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Physicochemical Characteristics, Mineral Content and Fatty Acid Profile of *Cucumeropsis mannii* Naudin Seed Oil from Côte d'Ivoire

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Abstract

In the context of valorization of African plant resources with high nutritional potential under-exploited, this study focused on the oil *Cucumeropsis mannii* to assess its mineral and physicochemical characteristics, as well as its chromatographic profile. The oil extraction from *C. mannii* used the Soxhlet method and yielded 48.01 %. X-ray fluorescence spectrophotometry (XRF) mineralogical analysis indicated a notable oil content, specifically 0.225 % sodium and magnesium (> 0.010 %). The physico-chemical analyses revealed a refractive index of 1.4765 ± 0.04; an acid of 6 ± 0.19 mg KOH/g; a saponification of 244.6 ± 1.24 mg KOH/g and an ester index of 238.6 ± 1.59 mg KOH/g. Furthermore, the oil has an iodine index of 121.3 ± 1.14 g I_2/100 g; a peroxide of 6,70 ± 1.04 Meq O2/g; a specific gravity of 0.899 ± 0.01; an unsaponifiable content of 0.34 ± 0.02 %; a pH of 6.45 ± 0.3; an ultraviolet absorbance at 270 nm of 0.23 ± 0.01 and an estimated total polyphenol content of 0.19 ± 0.02 µg GAE/mg oil. The results obtained indicate that *Cucumeropsis mannii* oil has characteristics compatible with valorization in human food, notably due to its oxidative stability and richness in compounds of nutritional interest. In addition, its physicochemical properties position it as a potential alternative to conventional vegetable oils such as sunflower, palm, Ackee and soy oils. This study highlights the promising prospects for exploiting this oil in the food, pharmaceutical and cosmetics industries.

Keywords: *Cucumeropsis mannii*, seed oils; mineralogical composition, physicochemical properties, fatty acid profile

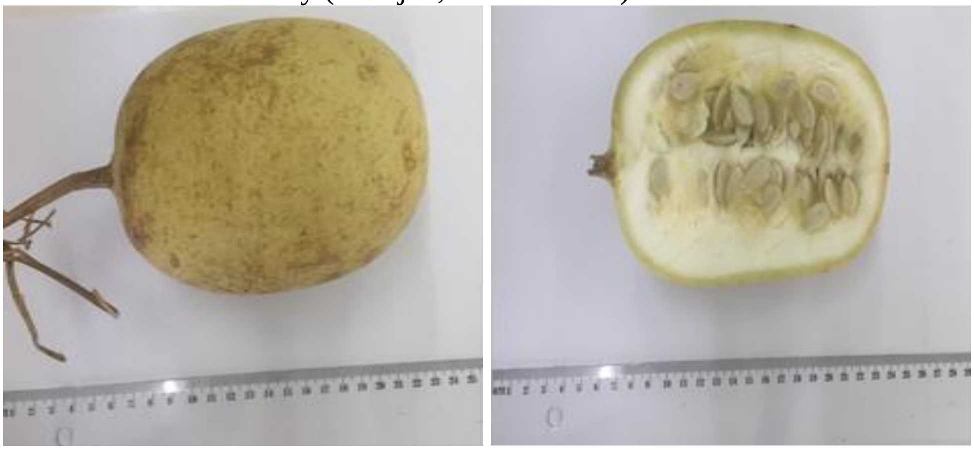
Introduction

The African flora constitutes an important reserve of plant resources exploited for centuries by local populations for food, traditional medicine and energy production as well as for artisanal and cultural uses (Van Wyk, 2020; Mekonnen *et al*., 2022; Kudamba *et al*., 2023).) Among the underutilized African vegetables with nutritional and economic value, *Cucumeropsis mannii* Naudin holds a significant position. This species, commonly known as¨ Gourd̈ in the Republic of Congo, ̇Egusï in Benin and Nigeria, and ̇Pistachioš in Côte d'Ivoire (Zoro Bi *et al.*, 2003), is a legume widely cultivated and consumed in several countries in West and Central Africa, notably in Benin, Nigeria, Côte d'Ivoire, Ghana, Cameroon and the Democratic Republic of Congo (Houdegbe *et al.*, 2016). Moreover, this plant is valuable not just for its edible uses, but also holds significance in the realms of cosmetics and energy, especially as a promising source for biodiesel production. (George *et al.*, 2010; Okwundu *et al.*, 2021). The seeds of *Cucumeropsis mannii* exhibit an exceptional nutritional profile, notably with a significant protein and lipid content, where the oily fractions can comprise over 40% of the dry matter. This nutritional richness holds potential benefits for enhancing food security and preventing protein-energy malnutrition (Nikiema *et al.,* 2024). Despite the presence of numerous vegetable oil sources in tropical zones, several oleaginous species remain inadequately exploited and valued, despite their nutritional, economic, and industrial potential (Ndlovu *et al.,* 2024; Mbyamungo *et al.,* 2025). It particularly pertains to *Cucumeropsis mannii* oil, whose nutritional and technological properties remain largely undocumented. In this context, the present study aims to contribute to the valorization of *Cucumeropsis mannii* oil through the determination of its mineral composition, physicochemical characteristics, and fatty acid profile, in view of its potential applications in the agri-food and therapeutic fields.

Material and methods

Plant material

Material for oil extraction, comprising the fruit of *Cucumeropsis mannii* (Figure 1A), includes husked and dried seeds (Figure 1B) at maturation.). This raw material was gathered from plots in an experimental field at Gueyo, which is part of the NAWA region in Côte d'Ivoire Raw materials were processed in the Biocatalysis Laboratory of Nangui ABROGOUA University (Abidjan, Côte d'Ivoire).



A : Fruit of *C. Mannii* B : Cross-section of the fruit of *C. Mannii*

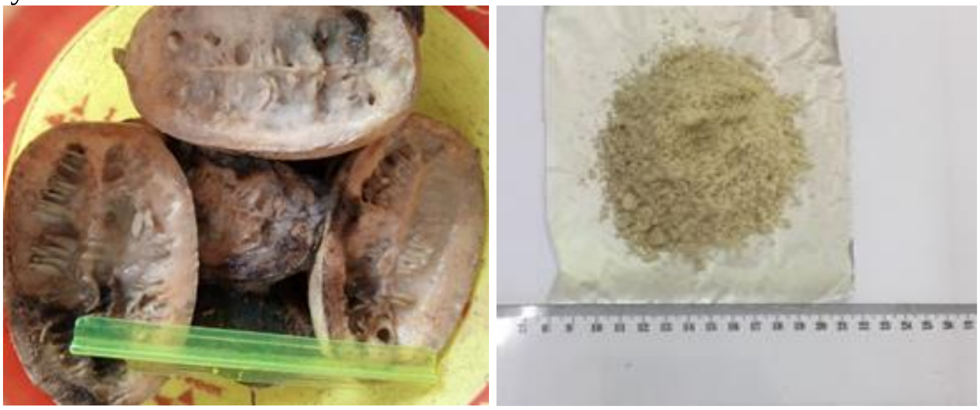
C : Seeds of *C. mannii*

Figure 1: *Cucumeropsis mannii* fruits and seeds

Methods

Method of extracting the seeds of *Cucumeropsis mannii* and producing the powder

Fruits of *Cucumeropsis mannii* were used in the process of flour manufacturing. The steps that led to obtaining the flour were as follows: after fermentation, the seeds extracted from the fermented fruit were mixed by hand and then rinsed with water to clean them. Subsequently, they were dried in an oven (35° C for 3 days) before being de-shelled to extract the almond. Extracted almonds were ground using a mixer (BINATONE, China). The final result was *Cucumeropsis mannii* powder (**Figure 2B**), sieved through a 250 µm sieve. The sample, sealed and capped, was then subjected to analysis at the Central Laboratory (LC), where it was extracted for oil and extensively studied for its physico-chemical properties, followed by mineral determination.



A : Fermented fruits of *C. Mannii* B : *C. mannii* powder mannii mannii

Figure 2 : Fermented fruits and powders of *C. mannii*

Process to obtain lime oil from *Cucumeropsis mannii* flour

The Soxhlet method **(**AOAC, 1995) with hexane utilized to extract the fat from *Cucumeropsis mannii* seed. The minerals were assessed by the Geochemistry Service of the National Oil Operation Company in Côte d'Ivoire (PETROCI) using an X-ray Fluorescence Spectrometer (XRF) on *Cucumeropsis mannii* oil.

Determination of the physico-chemical parameters of *Cucumeropsis mannii* oil

The moisture content in the fat of *Cucumeropsis mannii* has been assessed in accordance with ISO standard 662:2016. Saponification value, acid value, peroxide value and ester value of *C. mannii* were determined according to the (AOAC, 1995) method. Regarding the unsaponifiable matter of *C. mannii*, it extracted according to ISO 3596: 2000, while the total polyphenol content determined by colorimetry using Marigo (1973).

The content of fatty acids in the oil obtained from *Cucumeropsis mannii* seeds

Analyzing the fatty acids requires their conversion into methyl esters. The methyl esters of the samples were prepared by trans-esterification with sodium methylate according to the ISO 5509:2000 standard.

Statistical analyses

All determinations were carried out in triplicate; errors were recorded as standard deviation from the mean. Data were subjected to analysis of variance using STATISTICA 7.1 computer programme, while means were separated using New Duncan Multiple Range Test (NDMRT). Significance was accepted at 5% level of probability

Results And Discussion

The yield, color, and pH of *Cucumeropsis mannii* oil

The Soxhlet extraction of oil from *Cucumeropsis mannii* seeds resulted in a 48.01% yield (Table I), confirming the high oil content of this species. This value testifies to the potential of *Cucumeropsis mannii* as a vegetable oil alternative for culinary and agro-industrial uses (Okwundu *et al*., 2021). With a yield of 48.01%, the *Cucumeropsis mannii* oil obtained in this study shows a slightly higher lipid content compared to those reported by Okwundu *et al*., 2021 (46.1%) and Ezema *et al*., 2023 (40.8 %) in Nigeria; this is similar to 48.30 % obtained by Essien et al (2012) in Nigeria**.** This variability in yields could be explained by factors such as environmental influences, genotypes studied, geographic origins of seeds, maturity levels of grains, and experimental extraction conditions. Regarding the color of the oil extracted from the seeds of *Cucumeropsis mannii*, it is pale yellow (**table 1**); characteristics of many vegetable oils. This hue is typically linked to the presence of liposoluble natural pigments, notably the carotenoids. The findings of this study align with the color reported by Tibe et al. (2024) on oil derived from *C. manni* seeds in Botswana.

Table 1: Physical parameters of *C. mannii* oil

Parameters	***Cucumeropsis mannii***
extraction efficiency (%)	48.01
color	pale yellow
pH	6.45 ± 0.32

Figure 3 : *C mannii* oil

Mineralogical attributes of *Cucumeropsis mannii* oil

The mineralogical characteristics of *Cucumeropsis mannii* cucumber oil are presented in Table 2. The mineral analysis of the oil revealed a predominance of sodium (0.225 %), while magnesium, phosphorus, sulfur, potassium, and calcium are present in small amounts. The observed globally low mineral content in oil is consistent with the nature of the lipid substances. Indeed, during the extraction of oil, mineral elements generally remain associated with non-lipidic fractions of the seed, notably proteins and fibers, and are found in higher concentrations in residual meals. Recent studies on oleaginous by-products have shown that the main macroelements such as potassium, magnesium, phosphorus, sulfur, calcium, and sodium are mainly retained in oil cakes after extraction of the oil ((Vichare and Morya 2024 ; Hallouch *et al*., 2025). This outcome confirms the low mineral content typically noted in raw vegetable oils.

As for the trace elements, the *Cucumeropsis mannii* oil primarily includes iron at 0.0020 % and zinc at 0.0250 %. Despite some quantitative variations, these values are comparable to those reported in other studies on oils from tropical oilseeds. These differences are generally attributed to several factors, notably the soil and climate conditions, the mineral composition of the soils, the genotype of the plant, the stage of seed maturity as well as the extraction methods used (Tibe *et al.*, 2024). Furthermore, the inclusion of calcium, phosphorus, and magnesium, regardless of their low levels, improves the nutritional value of the oil. In fact, calcium and phosphorus are crucial for bone mineralization and the upkeep of skeletal integrity. A deficiency lasting a long time is linked to various bone disorders, particularly rickets in children and osteoporosis in the elderly (FAO/OMS, 2023; Aguemon, 2023). Magnesium is also a mineral of interest because of its involvement in more than 300 enzymatic reactions in the body. It is particularly involved in energy metabolism, neuromuscular transmission, heart function, and the maintenance of bone health. As per (FAO/OMS, 2023), adequate magnesium intake believed to help prevent a range of metabolic and cardiovascular issues. The detection of magnesium in *C. mannii* oil is of significant nutritional interest. Magnesium recognized as an essential cofactor in various enzymatic reactions and is crucial for bone health, neuromuscular function, and nervous system balance (Novidzro *et* al. (2019).

Table 2: Mineralogical results of *C. mannii* oil

Sign	Element	Level (%)
Na	Sodium	0,225
Mg	Magnesium	< 0,010
P	Phosphorus	0,004
S	Sulfur	0,002
Cl	Chlorine	-
K	Potassium	0,002
Ca	Calcium	0,001
Mn	Manganese	-
Fe	Iron	0,003
Cu	Copper	-
Zn	Zinc	-
I	Iode	0,005

- : in the form of traces

Physico-chemical parameters of the seed oil of *Cucumeropsis mannii*

Regarding the physico-chemical characteristics (**Table 3**), the saponification index of *Cucumeropsis mannii* oil is 244. 60 ± 1.24 mg KOH/g oil; which reflects a relatively high value compared to several vegetable oils commonly used in food. Moreover, the relatively high saponification index observed suggests a predominance of low molecular weight fatty acids. Indeed, according to Novidzro *et al.*, 2019, the higher the saponification index, the richer the oil is in short- or medium-chain fatty acids, which are easily hydrolyzed and quickly assimilated by the body. These characteristics give this oil potential interest both nutritionally and for certain industrial uses, particularly in the cosmetics and soap industry. The saponification value obtained in this study was higher than that reported for *Griffonia simplicifolia* oil (186.59 ± 063 mg KOH/g oil) by Novidzro et al. (2019) as well as the values ranges for sunflower seed oils (188-194 mg KOH/g oil), palm oils (190-209 mg KOH/g oil) and palm olein (194-202 mg KOH/g oil) (Tan *et al.*, 2021). However, this value remains relatively close to that reported by Tibe *et al.* (2024) for *Cucumeropsis mannii* oil in

Botswana (220.19 mg KOH/g). This characteristic could favor the use of *Cucumeropsis mannii* in the manufacture of soap, shampoos, and other cosmetic products, like certain vegetable oils and animal fats commonly used in the soap and cosmetics industries (Hoba *et al.*, 2018)

Regarding the acid value, *Cucumeropsis mannii* oil has a relatively low value of 6.00 ± 0.19 mgKOH/g oil. This corroborated by the work of Hoba *et al.*, 2018, for oil from roasted arils of *Blighia sapida* (Ackee) (6.28 ± 0.28 mg KOH/g oil). According to Tibe *et al.* (2024), the acceptable acid value limit for edible oils is ≤ 10 mg KOH/g oil, so the value obtained in this study suggests that *Cucumeropsis mannii* oil meets this quality criterion. The acid value is an indicator of the degree of triglyceride hydrolysis and reflects the free fatty acids present in the oil. It correspond to the amount of potassium hydroxide (KOH) expressed in milligrams, necessary to neutralize the free organic acids contained in 1 g of fat or oil. Low acid index values generally reflect low lipid degradation and are associated with better stability as well as a better preservation quality of the oil (El Diwani *et al.*, 2009 ; Igbalagh Chia, 2018)Thus, the low value of acid index observed in the present study indicates a good quality of *Cucumeropsis mannii* oil.

The peroxide index of *Cucumeropsis mannii* oil obtained is 6,70 ± 1.04 meqO2/kg; a value slightly higher than that reported by Nwoke *et al.* (2023) for the same species (2.95 meqO2/kg). This difference could be attributed to several factors, notably the conditions of seed storage and extraction processes. However, despite this variability, the peroxide value obtained remains low and below the maximum recommended limit for cold-pressed oils and virgin oils set at 15 meq O2/kg of oil (Tibe *et al.*, 2024). The peroxide index is an indicator of the primary oxidation of lipids and provides information on the degree of formation of hydroperoxides resulting from the oxidation of fatty acids. Thus, a low value reflects good oxidative stability of the oil at room temperature and low susceptibility to rancidity Igbalagh Chia, 2018. Also, oxidative rancidity leads to the alteration of the organoleptic and nutritional qualities of oils with the appearance of unpleasant odors and flavors. Therefore, the low peroxide value of *C.mannii* seed oil suggests that this oil has a good state of preservation and could be stored for a relatively long period without significant deterioration in its quality.

This study reports the refractive index of *C. mannii* to be 1.47 ± 0.04. This value is close to that reported by Azuaga et al. (2018), for mooring seed oil (1.4641 ± 0.0) suggesting a similarity in certain physicochemical characteristics of these oils. The refractive index is an important parameter for the characterization of vegetable oils. The value observed for *C. mannii* oil shows its good quality and relative stability. According to the work of some authors (Anwar et Rashid, 2007), oils with low levels of free fatty acids are generally more stable to oxidation and could therefore be recommended for seasoning salads and keeping longer.

The density of *Cucumeropsis mannii* oil is 0.90 ± 0.01. This value is comparable to that reported by Azuaga et al. (2018) (0.90 ± 0.00) for moringa seed oil. This result corroborates the fluid state of the studied oil. This proximity suggests similar physical characteristics and confirms the liquid state of the oil at room temperature.

The iodine index of *Cucumeropsis mannii* oil determined in this study is 121.30 ± 1.14 gI2/100g. This value is higher than that reported by Ezema *et al.*, 2023; who obtained an iodine index of 111.07 ± 0.15 gI2/100g for the same species during their work on the production of biodiesel from *C. mannii* seeds. This would mean that the oil from this study would contain a high content of unsaturated fatty acids. Indeed, the iodine index is an indicator of the degree of unsaturation of oils; and the higher its value, the greater the proportion of unsaturated fatty acids (Hoba *et al.*, 2018). Therefore, the oil from Cucumeropsis mannii is distinguished by a higher content of unsaturated fatty acids in comparison to saturated fatty acids. This composition gives it a certain nutritional interest, although it can also make it more sensitive to the phenomena of oxidations during storage.

The pH of the *C. mannii* oil obtained in this study is 6.45 ± 0.32, reflecting a weakly acidic character of this oil. However, this value is higher than that reported by the work of Essien et al (2012) (pH = 4.45). The differences observed could result from factors such as seed origin or storage conditions. However, the pH value obtained would suggest a low presence of acidic compounds in the analyzed samples.

As for the ester index in this study, the obtained rate is 238.60 ± 1.59 mgKOH/g, a value slightly lower than its saponification index (244.6 ± 1.36 mgKOH/g). These results corroborate the research work of Novidzro *et al.*, 2019, who reported in their studies on Griffonia simplicifolia seed oil (African black bean), an ester index of 163.50 ± 0.19 mg KOH/g compared to 186,59 ± 0.63 mg of KOH/g for the saponification value. The observed difference between these two parameters corresponds to the presence of free fatty acids in the oil. The value thus obtained suggests a moderate content of free fatty acids, indicating limited hydrolysis of triglycerides. However, in order to preserve the quality of the oil during storage and to limit spoilage phenomena that could affect its organoleptic properties and stability, preventive pre-refining, conditioning and preservation measures are recommended (Novidzro *et al.*, 2019).

Furthermore, the measurement of the ultraviolet absorbance at 270 nm revealed a value of 0.23 ± 0.01. According to the specifications described by CDRFoodlab®(n.d.) using the CDR OxiTester system, the accepted reference values for this parameter range from 0.02 to 1.57. However, the value obtained for *Cucumeropsis mannii* oil is within a compliance range, suggesting a low level of secondary oxidation. This result also shows good oil quality and limited deterioration of fatty acids, which is a favorable indicator of storage stability.

The polyphenol content in Cucumeropsis mannii oil, estimated at 0.19 ± 0.02 µg GAE/mg oil, suggests a relatively modest quantity of phenolic compounds. This value is lower than those reported for the fresh pulp of several cucurbita species, for which total phenolic content ranged from 62.91mg GAE / 100g FW in *cucurbita pepo* to 477.89 mg GAE/ 100g FW in *cucurbita moschita* (Stryjecka *et al.*, 2023). This observed difference could be explained by the nature of the analyzed matrix, phenolic compounds being generally more abundant in fresh plant tissues than in extracted lipid fractions. In addition, oil extraction processes can lead to a reduction in the amount of phenolic compounds transferred into the oily phase. Thus, the low content observed suggests that polyphenols contribute modestly to the antioxidant potential of *C manni* oil, which could also depend on other bioactive constituents such as tocopherols, carotenoids or certain minor lipophilic compounds. Indeed, vegetable oils contain various bioactive compounds (tocopherols, carotenoids, and phenolic compounds) whose antioxidant properties contribute to the oxidative stability and nutritional value of oils (Freitas *et al.*, 2025).

Lastly, the unsaponifiable portion of C manni oil amounts to 0.34 ± 0.02%, a figure notably lower than the values reported by Ketevi *et al.* (2015) (1,90 %). This low unsaponifiable content indicates that C manni oil is predominantly composed of saponifiable fatty acids, which is consistent with its high saponification index and suggests its potential ability to produce soap and other oleochemical derivatives.

Table 3: Physico-chemical parameters of *C. mannii* seed oil

Parameters identified	**Oil from *C. mannii***
Saponification index (mgKOH/g)	244.60 ± 1.24
Peroxide index (MeqO2/Kg)	6.70 ± 1.04
Acid index (mgKOH/g)	6.00 ± 0.19
Ester index (mgKOH/g)	238.60 ± 1.59
Absorbance in the ultraviolet at 270 nm	0.23 ± 0.01
Iodine index (mg d'iode / 100g)	121.30 ± 1.14
Refractive index	1.47 ± 0.04
Specific gravity	0.90 ± 0.01
Unsaponifiable content (%)	0.34 ± 0.02
Total polyphenols µg GAE/mg oil	0.19 ± 0.02

Fatty acid profile

The result of the fatty acid profile presented in **Table 4** is mainly composed of a high proportion of omega 9 fatty acid (oleic acid: 53.80 ±

0.15 %), followed by omega 6 fatty acid (linoleic acid: 29.60 ± 0.21%); with varying proportions of stearic, palmitic, and linolenic acids, palmitoleic acid and myristic acid. The fatty acid profile obtained in this study is globally comparable to that reported by Ketevi et al. (2015), who have also identified myristic, palmitic, stearic, oleic, linoleic, and linolenic acids in *C. mannii* oil, as well as the work of Adome et al. (2022)within the oils of *Ricinodendron heudelotii*, *Vitex doniana*, and *Cleome gynandra*. However, contrary to our results, these first authors highlighted the presence of arachidonic and gadoleic acids, while palmitoleic acid was not detected in *C mannii* oil. As part of their work, the fat was extracted from the flours of the seeds using hexane in an automatic Soxhlet extractor.

The total percentage of fatty unsaturated obtained in *C manni* seed oil (84.10 ± 0.10 %) in this study is comparable and slightly higher than the values reported for Lagenaria siceraria and Cucumeropsis mannii seed oils in Nigeria, (73.17- 81.31%) (Ogunbusola *et al*. 2017). The notable presence of unsaturated fatty acids in *Cucumeropsis mannii* oil contributes significantly to its nutritional value. Indeed, data from the literature indicate that saturated fatty acids tend to increase LDL cholesterol concentrations, while their replacement by polyunsaturated fatty acids helps reduce LDL cholesterol, a major marker of cardiovascular risk (Sacks *et al*., 2017). This observation is also in agreement with the work of Houdegbe *et al.* (2016), who reported that *C. manni* oil is characterized by a high proportion of polyunsaturated fatty acids, notably linoleic acid (63%), followed by oleic acid (16%). As an essential fatty acid, linoleic acid cannot be synthesized by the human body, thus it must be ingested through food. Given its high content of unsaturated fatty acids, oil could boost its nutritional profile, notably in enhancing cell membrane integrity and supporting cardiovascular health (ANSES, 2022). In addition, these essential fatty acids such as oleic, linoleic, and stearic acids, as well as omega-6 fatty acids, which are the main components of *C. mannii* seeds, according to some authors, have antimicrobial, antioxidant, and antiinflammatory, which explains their therapeutic potential against infections such as gastrointestinal infections, infertility, oxidative damage (Nwozo *et al*., 2023). Conversely, the predominance of unsaturated fatty acids found in the oil of *C. mannii* is consistent with the characteristics of edible vegetable oils as observed. Indeed, vegetable oils predominantly consist of mono-unsaturated and polyunsaturated fatty acids, particularly oleic acid and linoleic acid, with saturated fatty acids being in much lower amounts (Orsavova *et al*., 2015). The high concentration of unsaturated fatty acids is seen as beneficial for nutrition and enhances the nutritional value of vegetable oils. Furthermore, these differences observed between the chromatographic profiles could be attributed to several factors, notably the soil and climate conditions of cultivation, the geographical origin of the samples, the degree of maturity of the seeds and the extraction methods and solvents used. Tibe *et al.*, 2024 also reported such variations, emphasizing the substantial impact of these parameters on the fatty acid content of vegetable oils.

Table 4: Fatty acid profile of *C. manni* oil

Lipid components (g/ 100g)	***Cucumeropsis mannii* oil**
Acide Myristique (C14 :0)	0.10 ± 0.01
Acide Palmitique (C16 : 0)	6.40 ± 0.13
Acide Stéarique (C18 : 0)	9.10 ± 0.18
Acide Oléique (C18 : 1)	53.80 ± 0.15
Acide Linoléique (C18 :2)	29.60 ± 0.21
Acide Linolénique (C18 :3)	0.40 ± 0.03
Acide Palmitoléique (C16 :1)	0.30 ± 0.01
Total satured fatty acid (%)	15.60 ± 0.11
Total unsatured fatty acid (%)	84.10 ± 0.10

Conclusion

This investigation enabled the characterization of the physicochemical attributes, mineral content, and fatty acid profile of the oil produced from *cucumeropsis mannii* seeds. The results obtained reveal that this oil is an interesting source of unsaturated fatty acids, particularly linoleic and linolenic acids, as well as minerals such as sodium and magnesium, recognized for their importance in various physiological functions. The physicochemical parameters obtained also demonstrate the quality of this oil and its potential for food use. Thus, *C manni* appears as a promising oilseed resource whose valorization could contribute to the diversification of vegetable oil sources and the promotion of food resources. However, additional studies into oxidative stability and their functional properties might be warranted to evaluate their nutritional and technological potential.

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