

Chemical and physicochemical properties of the lipid extract of *Ricinodendron heudelotii* almonds (Euphorbiaceae) from Côte d'Ivoire

ABSTRACT

The study focused on the valorisation of the fat extracted from the kernels of *Ricinodendron heudelotii*, a plant of the Euphorbiaceae family grown in Côte d'Ivoire. Extraction was carried out using Soxhlet with n-hexane, followed by determination of the fatty acids and physicochemical parameters such as acid, ester, peroxide, saponification and iodine indices, calorific value and unsaponifiable matter content. The oil obtained has a pale yellow colour and a fat content of $38.70 \pm 0.45\%$. GC-MS analysis showed a low content of saturated fatty acids and a significant proportion of unsaturated fatty acids, mainly linoleic acid. These results suggest that *Ricinodendron heudelotii* fat could have potential applications in food and as a source of energy, although its high oxidative instability means that precautions need to be taken when using it in food.

Key words: physicochemical parameters, fatty acids, fatty matter, *Ricinodendron heudelotii*, Ivory Coast

INTRODUCTION

Ricinodendron heudelotii, a fruit tree belonging to the Euphorbiaceae family, is widespread in the humid tropical forest regions of West and Central Africa [1]. In Côte d'Ivoire and other African countries, its kernels are prized for their distinctive flavour, often used in a variety of dishes [2]. The fat content extracted from these almonds varies from 45 to 64% [3], with a notable concentration of α -eleostearic fatty acid (conjugated C 18:3), representing more than half of the total fatty acids [4]. In addition, various parts of *Ricinodendron heudelotii*, such as the stem bark, leaves, latex, sap and roots, are used in traditional medicine to treat a range of conditions including yellow fever, anaemia, toothache and malaria [5, 6, 7, 8]. However, there have been few studies carried out to add value to the fat extracted from this species in Côte d'Ivoire. The aim of this study was to enhance the value of *Ricinodendron heudelotii* kernels through a chemical and physicochemical study.

I. MATERIAL AND METHODS

I.1. Material

I.1. Plant material

The *Ricinodendron heudelotii* kernels come from Zoukougbeu, a town in the centre-west of Côte d'Ivoire (Haut-Sassandra region). The kernels were finely pulverised using an electric grinder.

I.1. Technical equipment and chemicals

The technical equipment includes the usual laboratory glassware, an electronic balance, a Soxhlet, a spectrophotometer, a rotary evaporator, an oven, and a gas chromatograph coupled to a mass spectrometer (GC-MS).

The chemicals used were Na_2SO_4 , hexane, N-O-bis-trimethylsilyl-trifluoroacetamide (BSTFA), KOH, etc...

I.2. Methods

I.2.1. Method of fat extraction

Thirteen grams (13 g) of *Ricinodendron heudelotii* almond powder were mixed with 3 g of Na₂SO₄. The fat was extracted using Soxhlet for 2 hours with n-hexane. The extract obtained was distilled under vacuum on a rotary evaporator to remove the extraction solvent. The fat obtained was weighed and analysed [9, 10].

I.2.2. Measurement of a number of physico-chemical parameters of butterfat

The physico-chemical parameters (saponification, acid, iodine, peroxide and ester indices, calorific value and unsaponifiable matter content) were determined using the procedures described in the literature.

The saponification index (Is) and acidity index (Ia) were determined respectively by standards NF T 60-206 and NF T60-204 [11, 12] and the unsaponifiable matter content by the method described in the work of Bamba and coll. [13]. The iodine value (Ii) and peroxide value (Ip) were determined in accordance with NF ISO 3961 and NF T60-220 respectively [14, 15]. Finally, the ester number (Ie) [16] and calorific value (PC) [17] were determined according to the following equations: $Ie = Is - Ia$ (mg KOH / g) and $PC = 47645 - 4,187Ii - 38,31Ie$ (kJ/kg).

I.2.3. Determination of fatty acids by GC-MS

Identification of fatty acids by GC-MS of *Ricinodendron heudelotii* fat was carried out using the method described by Bamba and coll. [9].

Fatty acids in *R. heudelotii* oil are determined in two stages. In the first stage, the fatty acids are extracted using dichloromethane and then concentrated. The acids are then derivatised with N-O-bis-trimethylsilyl-trifluoroacetamide (BSTFA) to obtain trimethylsilyl esters. In the second stage, the trimethylsilyl esters were analysed by gas chromatography-mass spectrometry (GC-MS) in selective ion acquisition mode. The GC-MS instrument consisted of a DB-5.625 capillary column measuring 30 m x 0.25 mm Di x 0.25 μ m. Helium was used as the carrier gas with a linear velocity of 1 mL/s. The oven temperature programme was 130°C for 2 minutes, followed by three programming stages: the first programming stage (Rate: 10°C/min; Final: 180°C for 0 minutes); the second programming stage (Rate: 3°C/min; Final: 245°C for 5 minutes) and finally the third programming stage (Rate: 15°C/min; Final: 300°C for 5 minutes). The temperature of the injector and detector was set at 250°C. Injection was carried out in splitless mode. The mass spectrometer parameters for the electron impact mode were: ionisation source temperature (230°C) and electron energy (70 eV). The concentration of fatty acids present in the sample is determined by comparing the chromatographic surfaces obtained at a given retention time with the surfaces of the standards used to establish the calibration curve under the same assay conditions.

II. RESULTS AND DISCUSSION

II.1. Fat content of *Ricinodendron heudelotii* kernels

The fat extracted from *Ricinodendron heudelotii* is pale yellow in colour. It has a content of $38.70 \pm 0.45\%$. This value is within the range of those of proven oilseed oils: cotton 35%-40% [18, 19], rapeseed 37.3%-42%; palm kernel 33.3%-50% and sunflower 36.7%-47.7% [18, 20]. *Ricinodendron heudelotii* could therefore be classified as an oilseed.

II.2. Chemical parameters of the fat content of *Ricinodendron heudelotii* kernels

The iodine, acid, peroxide, saponification, ester, calorific value and unsaponifiable content indices of *Ricinodendron heudelotii* kernel oil were determined and the results obtained are given in Table I.

The iodine value of *Ricinodendron heudelotii* kernel oil obtained was 109.51 ± 0.86 g iodine/100 g oil. This physico-chemical parameter provides information on the degree of establishment of an oil. When the value of this index is high ($I_i \geq 90$), it means that the fat studied is mainly made up of unsaturated fatty acids [18, 21]. In addition, the iodine value of *R. heudelotii* oil kernels is higher than those of certain known oils considered to be of very high quality, such as olive oil (75-94) and rapeseed oil (97-107) [18, 22]. This high iodine value in the fat of *R. heudelotii* kernels could mean that its fat is rich in unsaturated fatty acids and therefore recommended for use in food. In addition, this oil could be classified as a non-drying oil ($I_i < 110$) [18, 23].

The peroxide value of *R. heudelotii* oil is 23.33 ± 2.35 meq. O₂ / kg of oil. This index is used to assess the level of primary oxidation of an oil by oxygen. According to the Codex Alimentarius, the oil studied has a fairly high level of oxidation ($I_p > 10$ meq of O₂ / kg of oil) [24]. Moreover, it is higher than those of shea butter (14.5-17.5) [16, 18] and desert dates (9.78 ± 1.9) [18, 25]. This index is also higher than that of *Moringa oleifera* fat (0.74 ± 0.02) from Côte d'Ivoire [10, 26] and that of *Irvingia gabonensis* fat (20 ± 2.18) from Côte d'Ivoire [9], two plants commonly used in Côte d'Ivoire.

The saponification number obtained for *R. heudelotii* oil is 187.70 ± 11.19 mg KOH / g oil. This index generally gives the fatty acid content (esterified and free) of an oil. Its high value makes an oil a recommended raw material for soap making. The content of *R. heudelotii* oil in this study was lower than that of coconut (248-265) and palm kernel (230-254) oils [18, 24], which are oils commonly used in soap-making. In view of these findings, *R. heudelotii* fat is not recommended as an input in soap manufacture [18, 27].

The acid value of *R. heudelotii* kernel oil obtained in this work is 4.20 ± 1.14 mg KOH /g oil. This quantity is very close to that of the food standard ($I_a \text{ max} = 4$) [18, 24]. This value of the acid number thus reflects an acceptable quantity of free fatty acids in the oil in this study. Furthermore, the acid value of *R. heudelotii* oil is in the same range as those of edible oils such as coconut (4-7), palm kernel (4-7) and groundnut (0.08-6) [18, 25]. Moreover, this parameter for *R. heudelotii* oil is even better than that for soybean oil (7) [18, 25].

The ester number obtained for *R. heudelotii* oil was 183.50 ± 10.05 mg KOH / g oil. This value for the ester number of *R. heudelotii* kernel oil is slightly lower than that for the saponification number of the same oil (187.70 ± 11.19 mg KOH/g oil). This finding could mean that the fat of *R. heudelotii* contains a low quantity of fatty acid. However, this does not rule out the possibility that it may undergo treatment (pre-refining and conditioning) before use [9, 28].

The calorific value of *Ricinodendron heudelotii* kernel oil obtained was 40414.44 ± 427.36 kJ / kg of oil. This parameter provides information on the energy value of the fat for human consumption and its hypothetical use as a biofuel and engine lubricant. The calorific value of *R. heudelotii* kernel oil obtained in this study is greater than 35,000 kJ/kg, so it could be considered for use as a fuel and engine lubricant [16]. However, further research, particularly into the viscosity of this oil, could determine its potential as a biodiesel or engine lubricant. In this study, food use will be favoured for ethical reasons on the one hand, and on the other hand to provide a response to undernourishment in most tropical countries where food supplements are used [16]. The calorific value of this oil could make it a nutritional source of energy [16, 18, 26, 28].

The unsaponifiable matter content of *Ricinodendron heudelotii* kernel oil is $0.72 \pm 0.08\%$. This value is within the range of values reported in the literature for plant species (of the order of 0.5 to 4%) [18, 29, 30, 31, 32, 33, 34].

Table I. Chemical composition of *Ricinodendron heudelotii* fat

Characteristics studied	Results obtained
Iodine index (g iodine/100g oil)	109.51 ± 0.86
Peroxide index (meq O ₂ /kg oil)	23.33 ± 2.35
Saponification index (mg KOH / g oil)	187.70 ± 11.19
Acid index (mg KOH / g oil)	4.20 ± 1.14
Ester index (mg KOH / g oil)	183.50 ± 10.05
Calorific power (kJ/kg)	40414.44 ± 427.36
Unsaponifiable matter content	0.72 ± 0.08

II.3. Fatty acid content of *Ricinodendron heudelotii* fatty matter

The fatty acids in *Ricinodendron heudelotii* fat were identified and the chromatographic profile of the fat from *R. heudelotii* kernels is shown in Figure 1. This profile highlights the fatty acids present in this oil.

The fatty acids identified and their various levels are shown in Table II. In total, *Ricinodendron heudelotii* fat contains seven (7) fatty acids, including three (3) polyunsaturated fatty acids (PUFA), one (1) monounsaturated fatty acid (MUFA) and three (3) saturated fatty acids (SFA). The ratio of the percentage presence of polyunsaturated fatty acids and saturated fatty acids (PUFA/SFA= 2.11 > 1) and the value of the iodine index ($I_i = 109.51 \pm 0.86 > 90$) increase the potentially nutritional properties of *R. heudelotii* fat [21, 35].

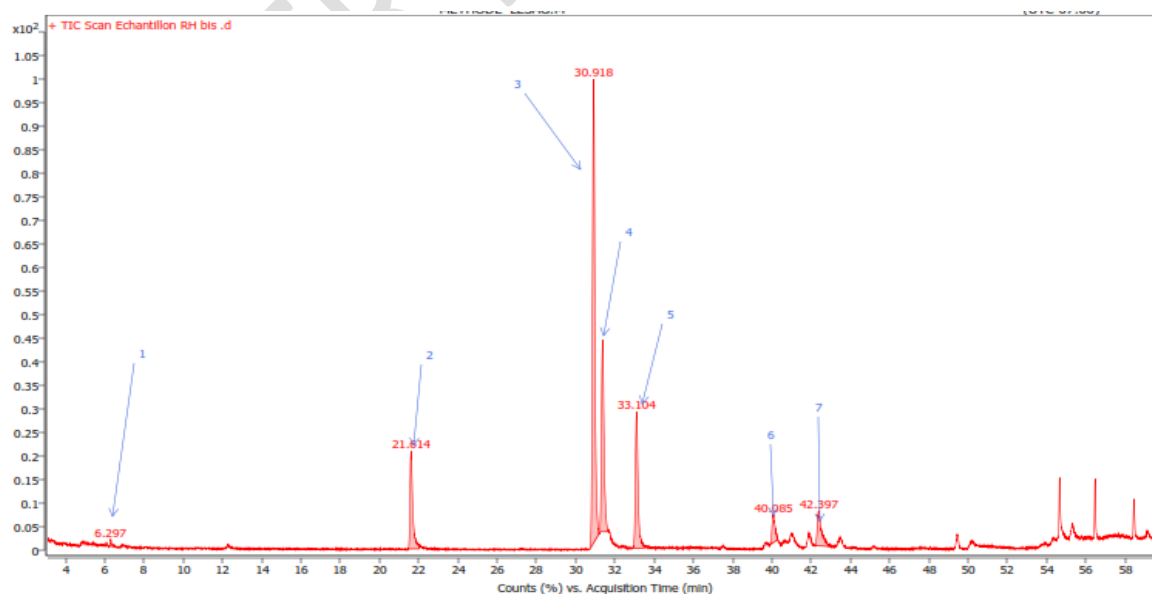


Figure 1 : Chromatographic profile of the fat content of *R. heudelotii*

Table III. Fatty acids identified in the fatty matter of *Ricinodendron heudelotii*

Order number	Fatty acids identified	Fatty acid family	Rate (in %)
1	Lauric acid	Saturated	0.49
2	Palmitic acid	Saturated	10.74
3	Linoleic acid	Polyunsaturated (Omega-6)	45.21
4	Oleic acid	Monounsaturated (Omega-9)	19.35
5	Stearic acid	Saturé	14.69
6	Linoleic acid	Polyunsaturated (Omega-6)	3.39
7	Gamma-linolenic acid	Polyunsaturated (Omega-6)	6.13
Saturated fatty acids (SFA)			25.92
Polyunsaturated fatty acids (PUFA)			54.73
Monounsaturated fatty acids (MUFA)			19.35

Omega-6 PUFAs are necessary for numerous physiological functions in the body and their protective role against cardiovascular disease is well known. The American Heart Association recommends a dietary intake of Omega-6 PUFAs of around 5-10% of total energy intake [36, 37]. Omega-6 PUFAs are fatty acids (FAs) characterised by a carbon chain with two or more cis double bonds, the first of which is located between the 6th and 7th carbon atoms of the methyl end (n-6 position). The PUFAs identified in *Ricinodendron heudelotii* almond oil include linoleic acid. This dietary acid is found in large quantities in vegetable oils from soya, maize and rapeseed. It is an essential fatty acid that cannot be synthesised by mammals. Its only source is therefore the diet [38]. In addition to its role as a precursor of hormones (eicosanoids), linoleic acid is involved in the formation of cell membranes and helps to maintain skin hydration by limiting water loss. Linoleic acid, the main PUFA in this oil and a diastereomer of linoleic acid, acts as a source of energy, while gamma-linolenic acid promotes joint health and emotional well-being during the menstrual cycle [39]. In Somme, this high omega-6 content in the fat of *R. heudelotii* (54.73%) is thought to help reduce levels of bad cholesterol in the blood [37, 39]. However, too much omega-6 compared with omega-3 tends to encourage the development of various diseases such as cardiovascular disease, cancer and various inflammatory and autoimmune diseases [40]. Furthermore, the presence of oleic acid (Omega-9) in the fat of *R. heudelotii* almonds (19.35%) could contribute to good control of hypertriglyceridaemia in diabetic rats [41]. This acid potentiates the effect of weight loss, which reduces cardiovascular risk in obese and diabetic patients [42].

CONCLUSION

This study was devoted to the determination of some physicochemical parameters and the determination of fatty acids by GC-MS of the fat extracted from the kernels of *Ricinodendron heudelotii* grown in Côte d'Ivoire. Soxhlet extraction of the oil yielded an extraction rate of $38.70 \pm 0.45\%$, enabling this plant to be classified as an oilseed. The physicochemical parameters and the fatty acids identified suggest that the oil could be useful in food and pharmaceutical applications. Further analysis will reveal whether the oil can be used as a biofuel and/or engine lubricant.

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