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Extraction of Oil from Safou Pulp (*Dacryodes edulis* (G. Don) H. J. Lam) by Hot Pressure: Yield and AG Composition

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Abstract

The actual launch of industrial or semi-industrial production of oil from safou pulp can only be effective if it is profitable enough to compete with the species currently being exploited. Studies on oil extraction by mechanical pressing, which is the main industrial processing technique for oilseeds, are outdated and need to be reevaluated using modern presses to better assess oil extraction yields. The present study, carried out using a screw press (KOMET type CA 59 G) on the pulp studied, gave an extraction yield of 81.18% of the total oil, more or less exceeding those reported in the literature. In addition, as the oil from the kernel has a similar fatty acid composition to that of the pulp, using the whole fruit could increase the fat content and eliminate the need for pitting, thereby reducing processing costs. The extracted oil has a fatty acid profile of C16:0>C18:2>C18:1>C18:0>C18:3, which has already been reported in the literature. Mechanical pressing has no influence on the fatty acid composition of the oil obtained.

Keywords

Safou pulp; oil; press extraction; yield; AG

1. Introduction

The ever-increasing growth of the world population, estimated at 9.8 billion by 2050 by the UN [1], is forcing decision-makers to focus on developing food supply strategies to ensure food security for populations. The demand for fats, which generally account for 30 to 40% of total energy intake (WHO, 2018; ANSES, 2021), corresponding to approximately 70 to 100 g of fat per day per person, demonstrates the importance attached to this class of metabolites [2]. Vegetable oils remain the most widely consumed and recommended fat in terms of nutritional quality and cardiovascular disease prevention (FAO) compared to animal fats.

Safou (*Dacryodes edulis*) is an unconventional oilseed crop that is promising and potentially nutritious [3-11], domesticated and highly prized in sub-Saharan Africa [12-17], and could help meet the demand for fat, especially in Africa, where increasing food insecurity is a growing concern [18]. This contribution can only be effective if cost-effective processing techniques are mastered, the effective implementation of which could also help reduce post-harvest losses of this species, which amount to more than 50% [9, 19-21].

Knowledge of yield and quality in finished products using mechanical presses, which offer automation, intelligent control, and energy savings, making the process accessible to small producers at the industrial level and constituting the main technique for industrial processing of oilseeds, is relatively old [5, 22, 23] and was not always one of the authors' main objectives [5, 22]. Updating knowledge in line with scientific advances, including the development of modern presses, is essential for a better appreciation of the qualities of this species.

2. Materials and Methods

2.1 Plant material

The safous studied were purchased at the Total market in Brazzaville (Republic of Congo). The only selection criterion was the ripeness of the fruit (dark blue or black color). According to the seller, these safous came from Cameroon.

2.2 Study methods

After purchase, the safous were transported to the laboratory. They were cleaned before being processed.

2.2.1 Morphological and physicochemical characteristics

The masses of the fruits and pulps studied were determined using a CONSTANT PN-Model precision balance: 14192-005R; Max: 620 g; d: 0.01 g, morphological dimensions (length, width) using a caliper, and water and oil content of the pulp using formula 1 after drying part of the pulp halves in an oven (T = 103°C, duration = 24 h) and by formula 2 after Soxhlet extraction with hexane for 3 h of these oven-dried pulp halves [24].

$$\%(water) = \frac{m_0 - m_1}{m_0} x100 \quad (1)$$

$$\%(oil) = \frac{m_1 - m_2}{m_1} x100 \quad (2)$$

avec:
m_0: initial mass of the half-pulp.
m_1: mass of the half-pulp after drying in an oven (or of the powder before extraction)
m_2: mass of the half-pulp cake after extraction.

2.2.2 Mechanical extraction of oil from pulp

The remaining pulp halves used to extract oil by pressing were dried in an oven at 60°C until the mass stabilized. Extraction (3 trials) was carried out using a KOMET CA 59 G press (IBG Montors Oekotec GmbH & Co. KG, Mönchengladbach, Germany) with a capacity of 3-5 kg/h and a power of 1.1 kW (Figure 1). In each test, 500 g of half-pulps were roasted at 80°C for 10 min. During extraction, the press speed was set to 2.4 AU, and a 7 mm diameter die was used.

Figure 1. Extraction of oil from safou pulp using the KOMET CA 59 G press.

2.2.3 Major fatty acid compositions of extracted oils

Fatty acid methyl ester (FAME) preparation and gas chromatography (GC) analysis for FA composition were performed according to the NF EN ISO 12966-2 (AFNOR, 2017). FAME was analyzed by GC (FOCUS GC chromatograph (Thermo Fisher Scientific, Massachusetts, USA)) equipped with a CP-Sil 88 column (50 m x 0.25 mm x 0.2 µm; Agilent, Santa Clara, USA) and a split injector (1:20 ratio). Carrier gas: helium, Flow rate: 1.0 mL/min. Injector temperature: 250°C. FID detector temperature: 270°C. The oven was heated from 185 to 225°C at a speed of 5°C/min and maintained at 225°C for 10 min. FAMEs were identified by comparing the retention times of each peak to those of the FAME mix standard and quantified as a relative percentage of total FA using Chromcard 2.3.32005 software (Thermo Fisher Scientific, Massachusetts, USA).

3. Results and Discussions

3.1 Morphological and physicochemical characteristics of the safous studied

The morphological and physicochemical characteristics of the safous studied (Table 1) show that they belong to size III, category III [25, 26] and class III [27].

Table 1. Characteristics of the safous studied

	Mean ± standard deviation
Characteristics	87
Length (cm)	8.41 ± 0.78
Width (cm)	4.93 ± 0.43
Thickness (cm)	0.98 ± 0.14
Fruit weight (g)	78.67 ± 7.57
Pulp mass (g)	56.74 ± 5.86
Water content (%)	62.44 ± 5.43
Oil content (%)	44.89 ± 3.72

The "*edulis*" variety [28], with a sphericity index (width/length) of ½, is the most widely grown and marketed variety in the sub-region [11].

3.2 Oil yield and fatty acid composition

The experimental results are shown in Table 2 below.

Table 2. Oil yield and major fatty acid composition

	Test 1	Test 2	Test 3	**Mean**	**Standard deviation**
Yield	36.38	36.45	36.48	36.44	0.05
C16:0	45.21	45.21	45.20	45.21	0.01
C18:0	5.74	5.71	5.69	5.71	0.02
C18:1n9c	19.03	19.06	19.02	19.04	0.02
C18:2n6c	28.96	28.86	29.02	28.95	0.08
C18:3n3	0.77	0.87	0.77	0.81	0.06
C20:0	0.29	0.29	0.29	0.29	0.00

3.2.1 Oil yield

The extraction yield was 36.38% for test 1, 36.48% for test 2, and 36.44% for test 3, with an average of 36.44 ± 0.05. This average yield, which represents 81.18% of the total oil contained in the pulps studied, slightly higher than those recently obtained using the same press on the dried pulps of *Raphia sese* [29], is higher than those obtained by [5] using an ALTECH electric press equipped with a BE 100 4/4 (2.2 kW) motor, varying between 53.80 and

60.49% of total oil. This yield is also very high compared to those obtained using traditional methods [23]. In a study on the “problems of safou pulp oil production in Cameroon,” the study mentions a yield of 6.75 L of oil extracted using a traditional press, compared to 15 L of oil extracted using a solvent, which is equivalent to 45% of the total oil. [9] reports this yield to be between 25 and 49%. If we rely on the yield mentioned by the same author during chemical extraction, between 40 and 65%, we obtain a margin of oil extracted by press between 62.50 and 75.38% of the total oil, which still appears to be lower than the yield obtained in the present study.

Although this process differs from that used in the production of palm oil (*Elaeis guineensis*), the most consumed and produced oil in the world [30], whose extraction yield is determined based on fresh fruit containing nuts, this yield appears to be slightly higher than that of this species, which yields an average of 20 to 23% of fresh fruit bunches. This yield, which can reach up to 31% from fresh fruit using modern presses, remains lower than that obtained from safou pulp in the present study. [31] report a yield of 36.14% oil extracted from fresh palm fruit using a Dékanmé press. However, if the oil extraction yield from safou pulp is compared to that from whole fruit, i.e., taking into account, as in the case of palm oil, the mass of the kernels, which represents more than 25% of the fruit mass (Table 2), this yield could approach 28%. Furthermore, safou pulp has the advantage of producing oil with a fatty acid composition similar to that of the kernel [32, 33]. Using the whole fruit could increase the fat content [32] and eliminate the pitting stage, thereby reducing processing costs.

This study shows that safou pulp offers satisfactory potential for industrial or semi-industrial exploitation. The total oil yield obtained using this screw press will be able to compete with that of species currently being exploited.

3.2.2 AG composition

The fatty acid composition of the oil extracted from safou pulp using the KOMET press has a profile of C16:0>C18:2>C18:1>C18:0>C18:3, which has already been reported in the literature [11] for safou from Brazzaville. This fatty acid profile, obtained from hexane extraction and representing 32.65% of the 50 trees studied, comes after the C16:0>C18:1>C18:2>C18:0>C18:3 profile, which is the most commonly found profile in the literature [5, 8, 9, 34, 35, 36, 37, 38] and before the C16:0>C18:2>C18:1>C18:3>C18:0 profile representing 2.04%. Another profile, C18:1>C18:2>C16:0>C18:0>C20:0, rarely encountered in the literature, was obtained in Ibadan in Oyo State, Nigeria [33]. Thus, these observations show that the fatty acid composition of safou pulp oil can vary from one tree to another and from one ecological zone to another, with a common profile of C16:0>C18:1>C18:2>C18:0>C18:3, and that the type of extraction has no influence on the fatty acid composition of safou pulp oil.

The differences in FA content obtained and found in the literature remain genotypic in nature. Furthermore, the overall saturated (≃ 50%) and unsaturated (≃ 48%) FA contents are similar to those of oils found in the literature, extracted by pressing [3] and solvent extraction [39, 8, 36, 37], except for samples from [37], which had saturated FA (C16:0, C18:0, and C20:0) contents of 34.12% and unsaturated FA (C18:1 and C18:2) contents of 63.62% (Table 3).

Table 3. Fatty acid composition of safou pulp oil extracted by pressing and solvent extraction, as reported in the literature

Extraction type	Press				Solvent (Soxhlet)							
Author	[5] Boko-Rep. Congo			[39]	[3] Brazzaville-Rep. Congo			[8] Cameroun		[34] Brazzaville-Rep. Congo	[33] Nigeria	[37] Nigeria
Press/Solvent	Altech BE 100 4/4 (2,2kW)			-	Petroleum ether (harvest date: 01/30/87))			Hexane		Methanol/Chloroform (2/1)	Hexane	Petroleum ether
	E1*	E2	E3		A1**	A2	A3	C1***	C2			
C16:0	46.1	44.9	44.8	47.89	47.5	52.1	49.3	39.0	44.0	43.2 ± 0.4	17.18	44.31
C18:0	2.5	2.6	2.4	2.13	3.3	2.7	3.7	3.7	2.3	2.3 ± 0.1	14.84	8.07
C18:1	29.8	32.0	31.4	31.25	23.2	27.1	39.5	31.0	34.2	28.3 ± 0.1	40.45	42.45
C18:2	19.8	18.6	19.8	17.5	26.0	14.2	7.5	24.9	18.6	25.0 ± 0.1	23.17	5.17
C18:3	0.7	0.6	0.7	0.29	-	3.9	-	1.3	0.7	1.1 ± 0.9	-	-
C20:0	0.8	-	-	0.21	-	-	-	-	-		2.10	-

Notes. *Sample 1, **Tree 1, ***Cultivar 1

4. Conclusion

The pulp of the safou studied has an average oil content of 44.89%. The average extraction yield obtained by mechanical hot pressing was 36.44% for three trials, with a low standard deviation of 0.05%. This yield, which represents 81.18% of total oil, is very satisfactory for a screw press and exceeds those of previous studies, making safou a competitive oilseed compared to species currently in production.

The FA composition has a C16:0>C18:2>C18:1>C18:0>C18:3 profile already found in the literature, with saturated and unsaturated FA contents of around 50% and 48%, respectively, similar to those of oils found in the literature, extracted by pressing and solvent extraction. Mechanical pressure extraction has no influence on the fatty acid composition of safou pulp oil.

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