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Fatty Acid Composition of Hazelnut Kernel Oil from *Coula edulis* Collected in the Republic of Congo

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Abstract

Coula edulis is non-timber forest product (NTFP) used in Africa for its hazelnuts, which contain edible seeds with a demonstrated nutritional potential. However, there have been very few scientific studies of this species in the Republic of Congo. Thus, the aim of the current study was therefore to determine the fatty acid composition of the oil extracted from *Coula edulis* hazelnut seeds collected at random in the Republic of Congo. The oil was extracted using the Soxhlet method and its fatty acid composition was determined by gas chromatography. The extracted oil from *Coula edulis* hazelnut kernels is rich in monounsaturated fatty acids (95.28%), particularly oleic acid (94.5%), which classifies it as an oleic oil and gives it interesting nutritional and therapeutic properties. On the other hand, saturated fatty acids (4.15%) and polyunsaturated fatty acids (0.35%) are not well represented. Its low poly-unsaturated fatty acid content makes it more stable when stored at room temperature.

Keywords

Coula edulis, Fatty Acids, Oil, Seeds, Hazelnuts, Republic of Congo, NTFP

1. Introduction

Dietary fats and oils are the primary sources of energy, providing 9 Kcal/g, and essential nutrients that prevent nutritional deficiencies and certain pathologies in humans [1]. Edible oils contain fatty acids that are generally classified as saturated, monounsaturated, and polyunsaturated. The ratio of unsaturated to sa-

turated fatty acids in dietary oils and fats is a major factor influencing human nutrition and health related to plasma cholesterol. Epidemiological data indicates that a higher intake of saturated fats is associated with an increased incidence of cardiovascular diseases. However, replacing saturated fats with polyunsaturated and monounsaturated fats can reduce the risk of cardiovascular diseases [2]. It is recommended to consume a diet that is low in saturated fatty acids and high in monounsaturated and polyunsaturated fatty acids. In sub-Saharan Africa, including the Republic of Congo, a significant portion of the lipid content of diets comes from vegetable oils such as palm, palm kernel seed, and animal fats, which are rich in saturated fatty acids. This type of diet is believed to increase the risk of cardiovascular diseases in the population. Therefore, it is important to reduce the consumption of these types of fats and increase the intake of healthier fats. To tackle this problem, it is recommended to promote the consumption of vegetable oils as sources of mono- and polyunsaturated fatty acids in the diet. In the Republic of Congo, there are various food plants that could potentially serve as sources of lipids, but they are currently underutilized. We were interested in *Coula edulis* hazelnuts. *Coula edulis Baill* (Olacaceae), also known as African hazelnut or Gabon hazelnut, is a tree commonly found in the evergreen forests of Africa. It is renowned for the non-timber forest products (NTFPs) that it provides to local populations. Its fruits are regularly collected and sold. The seeds, which are consumed by rural populations, yield a yellow, odorless oil with a sweet flavor and high nutritional value [3].

According to studies conducted by [4] in Côte d'Ivoire and [5] in Nigeria, *Coula edulis* kernels contain 28.31% to 34.85% and 24.31% lipids, respectively. Additionally, *Coula edulis* hazelnuts collected in Côte d'Ivoire yield a yellow oil with a high oleic acid content of 93.93% as reported in [6]. These kernels are also rich in protein, calcium and vitamins [7]. However, limited research has been carried out on the chemical composition of the lipid fraction of *Coula edulis* hazelnuts in the Republic of Congo. The objective of this study is to determine the fatty acid composition of the oil extracted from the kernels of *Coula edulis* hazelnuts, in order to promote their consumption and valorization.

2. Materials and Methods

2.1. Plant Material

Coula edulis hazelnuts were randomly collected at maturity in April 2022 under the trees of the equatorial forest at Zoulaboth in the sub-prefecture of Sembé, which is located in the Department of Sangha in the Republic of Congo. The collected hazelnuts were air-dried and transported to the laboratory in Brazzaville.

2.2. Sample Processing

The hazelnuts transported to the laboratory in Brazzaville were mechanically crushed using a pestle to separate the seeds from the shells. The resulting seeds were then oven-dried at a temperature of 70˚C until their mass had stabilized.

After drying, the seeds were cooled at the room temperature, and transformed into a powder using a porcelain mortar. The obtained powder was used to extract the lipid fraction.

2.3. Oil Extraction

The oil extraction was performed using the Soxhlet method [8]. 30 g of *Coula edulis* seed-kernel powder was placed in filter paper, and then inserted into a Soxhlet-type extractor connected to a refrigerator. The flask containing 200 mL of hexane was placed on the heating block of the Soxhlet. The extraction was carried out continuously for 3 hours. After evaporation of the solvent using the heating flask, the oil was recovered and stored in glass jars. The oil was analyzed at the ITERG laboratory in France between September and October 2022 to determine the fatty acid profile.

2.4. Processing of Methyl Esters

Fatty acid methyl esters (FAMEs) were obtained from fatty acids extracted from almonds using the transmethylation method with a boron trifluoride (BF3) catalyst, according to the ISO 12966-2 standard [9]. Two drops of oil dissolved in 1 mL of hexane were added to 0.4 mL of methanolic sodium hydroxide solution. The mixture was then boiled under reflux at 60˚C for 10 min after adjusting the condenser. Subsequently, 0.5 mL of BF3 solution and 1 mL of hexane were added to the mixture. That mixture was heated for three minutes and then cooled to room temperature. After vigorously stirring, the mixture was left to stand until two phases were obtained. The upper organic phase, which was hexanic and contained the fatty acid methyl esters, was recovered for analysis.

2.5. Separation by Gas Chromatography

In this study, gas chromatography was employed to separate compounds. The experimental setup included an HP 5890 chromatograph equipped with an apolar column (HP 5M) measuring 30 meters in length, with an internal diameter of 0.25 mm and a thickness of 0.2 µm. Additionally, a Flame Ionization Detector (FID) was utilized, following the ISO method 12966-4 [10]. The carrier gas used was helium, flowing at a rate of 1 mL/min. The temperature of the furnace was programmed to increase from 50˚C to 280˚C at a gradient of 5˚C/min. Furthermore, the injector and detector temperatures were set to 250˚C and 280˚C, respectively. Finally, a volume of 1 µL of fatty acid methyl esters was injected for analysis.

2.6. Identification of Fatty Acids

The fatty acids were identified on the basis of their respective retention times. A mixture of known fatty acids, present in defined proportions, was injected under the same experimental conditions as the sample to be analyzed. The retention time for each fatty acid was determined, and its corresponding area was record-

ed. In order to identify the fatty acids in the sample, their retention times were compared with those of known standards. The quantification of fatty acids was achieved by measuring the areas of the peaks. A known concentration standard, heptadecanoic acid (C17:0), was used in this process. The internal calibration method was employed to quantify the fatty acids through their methyl esters. By adding a known amount of C17:0 to the studied fat, we were able to accurately determine the fatty acids present in the sample. The comparison of their peak areas was done in relation to that of C17:0 as follows:

$$AG(\text{mg}) = \text{mass}(\text{C17}:0) * \left[\frac{\text{Area}(AG)}{\text{Area}(C17:0)}\right]$$

$$AG(\%) = \left[\frac{AG(\text{mg})}{\text{Total } AG(\text{mg})}\right]$$

3. Results

Table 1 shows the profile and fatty acid yields of the oil extracted from *Coula edulis* kernels. A total of 18 fatty acids were identified in this study, especially 9 saturated fatty acids, 6 monounsaturated fatty acids and 3 polyunsaturated fatty acids. This table indicates that the analyzed *Coula edulis* oil has a high content of monounsaturated fatty acids (MUFA), a low content of saturated fatty acids (SPA) and a very low content of polyunsaturated fatty acids (PUFA), with total values of 95.28%, 4.15% and 0.35%, respectively.

Palmitic (C16:0) and stearic (C18:0) acids are the most commonly found saturated fatty acids of *Coula edulis* oil, with respective values of 2.30 % and 1.43%. Myristic (0.13%) and arachidic acids (0.16%) are minor saturated fatty acids. Additionally, capric, lauric, margaric, behenic and lignoceric acids are present in trace amounts (<0.05%) in the studied *Coula edulis* oil.

Among the six monounsaturated fatty acids identified in *Coula edulis* oil, the most represented is oleic acid (C18:1n-9), with a content of 94.58%. In contrast, gondoic acid is present at a low level, with a content of 0.70%. Other monounsaturated fatty acids identified in this study, such as heptadecenoic, palmitoleic, erucic and nervonic are present in trace amounts (<0.05%). The data on the polyunsaturated fatty acid content (Table 1) show the very low values for the 3 fatty acids identified. These acids include omega-3 fatty acid in the form of a-linolenic acid (18:3n-3) and omega-6 fatty acid in the form of linoleic acid (18:2n-6), with respective contents of 0.16% and 0.19%. The third acid, conjugated linoleic acid (C18:2 trans), was found in trace amounts (<0.05%).

4. Discussion

The analysis of the extracted oil from the kernels of *Coula edulis* hazelnuts has led to the identification of 18 fatty acids, and the oleic acid was the predominant one. Similar results were also reported by [4] and [6] on *Coula edulis* oil collected in Côte d'Ivoire, with oleic acid values of 93.66% ± 1.03% and 93.93%,

Table 1. The profile and yields fatty acids of the oil from *Coula edulis* kernels.

Fatty acid groups	Common name of FA	Symbol	Yields (%)
SFA	Capric acid	C8:0	0.07
	Lauric acid	C12:0	0.06
	Myristic acid	C14: 0	0.13
	Palmitic acid	C16:0	2.30
	Margaric acid	C17:0	<0.05
	Stearic acid	C18:0	1.43
	Arachidic acid	C20:0	0.16
	Behenic acid	C22:0	<0.05
	Lignoceric acid	C24:0	<0.05
Total			4.15
MUFA	Palmitoleic acid and its isomers	C16:1	<0.05
	Heptadecenoic acid	C17:1	<0.05
	Oleic acid (and its cis isomers)	C18:1	94.58
	Gondoic acid	C20:1	0.70
	Erucic acid	C22:1	<0.05
	Nervonic acid	C24:1	<0.05
Total			95.28
PUFA	Linoleic acid	C18:2 cis (Omega-6)	0.19
	Linoleic acid	C18:2 trans	<0.05
	Linolenic acid	C18:3 (n-3) cis	0.16
Total			0.35

SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids; FA: Fatty acids.

respectively. A predominance of oleic acid was also observed in conventional oils, such as olive (75.31% ± 3.5%, 67.23% - 73.5%) [11] [12], canola (60.58%) [11], peanut (56%), rapeseed (80%) and sunflower (82%) [13]. Similar results were also observed with non-conventional oils such as *Moringa oleifera* (72.5%) and *Cyperus esculentus* (67.76%) [6], *Jujube* (62.49%) [14] and *Pachira glabra* (53.72%) [15]. The results of this study indicate that *Coula edulis* oil is a potential source of oleic acid. Therefore, it may be classified as an oleic oil comparable to olive oil. Oleic acid has a number of nutritional functions, regulating physiological processes and helping to prevent chronic diseases [16]. An experimental study on rats showed that a diet rich in oleic acid from olive oil increased levels of omega-3 polyunsaturated fatty acids, such as EPA and DHA [16]. This increase was positively associated with a reduced risk of cardiovascular diseases [17]. In addition, a diet rich in oleic acid can increase HDL cholesterol levels,

lower triglyceride levels and reduce body weight [17] [18]. Replacing saturated fats with monounsaturated ones has been shown to be effective in reducing LDL cholesterol [18] [19] [20]. The use of *Coula edulis* oil, rich in oleic acid, could therefore be a promising alternative for the prevention of cardiovascular and chronic diseases. It should be noted that the analyzed *Coula edulis* oil has a low level of saturated fatty acid: of the identified saturated fatty acids, palmitic acid is the predominant one, with a level of less than 8% (the threshold set by the French Agency for Food, Environmental and Occupational Health and Safety) [21]. Similar results were obtained on *Coula edulis* oil collected in Côte d'Ivoire, with a saturated fatty acid content of 5.23% and palmitic acid also being the most abundant [4]. The low content of saturated fatty acids found in this study is an advantage for *Coula edulis* oil. Indeed, various studies have shown that the consumption of fats rich in saturated fatty acids, particularly palmitic acid (a hypercholesterolemia fatty acid), can be a risk factor for cardiovascular diseases and type 2 diabetes. Thus, the use of *Coula edulis* oil could help prevent these diseases [22].

According to the present study, *Coula edulis* oil is no source of polyunsaturated fatty acids. This actually makes it more stable during storage, as confirmed by [4]. The same authors claimed that the oil could be stored at room temperature for up to 90 days. Polyunsaturated fatty acids are sensitive to oxidation, which can occur both exogenously during food preservation or processing, and endogenously during digestion. Lipid oxidation impacts the sensory, olfactory, and taste qualities, as well as the nutritional value of fatty acids, by reducing the intake of essential fatty acids [23].

Despite the limitations of this study, such as the random method of collecting plant material, the delay between the extraction of the oil carried out in the Brazzaville laboratory and the analysis of this oil in the laboratory in France, as well as the lack of repeatability of the tests, the results revealed that the oil from *Coula edulis* kernels collected in the Republic of Congo contained a high content of monounsaturated, mainly oleic acid, and a low content of saturated fatty acids. Similar results were also obtained with *Coula edulis* hazelnuts from Côte d'Ivoire [4] [6]. Therefore, the use and valorization of under-exploited *Coula edulis* hazelnuts in the Republic of Congo should be encouraged.

5. Conclusion

The objective of this study was to determine the fatty acid composition of oil extracted from *Coula edulis* kernels, an under-exploited fruit in the Republic of Congo. The quantitative and qualitative analysis of the oil revealed a predominance of oleic acid in the kernel oil. This may confer similar nutritional and pharmacological properties to those of olive oil, which is classified as an oleic oil. Additionally, the oil of *Coula edulis* is highly stable during storage due to its low content of linolenic and linoleic acids, which makes it resistant to oxidation.

Author Contributions

Josiane Enzonga Yoca: result analysis and writing; Jean Paul Latran Ossoko: collecting plant material and reading the manuscript; Yves Okandza: laboratory analyses; Michel Didace Mvoula Tsieri: reading the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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