (2009). *Graines oléagineuses — détermination de la teneur en huile (Méthode de référence)*. Geneva, Switzerland: International Organization for Standardization.

ISO 665 (2020). *Graines oléagineuses — détermination de la teneur en eau et en matières volatiles volatiles*. Geneva, Switzerland: International Organization for Standardization.

ISO 660 (2020). *Corps gras d'origines animale et végétale - Détermination de l'indice d'acide et de l'acidité*. Geneva, Switzerland: International Organization for Standardization.

Jacklin, A., Ratledge, C., Welham, K. J., Bilko, D., and Newton, C. J. (2003). The sesame seed oil constituent, sesamol, induces growth arrest and apoptosis of cancer and cardiovascular cells. *Ann. N. Y. Acad. Sci.* 1010 (1), 374–380. doi:10.1196/annals.1299.068

Jorhem, L., Engman, J., Arvidsson, B. M., Åsman, B., Åstrand, C., Gjerstad, K. O., et al. (2000). Determination of lead, cadmium, zinc, copper, and iron in foods by atomic absorption spectrometry after microwave digestion: NMKL 1 collaborative study. *J. AOAC Int.* 5, 83 1089–1023.

Khyber, J. A., and Ali, S. (2014). Growth and yield components of sesame (Sesamum Indicum L.) As influenced by phosphorus levels under different row spacing. *J. Environ. Earth Sci* 4, 22.

Makinde, F. M., and Akinoso, R. (2013). Nutrient composition and effect of processing treatments on anti nutritional factors of Nigerian sesame (*Sesamum indicum* L) cultivar. *Int. Food Res. J.* 20 (5), 1–8.

Mohammed, F., Abdulwali, N., Guillaume, D., Tenyang, N., Ponka, R., Al-Gadabi, K., et al. (2018). Chemical composition and mineralogical residence of sesame oil from plants grown in different Yemeni environments. *Microchem J.* 140, 269–277. doi:10.1016/j.microc.2018.04.011

Montreuil, J., and Spik, G. (1969). *Micro dosage des glucides, méthodes colorimétriques de dosage des glucides totaux*. Lille, France: Faculté des Sciences Université de Lille France.

Mostashari, P., and Mousavi Khaneghah, A. (2024). Sesame seeds: a nutrient-rich superfood. *Foods* 13, 1153. doi:10.3390/foods13081153

Nakelse, T., Del Prete, D., Yameogo, A., and Bicaba, M. B. (2025). *Prioriser pour mieux diversifier les exportations du Burkina Faso-Analyse du potentiel de diversification de seize produits agricoles*. Rome: Food and Agriculture Organization of the United Nations.

Nzikou, J. M., Matos, L., Bouanga-Kalou, G., Ndangui, C. B., Pambou-Tobi, N. P. G., Kimbonguila, A., et al. (2009). Chemical composition on the seeds and oil of sesame (*Sesamum indicum* L.) grown in Congo-Brazzaville. *Adv. J. Food Sci Technol.* 1 (1), 6–11.

Nzikou, J. M., Mvoula-Tsiéri, M., Ndangui, C. B., Pambou-Tobi, N. P. G., Kimbonguila, A., Loumouamou, B., et al. (2010). Characterization of seeds and oil of sesame (*Sesamum indicum* L.) and the kinetics of degradation of the oil during heating. *Res. J. Appl Sci, Eng Technol.* 2 (3), 227–232.

Oboulbiga, E. B., Douamba, Z., Compaoré-Sérémé, D., Semporé, J. N., Dabo, R., Semde, Z., et al. (2023). Physicochemical, potential nutritional, antioxidant and health properties of sesame seed oil: a review. *Front Nutr* 10, 10. doi:10.3389/fnut.2023.1127926

Ouedraogo, J. R. (2022). International Journal of Strategic Management and Economic Studies (IJSMES) Filières agricoles et développement du Burkina Faso: cas de la filière sésame. *Int J. Strat Manag Eco Stud*, 1–22. doi:10.5281/zenodo.8238836

Prasad, M. N. N., Sanjay, K. R., and Prasad D, S. (2012). A review on nutritional and nutraceutical properties of sesame. *J. Nutr. Food Sci.* 02 (02), 02. doi:10.4172/2155-9600.1000127

Raikwar, R. S. (2016). Stability for grain yield and its contributing traits in sesame (*Sesamum indicum* L.). *Electron J Plant Bree.* 7 (4), 1033–1039. doi:10.5958/0975-928X.2016.00141.1

Roy, B., Pal, A. K., and Basu, A. K. (2021). Assessment of genetic divergence of sesame seeds based on biochemical parameters. *Plant Sci. Today* 8 (1), 1–8. doi:10.14719/pst.2021.8.1.752

Sanfo, Z. (2022). Analysis of the effect of crop diversification on food security in Burkina Faso. *African Scientific J.*, 1–27.

Selvarajan, K., Narasimhulu, C. A., Bapputty, R., and Parthasarathy, S. (2015). Anti-inflammatory and antioxidant activities of the nonlipid (aqueous) components of sesame oil: potential use in atherosclerosis. *J. Med. Food* 18 (4), 393–402. doi:10.1089/jmf.2014.0139

Sene, B., Sarr, F., Diouf, D., Kane, A., and Traore, D. (2018a). Study of mineral composition and contents about proteins and fats of eight sesame varieties (*Sesamum indicum* L.) introduced in Senegal for variety screening. *OCL - Oilseeds fats, Crops Lipids* 1 (6), 25.

Sene, B., Sarr, F., Diouf, D., Sow, M. S., Traore, D., Kane, A., et al. (2018b). Synthèse des connaissances et quelques acquis de recherche sur le sésame (*Sesamum Indicum* L.) au Sénégal. *Int. J. Biol. Chem. Sci.* 12 (3), 1469. doi:10.4314/ijbcs.v12i3.32

Wei, P., Zhao, F., Wang, Z., Wang, Q., Chai, X., Hou, G., et al. (2022). Sesame (Sesamum indicum L.): a comprehensive review of nutritional value, phytochemical composition, health benefits, development of food, and industrial applications. *Nutrients* 14 (19), 4079. doi:10.3390/nu14194079

Wu, M. S., Aquino, L. B. B., Barbaza, M. Y. U., Hsieh, C. L., Castro-Cruz, K. A. D., Yang, L. L., et al. (2019). Anti-inflammatory and anticancer properties of bioactive compounds from Sesamum indicum L.—A review. *Mol* 24 (24), 4426–4428. doi:10.3390/molecules24244426

Yewande Bamigboye, A., Chinyeaka Okafor, A., and Thomas Adepoju, O. (2010). Proximate and mineral composition of whole and dehulled Nigerian sesame seed. *Afr. J. Food Sci Tech*, 1.

Zebib, H., Bultosa, G., and Abera, S. (2015). Physico-chemical properties of sesame (*Sesamum indicum* L.) varieties grown in northern area, Ethiopia. *Agric. Sci.* 06 (02), 238–246. doi:10.4236/as.2015.62024