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Research Article

High Food Potential Seeds: Physicochemical Composition of Cucurbit Cultivars in Ivory Coast

Nikiema Diakaridja[1, 2, *], Dosso Ouehi[2], Valentin Romain[1], Lacroux Éric[1], Cerny Muriel[1], Mouloungui Zéphirin[1], Koua Oi Koua[2]

[1]Laboratory of Agro-Industrial Chemistry, National Polytechnic Institute-National Higher School of Engineers in Chemical and Technological Arts, Toulouse, France

[2]Laboratory of Constitution and Reaction of Matter, Unity of Formation and Research Science of Structure Matter and Technology, Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire

Abstract

The richness in protein and oil of curcubit seeds is highly coveted in the food field. In addition, in the cosmetics industry, it is a very popular ingredient. The oils of these seeds contain a diversity of fatty acids that can be advantageous during topical application. This study evaluated the physicochemical properties of the seeds and seed oils of five cucurbits (*Cucumeropsis Mannii, Citrullus colocynthis, Cucumis Melo, Citrullus mucosospermus, and Citrullus lanatus*) cultivars cultivated in Ivory Coast. Analysis of free fatty acid composition revealed a high linoleic acid content ranging from 24 and 70%. As well as the presence of α-linolenic acid (6.8 - 8.6%) and γ-linolenic acid (7.3 - 8.2%) in Citrullus colocynthis and Citrullus mucosospermus oils. The water and dry matter contents of the kernels vary between 3 and 4% and between 96 and 97%. The kernels of these cucurbits are rich in protein, with a high content of 25.9 ±0.4% for Cucumeropsis Mannii, 29.0 ±1.2% for Citrullus *colocynthis*, 24.1 ±0.6% for *Cucumis* Melo, 24.8 ±0.5% for *Citrullus mucosospermus* and 25.5 ±0.4% for *Citrullus lanatus.* The quantity of lipids extracted by the Soxhlet method varied from 42 to 55%. These lipids have low acidity levels varying between 1.13 ±0.1 to 2.01 ±0.3% with densities of approximately 0.92 ±0.01. The iodine values determined for these oils vary between 114.23 ±0.2 to 122.15 ±0.3. As for the saponification index, they are between (190 to 202 mgKOH/g).

Keywords

Cucurbit, Cultivar, Linoleic Acid, α-linolenic Acid, γ-linolenic Acid

1. Introduction

Oilseeds are an essential source of molecules of interest (fatty acids and proteins) in human and animal food and are also essential in various industries [1-3]. Indeed, the seeds of these plants are both rich in oil (lipids) and proteins.

Today, the worldwide production and availability of oilseeds and protein crops contribute to food security. Scientific studies carried out on the nutritional values of certain seeds show that they are industrial crops. Examples include soybean, rapeseed, sunflower, and chia seeds. These seeds therefore provide diversified sources of nutrients (oils, flours,

*Corresponding author: nikiema1978@outlook.fr (Nikiema Diakaridja)

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proteins, and other derived products).

In Ivory Coast, there are several species of oil-producing plants, so seeds are produced on a small scale for local consumption. Cucurbits are a good example; They are traditionally grown for food purposes in certain regions of the country [4, 5].

According to some studies, cucurbits rank among the world's most economically important crops. They are grown in temperate and tropical regions, and therefore in different parts of the world [6, 7]. Cucurbit crops are thus less sensitive to climatic shocks (water and heat stress) or problems linked to production in a single geographical area.

In Ivory Coast, cucurbits are commonly known as pistachios. Cucurbits are generally grown by women in rural areas using permaculture and crop rotation. Pistachio plants are combined with other crops such as yams, maize, okra, chilies, and cassava on small plots. Almonds are produced in small quantities by the traditional fruit processing method.

Part of this production is destined for domestic use by the growers, while the rest is sold on local markets. The almonds extracted from the seeds are usually made into a paste for sauces [8]. These almonds are highly prized by the local population in production areas and in some of Côte d'Ivoire's major cities. Among these cucurbits, the best known and used for dishes are Cucumeropsis Mannii, Citrullus colocynthis, Cucumis Melo, Citrullus mucosospermus, and Citrullus lanatus.

Table 1 lists the vernacular names of these cucurbits in the central-eastern and central regions of Côte d'Ivoire.

Table 1. *Common name for cucurbits in "Akan" country.*

The common name "Baoulé and Agni language"	Scientific name of plant species
N'vièlè	Cucumeropsis Mannii
Bébou	Citrullus colocynthis
Lomi n'gatè	Cucumis Melo
Bèdie bissa	Citrullus mucosospermus
Wèrèwèrè	Citrullus lanatus

The use of pistachio kernels is closely linked to people's eating habits. Traditionally, among the Akan people in Ivory Coast, it is a delicacy, a high-quality food, offered during exceptional events (traditional festivals and ceremonies).

The existing pistachio cultivars in Côte d'Ivoire are traditional, unimproved varieties. However, they have a high seed yield. These plants adapt to different climatic conditions and the seeds have excellent storage capacity [4, 5, 9, 10].

Cucurbit plants and seeds have been the subject of several scientific studies in recent years. Studies of almonds extracted from seeds have reported an oil content of 12 to 50%, depending on the extraction technique used and the species [8, 11]. These are potentially important natural oil resources, due to the high oil content of these seeds. These oils, extracted from cucurbit seeds, contain mainly linoleic, oleic, palmitic, and stearic acids.

In general, the conventional sources of vegetable oils used in Ivory Coast are palm seeds, shea butter, and cottonseed oil, as well as imported oils (olive, peanut, sunflower, and rapeseed). oils no longer meet needs due to increasing demand for domestic and industrial purposes. Therefore, research is being carried out to identify new lipid resources to meet the growing demand of populations and food industries.

The present study was undertaken to determine the properties of the constituents of five species of cucurbits produced in Ivory Coast, the seeds of which are traditionally used as culinary thickeners. In particular, it is a comparative study of the chemical composition (protein content, oil content, fatty acid profiles) and physicochemical properties (saponification index, iodine index, acid index) of oils obtained from almonds produced traditionally.

2. Material and Methods

2.1. Material

The pistachio seeds used in this study come from Daoukro, a locality in the Iffou region of Ivory Coast, West Africa. The fruits were collected during August 2016. The seeds were extracted from the fruit pulp by hand after six to seven days of fermentation and dried in a ventilated shelter for a week. The seeds were then frozen and stored in bulk freezer bags at +4 ℃ until transport to the agro-industrial chemistry laboratory in Toulouse, France; they were then stored in a cold room at +4 ℃.

Table 2 lists the species studied and the seed masses obtained after fruit processing.

Table 2. *The five species of cucurbits.*

Plant species	Coding	Quantity of dried seeds (g)
Cucumeropsis Mannii	*Cma*	*2058.41*
Citrullus colocynthis	*Cco*	*1850.55*
Cucumis Melo	*Cme*	*2134.53*
Citrullus mucosospermus	*Cmu*	*1911.53*
Citrullus lanatus	*Cla*	*1721.87*

2.2. Seed Extraction Methods

Generally speaking, the seeds of the plant species studied consist of a kernel surrounded by an envelope. The seeds are inside a berry whose shape varies according to the species.

The most used technique to separate the seeds from the berry is traditional processing, carried out in three stages. Firstly, the fruits (each species) harvested by collection are crushed using a piece of wood. The second stage is fermentation, the fruits are fermented in a 30-liter round stainless-steel bowl for a week under regular control. This process allows the fermentation of cracked fruit berries to facilitate their extraction. The final step is to release the seeds by hand and wash the fermented fruit with water.

2.3. Extraction of Oil from Cucurbit Almonds

Depending on the quantity and quality of oil required for analysis, we extracted the oils from these kernels using two oil extraction methods. We extracted total lipids in the solvent with a Soxhlet extractor for oil content measurements. The oil used for chemical and physicochemical characterization was cold extracted from cyclohexane. The various lipid extractions obtained by solvent were carried out at least three times.

2.3.1. Solvent Extraction of Lipids by Soxhlet

A mass of 15 grams of almonds of each species is crushed and placed in a cartridge and placed in the soxhlet extractor. Using 150 ml of cyclohexane contained in a 200 ml flask, the fat contained in the ground material is exhausted by heating the solvent (approximately 85 ℃). The heating is stopped after six (6) hours. The oil is obtained after evaporation of the solvent on a rotary evaporator at 40 ℃ under vacuum at 200 mbars.

2.3.2. Cold Extraction in Cyclohexane

A 5 g mass of kernels of each species ground in a blade mill was placed respectively in a 30 ml centrifuge tube with 25 ml cyclohexane. The tubes were swirled for 30 s and then centrifuged for 15 min at 10,000 × g. The supernatant was decanted and the phase (lipid material) was recovered. This process was repeated three times. All of the collected organic phases were combined and filtered through a funnel containing fiberglass filter paper on which a few grams of anhydrous sodium sulfate was placed. The oil is obtained after evaporation of the solvent on a rotary evaporator at 50 ℃ under vacuum at 200 mbars.

2.4. Determination of Protein Content of Meal

The method used is an indirect method which consists of determining the percentage of nitrogen (% N) by the Kjeldahl method according to standard NF V 18-100 revised 2014. The Kjeldahl method consists of mineralizing the organic nitrogen contained in the sample in the form of ammonia and then dosing it with an acid [12].

For mineralization, 0.8 g of dried and defatted oilcake is placed in a glass tube to which 12.5 ml of 95% concentrated sulfuric acid has been added. The mixture is put under a host for 16 hours. After 16 hours, two catalyst tablets are introduced into the tube. The mixture is then mineralized at 400 ℃ for 1 hour. Finally, the analysis is carried out by a KjeltecTM 8400-type analyzer.

2.5. Determination of oil Indices

The determination of the acid and iodine indices and the acidity was done by volumetric dosage methods following the standard protocols: NF EN ISO 3961 for the iodine index, NF EN ISO 660 for the acid index and acidity, and NF EN ISO 3657 revised in 2020 and 2023 for the saponification index. The determination of acidity was carried out by the theoretical method based on the fatty acid profile of the oil of each species.

2.6. Determination of Moisture and Fiber Content

The humidity level was determined according to the AOAC method (2005). 2g of ground material of each species obtained after grinding the almonds is placed in a previously tared watch glass. The samples are placed in an oven (Memmert) at 103 ±3 ℃ until a constant mass is obtained. The determination of the fibers was carried out by difference calculation.

2.7. Fatty Acid Profile by GC

The fatty acid profile of the oils was carried out following the Schulte method [13]. The oil (15 mg) was solubilized in 1 ml of TBME (Tert-Butyl Methyl Ester), after methylation using TMSH, the fatty acid methyl esters obtained are analyzed by GC. The gas chromatograph used is of the Varian 3900 type; 1 µl of the previous solution is injected into this chromatograph with the following parameters: Injector in split mode, a ratio of 1/100, 250 ℃ (55 min). CP-Select CB for FAME fused silica WOCT type column, 50 mx 0.25 mm, film thickness 0.25 µm. Carrier gas: helium with a flow rate of 1.2 ml/min. Oven temperature: initial 185 ℃ for 40 minutes, then increased by 15 ℃/min to 250 ℃ and maintained at 250 ℃ for 10.68 min. The identification of fatty acid methyl esters was based on the retention times obtained for a mixture of methyl esters using commercial standards Mix 37 (Sigma Aldrich).

3. Results and Discussion

3.1. Cucurbit Seeds in Côte d'Ivoire

In Côte d'Ivoire, cucurbit fruits (the cultivars studied) are generally harvested after the plant stems have wilted. The cultivation of these cucurbits is carried out on almost the entire territory. This culture is done informally and marginally. There is therefore no structured sector yet. The quantity of almonds harvested per year nationally therefore remains undetermined. However, almost all of this activity, namely growing plants, harvesting and processing fruits, as well as sales, is carried out individually by women in different regions of the country.

Almonds obtained from cucurbit fruits are almost exclusively intended for consumption by the local population. However, part of this production is intended to supply the markets of the large cities of Côte d'Ivoire (Abidjan, Yamoussoukro, Man, San Pédro, and Bouaké) for reasons of profitability and strong demand. Indeed, these almonds are very popular with the population and represent a delicacy, which explains this high demand as well as the high cost of these almonds. On Adjamé market, Abidjan, the price charged is around 2000 CFA Francs (equivalent to 3 Euros) for 100 grams of peeled cucurbit almonds. Among the five cultivars found in Ivory Coast (*Cucumeropsis Mannii, Citrullus colocynthis, Cucumis Melo, Citrullus lanatus, and Citrullus mucosospermus*) the best known are *Cucumeropsis Mannii and Citrullus lanatus.* This is explained by the fact of the abundant bioavailability of the seeds of these two cultivars as seeds.

3.2. The Composition of Almonds from Cucurbit Seeds

Table 3 presents a distribution of the contents of the kernels of the five species obtained by the traditional processing method of shelling. A commonly used method to isolate almonds from seeds in rural areas. The water and dry matter contents of almonds are respectively between 3 to 4% and between 96 to 97%. We note a slight variation in these contents. According to Fellows et al., (2000), humidity is a very important factor in the study of raw materials. This parameter gives an idea of the duration for which a raw material can be stored without molding [14]. These results clearly show that, whatever the species studied, the water and dry matter content does not vary significantly. Drying of these seeds was done easily under optimal conditions.

These values of water and dry matter contents therefore ensure good quality, better conservation, and processing of the seeds studied for food safety. This could explain the good conservation of these almonds by women in production areas and on markets for sale. Almonds are stored in bulk in unshelled food bags. They are kept in kitchens in a dry place, away from light and humidity for around 3 years. On the other hand, on the markets, almonds are sold either shelled and/or crushed to facilitate their use.

Table 1. *Contents of almond constituents of the five species.*

Content of constituents %	*Cucumeropsis Mannii*	*Citrullus colocynthis*	*Cucumis Melo*	*Citrullus mucosospermus*	*Citrullus lanatus*
Humidity level	3.9±0.1	3.4 ±0.2	3.1 ±0.2	3.5±0.1	3.6±0.3
Dry matter	96.1±0.3	96.6 ±0.1	96.9 ±0.1	96.5±0.2	96.4±0.3
ash	2.3±0.2	3.4 ±0.3	5±0.2	1.8±0.1	1.2±0.3
Fiber	24.7±0.1	9.0 ±0.2	25.4±0.3	27.7±0.3	17.0±0.0
Protein	25.9±0.4	29.0 ±1.2	24.1±0.6	24.8±0.5	25.5±0.4
Oil (soxhlet)	43.2±0.2	55.2 ±0.5	44.9±0.3	42.2±0.2	52.7±0.1
Oil color	Yellow	Light yellow	Yellow	Green	Yellow

The fiber content of almonds is 24.7% for *Cucumeropsis Mannii*, 9% for *Citrullus colocynthis*, 25.4% for *Cucumis Melo*, 27.7% for *Citrullus mucosospermus*, and 17% for *Citrullus lanatus*. These values indicate that the kernels of pistachio cultivars are rich in fiber, the intake of which in the diet would be beneficial. These fibers have a favorable effect on intestinal and digestive transit. In addition, they have a high protein content, i.e. 25.9 ± 0.4% for *Cucumeropsis Mannii*, 29.0 ± 1.2% for *Citrullus colocynthis,* and 24.1 ± 0.6% for Cucumis Melo 24.8 ±0.5% for *Citrullus mucosospermus* and 25.5 ±0.4% for *Citrullus lanatus*.

The protein content of *Citrullus colocynthis* kernels is consistent with the protein content of 29% reported by Al-Khalifa and al, (1996) [8]. As for the values of the protein content of *Cucumeropsis Mannii* (25.9 ± 0.4) and *Citrullus lanatus* (25.5 ±0.4%), they are similar to those determined by N'Goran and al (2015).) and by the Taiwo team [15, 16].

However, some studies report varying amounts of protein content in cucurbit almonds. Thus, regarding *Cucumis Melo* almonds, the protein content varies between 21.05% ±0.01 and 36.30% ±3.06 according to the following studies [17-21].

The crude proteins of the seeds studied compare favorably to the proteins of high-protein seeds and almonds such as *Ricinodendron heudelotii* (21%), *Vigna unguiculata* (cowpea) (18.2% to 30.4%), and soybeans (35%). %) [1, 22-24].

According to these results, whatever the almond used, the quantity of lipids extracted by the Soxhlet method is between 42 and 55% by mass of the contents of the almond. The lipid content of these almonds is 43.2 ±0.2, 55.2 ±0.5, 44.9 ±0.3, 42.2 ± 0.2, and 52.7 ± 0.1% respectively for *Cucumeropsis*

Mannii, *Citrullus colocynthis*, *Cucumis Melo*, *Citrullus mucosospermus* and *Citrullus lanatus*. Similar results were obtained by N'Goran and al. (2015) and Atef Abd El-Rahman and al. (2022) These authors report oil extraction rates by the Soxhlet method of 51% for *Cucumeropsis Mannii* and 47.22% for *Citrullus lanatus* almonds.

The results obtained for protein content and lipid extraction rate clearly and unambiguously indicate that the seeds of these five cucurbit species can be considered oilseeds. These seeds therefore constitute a good source of lipids, proteins, and fiber. According to studies by Loukou and al., (2007); Enzonga-Yoca and al., (2011); Koffi and al., (2013) cucurbits are cultivated for seed consumption because they are rich in lipids (60%) and proteins (30%) [25-27].

Cucurbit seeds are edible and have already been introduced into the eating habits of the population. They are more popular than groundnuts in central, eastern, and northern Côte d'Ivoire. Given their richness in essential nutrients, these seeds could be used in the formulation of food for humans as well as for livestock (poultry, cattle, fish, and rabbits).

3.3. Physicochemical Characterization of Oils

Table 4 summarizes the results for acid value, acidity, iodine value, saponification value, and density for oils extracted from kernels obtained from seeds using the traditional processing method. The free fatty acid value (Acidity) of the oil sample ranged from 1.13±0.1 to 2.01±0.3%. Determining this value is an important factor in oil quality control, as the lower the acidity value, the better the oil quality. The low levels of free fatty acids in our various oils indicate good stability. This may explain why oil-rich pistachio pastes sold in big city markets keep so well.

The densities of the oil samples obtained are almost identical, ranging from 0.92 ±0.0 to 0.93 ±0.3.

Table 4. *Physicochemical characteristics of oils from five cucurbit species.*

Physical characterization of oils	***Cucumeropsis Mannii***	***Citrullus colocynthis***	***Cucumis Melo***	***Citrullus mucosospermus***	***Citrullus lanatus***
Acid number	0.4 ±0.0	0.0 ±0.0	0.3 ±0.1	0.2 ±0.2	3.7±0.1
Acidity (%)	1.72 ±0.0	1.23±0.2	2.01±0.3	1.13±0.1	1.82±0.4
Iodine index	115.78 ±0.2	120.70±0.1	117.27±0.2	122.15±0.3	114.23±0.2
Saponification index (mgKOH/g)	191.09 ±0.3	201±0.5	195.92±0.4	199.6±0.2	192.50±0.3
Density (g/ml at 25 °C)	0.92±0.3	0.93±0.1	0.92±0.0	0.93±0.3	0.92±0.2

The iodine index values obtained here confirm those reported in previous studies. According to studies by Oluwatoyin and Zhana and colleagues, this value is about 117 for *Cucumis Melo* oil [18, 21].

In this study, the iodine index values of oils extracted from the kernels of the five pistachio species varied slightly from 114.23 ±0.2 to 122.15 ±0.3.

On the iodine index reference scale, the experimental values determined (see Table 4) are between 90 and 130. These oils are therefore semi-drying. The lower the iodine value, the lower the degree of unsaturation, and the less the oil oxidizes and dries when exposed to open air. These semi-drying oils therefore form a more flexible, sticky film in contact with air. They can be used in applications where a certain degree of flexibility is required. They can therefore be used to formulate paints, varnishes, cosmetics, and soaps.

The saponification value of *Citrullus colocynthis* (201 ±0.5 mgKOH/g) and *Citrullus mucosospermus* (199.6 ±0.2 mgKOH/g) kernel oils is higher than that of *Cucumeropsis Mannii* (191.09 ±0.7 mgKOH/g), *Cucumis Melo* (195.92 ±0.4 mgKOH/g) and *Citrullus lanatus* (192.50 ±0.3 mgKOH/g). These results are similar to those of Mabaleha and al. (2007) and Anhwange and al, (2010) who place the saponification index of cucurbit oils in a range of (182.1 - 203.4 mgKOH/g) [28-30].

These values are therefore good indicators for cosmetics formulators to calculate the exact amount of base (NaOH or KOH) needed to saponify a specific quantity of oil in a formulation.

3.4. Fatty Acid Composition of Oils

The fatty acid profile of the triglycerides present in the kernel oils of the pistachio cultivars studied is presented in Table 5. Three groups of fatty acids were detected: saturated fatty acids (myristic, pentadecylic, palmitic, and stearic acid), monounsaturated fatty acids (cis-vaccenic and oleic acid) and polyunsaturated acids (linoleic, linoleic, α- and γ-linolenic acid).

Table 5. *Fatty acid profile of oil extracted from cucurbits.*

Fatty acid profit	*Cucumeropsis Mannii*	*Citrullus Colo-cynthis*	*Cucumis Melo*	*Citrullus mucoso-spermus*	*Citrullus Lanatus*
C14:0 myristic acid	0.1 ±0.1	ND	1.0 ±0.1	ND	0.5±0.1
C15:0 pentadecylic acid	ND	ND	0.3±0.0	ND	0.1±0.0
C16:0 palmitic acid	12.9±0.0	15.4±0.0	9.5±0.0	21.7±0.1	16.2±0.0
C18: 0 stearic acid	6.8±0.0	9.6±0.0	10.5±0.1	9.7±0.0	8.7±0.1
saturated fatty acids	19.8±0.1	25±0.0	21.3±0.2	31.4±0.1	25.5±0.1
C18:1n9c oleic acid	8.9±0.1	14.5±0.1	10.9±0.0	26.8±0.0	26.1±0.0
C18:1n7c cis-vaccenic acid	ND	ND	ND	0.9±0.1	ND
Monosaturated fatty acids	8.9±0.1	14.5±0.1	10.9±0.0	27.7±0.1	26.1±0.0
C18:2n6t linolelaidic acid	1.7±0.0	ND	ND	ND	1.5±0.0
C18:2n9c linoleic acid	69.6±0.1	46.4±0.0	66.8±0.0	24.1±0.0	46.9±0.1
C18:3n3 γ-linolenic acid	ND	7.3±0.0	1.0±0.1	8.2±0.0	ND
C18:3n3 α-linolenic acid	ND	6.8±0.1	ND	8.6±0.1	ND
Polyunsaturated fatty acids	71.3±0.1	60.5±0.0	67.8±0.1	40.9±0.1	48.4±0.2

Based on the different free fatty acid profiles shown in Table 5. Oils can be divided into two groups. On the one hand, we have oils rich in linoleic acid, namely *Cucumeropsis Mannii*, *Cucumis Melo*, and *Citrullus lanatus* oils. The spectra of the fatty acid profiles of the oils in this group are shown in diagrams 1, 2, and 3. Secondly, oils rich in both linoleic and linolenic acids, namely *Citrullus colocynthis* and *Citrullus mucosospermus* oils, are shown in diagrams 3 and 4.

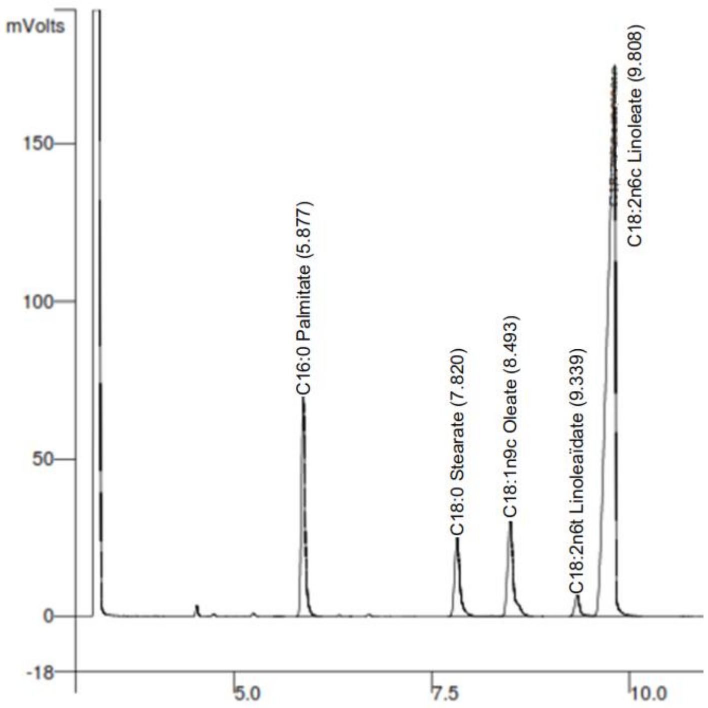

Figure 1. *Fatty acid profile spectrum of Cucumeropsis Mannii oil.*

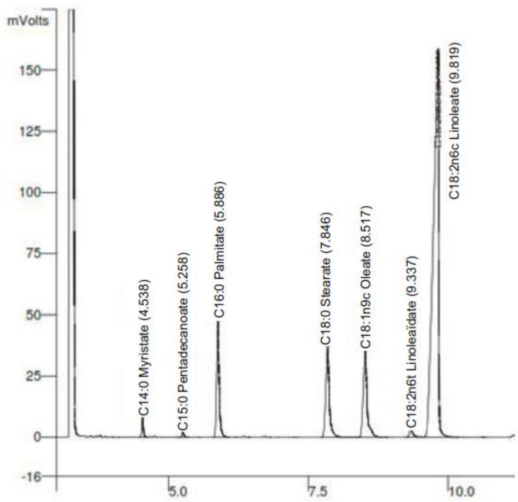

Figure 2. Fatty acid profile spectrum of Cucumis Melo oil.

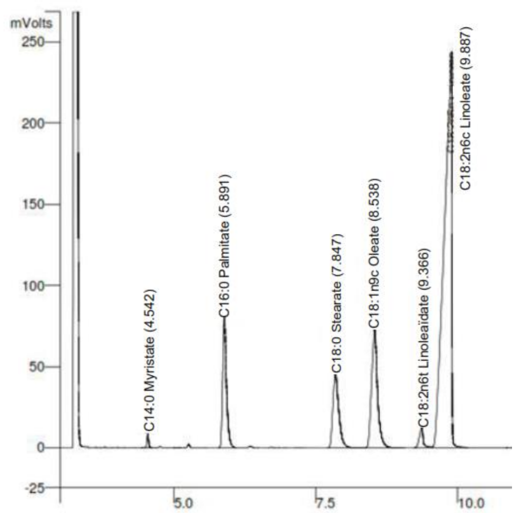

Figure 3. Fatty acid profile spectrum of Citrullus lanatus oil.

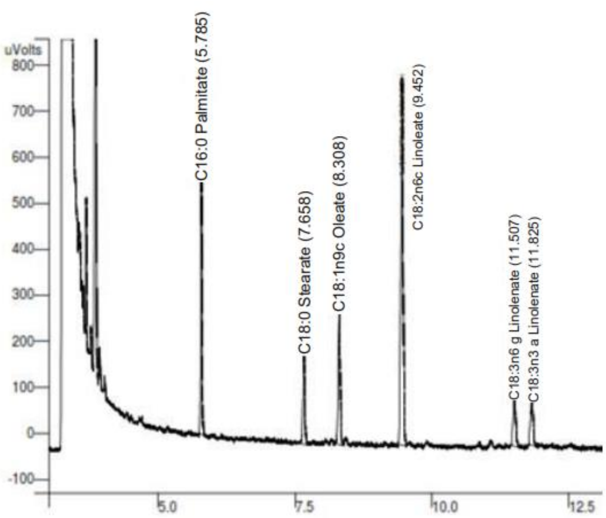

Figure 4. Fatty acid profile spectrum of Citrullus colocynthis oil.

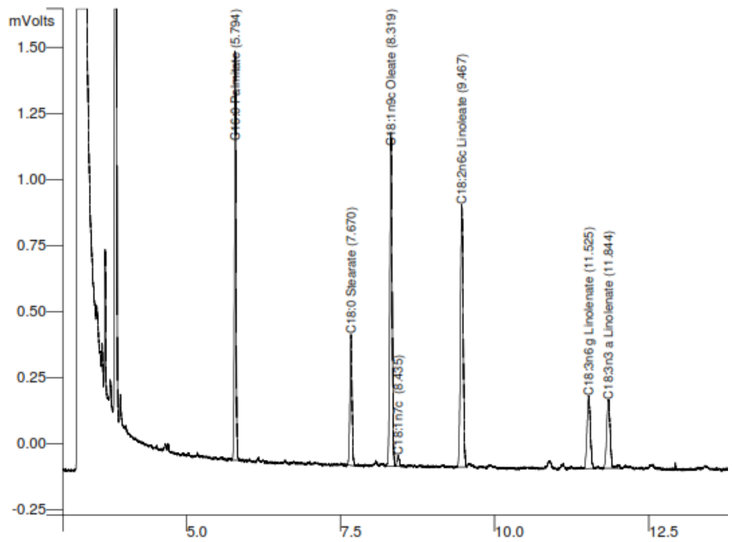

Figure 5. *Fatty acid profile spectrum of Citrullus mucosospermus oil.*

For the first group, the results show that the major fatty acid in *Cucumeropsis Mannii* almond oil is linoleic acid at 69.6 ±0.1%. The other fatty acids identified were palmitic (12.9 ±0.0%), stearic (6.8 ±0.0%), and oleic (8.9 ±0.1%).

The fatty acid profile of *Cucumis Melo* almond oil is similar to that of *Cucumeropsis Mannii*, with linoleic acid at 66.8 ±0.0%. The proportion of other acids is 10.9 ±0.0% oleic acid, 10.5 ±0.1% stearic acid, 9.5 ±0.0% palmitic acid, and 1.0 ±0.1% myristic acid. Compared with *Cucumeropsis Mannii* and *Cucumis Melo* oils, *Citrullus lanatus* oil is composed mainly of linoleic acid (46.9 ±0.1%), oleic acid (26.1 ±0.0%), palmitic acid (16.2 ±0.0%) and stearic acid (8.7±0.1%).

These results are in line with several reported studies. These studies show that *Citrullus lanatus* and *Cucumis Melo* kernel oils contain linoleic acid as a major compound. [21, 31, 32]. According to Lawal and al. (2012) and Komane et al. (2017) *Citrullus lanatus* almond oil has linoleic acid (43.3-51.4%), oleic acid (37.36%), palmitic acid (6.3-16.74%) and stearic acid (0.01-5.6%) as its main fatty acids.

Results for the second group show that *Citrullus colocynthis* oil is predominantly composed of linoleic acid at 46.4±0.0%. Other fatty acids identified are palmitic (15.4 ±0.0%), stearic (14.5±0.0%), and oleic (8.9±0.1%). We also note the presence of γ-linolenic and α-linolenic acid with values of 7.3±0.0% and 6.8 ±0.1% respectively. In *Citrullus mucospermus* oil, the main fatty acids are oleic acid (26.8±0.0%), palmitic acid (21.7±0.1%), linoleic acid (24.1±0.0%), stearic acid (9.7±0.0%), γ-linolenic acid (8.2±0.0%), and α-linolenic acid (8.6±0.1%). The oils in this group are a natural source of linoleic acid (LA), γ-linolenic acid (GLA), and α-linolenic acid (ALA). Figure 6 shows the essential fatty acid composition of the oil from the five cucurbits, in comparison with some widely consumed oils in Côte d'Ivoire.

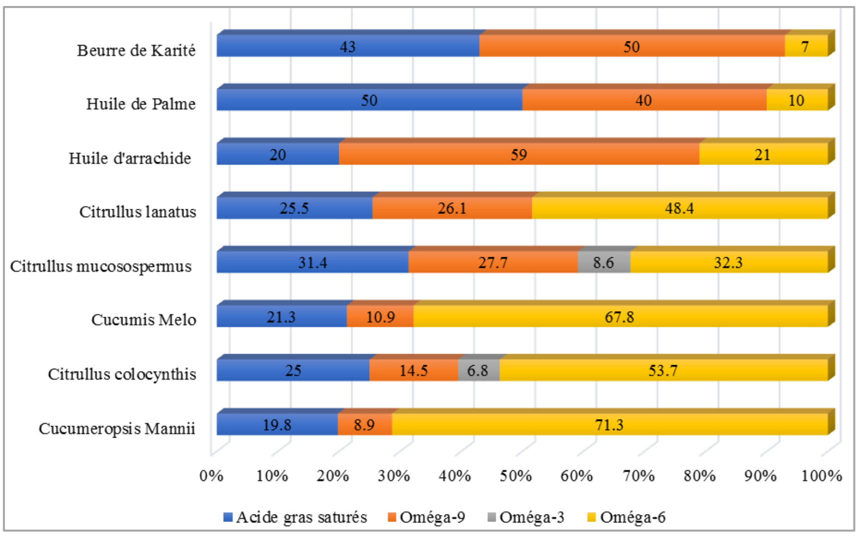

Figure 6. *Comparison of the essential fatty acid composition of cucurbit oils and some mass-market oils.*

Looking at the fatty acid composition, we can clearly say that the various cucurbit oils contain the highest concentration of Omega-6 (linoleic and γ-linolenic acid), compared to commonly used oils. In addition, we note the presence of omega-3 (α-linolenic acid) in Citrullus colocynthis and Citrullus mucosospermus oils.

According to studies, γ-linolenic and α-linolenic acids are essential for human health due to their important roles in regulating inflammation, cellular function, and cardiovascular health.

Studies have reported relationships between the fatty acid composition of the diet and diseases, such as diabetes or cardiovascular disease. Indeed, unsaturated fatty acids contribute to the proper functioning of the brain, eyes, and the entire nervous system [33, 34]. Studies by the Kushi and Gretchen groups revealed that unsaturated fatty acids lower cholesterol and reduce the risk of breast cancer [35, 36].

The cucurbit oils studied have an unsaturated fatty acid composition of between 70 and 80%. In addition, the presence of linoleic acid (LA) as the majority compound and linolenic acids (GLA and/or ALA) is clearly defined. The composition of these oils in essential fatty acids makes them healthy oils for human consumption. These results could help support the valorization of cucurbit seeds and the creation of a well-structured sector by involving more women in rural areas in the production, processing, and marketing of seeds.

4. Conclusion

This work reports the physicochemical characteristics of seeds and oils from cucurbits (*Cucumeropsis Mannii*, *Citrullus colocynthis*, *Cucumis Melo*, *Citrullus mucosospermus*, and *Citrullus lanatus*). The lipid contents of the seeds and the protein contents of the cakes of the five cucurbits are relatively high. The almonds of these species are of certain nutritional interest, they therefore constitute an important source of proteins and lipids. The oils of these cucurbits are characterized by their richness in omega-6 (linoleic and γ-linolenic acid). We also note the presence of omega-3 (α-linolenic acid) in *Citrullus colocynthis* and *Citrullus mucosospermus* oils.

Current production of cucurbit kernels is carried out in small quantities by women in the informal sector. This is linked to the organizational difficulty of the sector from cultivation to almond production, the traditional production system, and the uncontrolled market. After examining the nutritional values of these cucurbits, a sector must be created whose structuring will be supported by the State to improve the economic, legal, and institutional environment. The valorization of almonds and cucurbit almond oil should make it possible to increase productivity, improve product quality, and structure, and expand the market.

Abbreviations

ALA	α-Linolenic Acid
GC	Gas Chromatography
GLA	γ-Linolenic Acids
LA	Linoleic Acid
ND	Not Determined
TBME	Tert-Butyl Methyl Ester

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Author Contributions

Nikiema Diakaridja: Conceptualization, Formal Analysis, Writing – original draft, Writing – review & editing

Dosso Ouehi: Writing – original draft

Valentin Romain: Formal Analysis

Lacroux Éric: Formal Analysis

Cerny Muriel: Formal Analysis

Mouloungui Zéphirin: Supervision

Koua Oi Koua: Conceptualization, Funding acquisition, Supervision, Validation

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Conflicts of Interest

The authors declare no conflicts of interest.

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