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Quassia undulata Oil Exploitation: Extraction's Yield, Phytochemical Profile of Seeds and Oilcake Nutritional Value

Ndiaye Seyni[1,2], Ndiaye Bou[1], Cissé Oumar Ibn Khatab[1], Cissé Mady[1], Gueye Mathieu[3], Qi Zhang[2], Ayessou Nicolas Cyrille Mensah[1*]

[1]Center for Studies on Food Safety and Functional Molecules (CESAM-RESCIF), ESP-UCAD, Dakar, Sénégal
[2]Oil Crops Research Institute of Chinese Academy of Agricultural Sciences (OCRI-CAAS), Wuhan, China
[3]Laboratoire UMI 3189, Institut Fondamentale d'Afrique Noire (IFAN) Cheikh Anta Diop, Département de Botanique et de Géologie, Dakar, Senegal
Email: *nayessou@yahoo.fr, *nicolas.ayessou@ucad.edu.sn

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Abstract

Quassia undulata is a plant that belongs to the Simaroubaceae family. In Africa, it occurs in the wooded savannah from Senegal in the west to the Central African Republic in the east. The seeds from the plant are very rich in oil. The traditional extraction of this oil involves a phase of boiling the powder from the seeds in a decoction of *Piliostigma thonningii* leaves. Thus, the aim of this study is to determine the impact of *Piliostigma thonningii* leaves on the extraction yield, to assess the phytochemical profile of seeds and oilcake and, to determine the nutritional value of the cakes obtained after extraction. Thus, the traditional extraction of oil was carried out in the laboratory and physico-chemical and phytochemical analyses were carried out on the water decoction, the oil and, the oilcake. The results showed that the traditional extraction gives a low extraction yield (5.18% with PD and 6.12% without PD) compared to the Soxhlet extraction (56.9%). On the other hand, it was found that oil obtained by traditional extraction in the presence of *Piliostigma thonningii* leaves was of better physicochemical quality. Finally, oilcake very rich in proteins (36.71% - 42.69%) and mineral elements (110.9 - 152.33 mg/100g of calcium, 544.75 - 620.77 mg/100g of Potassium and 331.11 - 459.68 mg/100g of Magnesium) justify their use in human food. However, investigations should point to the impact of this traditional technique on the elimination of quassinoids, toxins and antihelminth compounds present in the seeds.

Keywords

Quassia undulata, *Piliostigma thonningii*, Oil Extraction, Phytochemical

1. Introduction

The species *Quassia undulata* (*Q. undulata*), in Africa, occurs in the wooded savannah and is a small tree that can grow up to 8 m high [1]. *Q. undulata* belongs to the Simaroubaceae family [2] which includes 32 genera distributed in 170 species of trees and shrubs exclusively distributed in the tropics and subtropics [3]. The bitter taste of all the parts of the plants of this family constitutes one of their botanical identification criteria. These molecules, mainly quassinoids, are taxonomic markers of Simaroubaceae [3] [4]. In Senegal, the tree is found from Casamance region [5] to Kédougou region [2]. The oil from the seeds of *Q. undulata* is a good raw material for the production of high quality biodiesel [6] that is still extracted traditionally [7]. In Africa, the traditional way of extracting oil is mainly a mixture of water and powdered seeds. Mixing can be done at normal room temperature or at high temperature (boiling step) to separate the oil from the ashes [8]. Argan oil in Morocco [9], *Elaeis guineensis* oil, *Butyrospermum parkii* oil [10] or *Carapa* oil (*Carapa* spp. Meliaceae) [11] are extracted in that way. In some cases, plant leaves are added during the boiling step such as *Carapa procera*. The same procedures have been observed during traditional extraction of *Q. undulata* oil [7]. However, the physicochemical properties of the oil vary depending on the extraction method. Thus the objective of this study is to determine the impact of *Piliostigma thonnigii* leaves on the extraction yield, on the phytochemical profile and, on the physicochemical characteristics. The aim is also to determine the nutritional value of the oilcakes after extraction.

2. Materials and Methods

2.1. Oilseed Extraction

Oil extraction was done at the laboratory level on the one hand according to the traditional diagram and in another hand, by using Soxlhet method with hexane as solvent.

According to the traditional method, the powder of *Quassia undulata* seed was boiled in one part with the decoction of the leaves of *P. thonningii* and in another part with distilled water [7]. The oil was weighed at the end of the experiment. A second comparative extraction by solvent was done by using a Soxhlet extractor using hexane, for 6 hours. The total fat content, expressed as a percentage of the mass of the product, is given by the following formula:

$$MG = \frac{(M2 - M1)}{PE} * 100$$

PE: mass in grams of the test sample.

M1: mass in grams of the flask.

M2: mass in grams of the flask and the residue.

MG: fat content in percentage.

2.2. Phytochemical Screening of Seeds

The presence of saponins, tannins, steroids, flavonoids, and terpenes was eva-

luated in the decoction of *P. thonningii* leaves before and after oil extraction and in the oilcake.

2.2.1. Saponin Detection

The experiment was as conducted according to different authors [12] [13] [14]: Macerate for 24 hours 5 g of powder in 500 ml of distilled water and evaporate to dryness; recover the residues with 10 ml of distilled water; take 30 ml of the solution in 2 test tubes and shake for one minute and let stand for 30 minutes and finally measure the height of the persistent foam that indicates the presence of saponins.

2.2.2. Flavonoids Detection

Transfer 3 ml of each aqueous extract in two test tubes: add 1 ml of KOH and the other 1 ml of NaOH. The appearance of deep stains testifies the presence of flavonoids [12].

2.2.3. Tannins Detection

A few drops of 1% neutral ferric chloride solution were added to the plant extract. Blackish-blue color development indicates tannins' presence [15].

2.2.4. Terpenes Detection

According to the "Salkowski test," 5 ml extract was added with chloroform 2 ml and concentrated sulphuric acid 3 ml. A reddish-brown color of interface state of a positive result [14].

2.2.5. Steroids Detection

The experiment was done accordingly to the "Liebermann-Burchardt test." To 1 ml of methanolic extract, chloroform 1 ml, acetic anhydride 2 to 3 ml, and concentrated sulphuric acid 1 to 2 drops were added. A positive result is obtained when the color change to blue or green [14].

2.2.6. Polyphenols Detection

The experiment was done according to Ferric Chloride Test. To 2 ml of extract add alcohol and few drops of neutral ferric chloride solution. Formation of greenish blue colour indicates the presence of polyphenol [16].

2.3. Quantitative Phytochemical Characterization

Tannins were evaluated according to the colorimetric method of Folin Denis, described by Joslyn (1970) [17]. Flavonoids were determined according to previous author [18]. Total phenolics were evaluated using the spectrophotometric analysis with Folin-Ciocalteu's phenol reagent [19].

2.4. Oil Physicochemical Analysis

Oil samples traditionally extracted were subjected to chemical analysis. All the analysis was done in duplicate, and the results were given as mean ± standard deviation. The acid index was determined according to the standard method NF

ISO 660, while the Iodine index was conducted according to the standard method NF ISO 3961. The standard method NF ISO 3657 method was used to determine saponification index and NF ISO 3960 for peroxide index. The refractive index was determined on the perfectly anhydrous and filtered sample according to standard method NF ISO 6320 with a refractometer.

2.5. Oilcake Physicochemical Characterization

Total sugar was determined according to Luff-Schoorl method; Proteins according to Kjeldahl method and mineral elements (Ca^{+}, Na^{2+}, Mg^{2+} and K^{+}) using ionic chromatography method.

3. Results and Discussion

3.1. Extraction Yield

Soxhlet extraction gave an oil with a yield of 56.9%. This yield is quite similar to 55.6% obtained by Mirailles *et al.* 1988 [20]. The traditional way, carried out at the laboratory gave a yield of 6.12% with *P. thonningii* decoction (PD), and 5.18% without *P. thonningii* decoction. These values agree with those obtained during the survey done with women from Kedougou/Senegal (5.4% with PD and 5.3% without *PD*) [7]. There is no significant difference in oil extraction yield when the PD is used or not. Therefore the *P. thonningii* leaves role would be more to improve the oil physicochemical quality than to improve the extraction yield. However, oil extraction made with Soxhlet gave a yield 10 times higher than oil extraction done with traditional mode which is normal because soxhlet extraction is known to give the best conditions of extraction [21] [22]. **Table 1** gives the results of extraction yield according to extraction mode.

3.2. Phytochemical Profile of *P. thonningii*'s Decoction

Phytochemical tests were carried out on the decoction of *P. thonningii* leaves before and after oil extraction and on the oilcake. These tests consisted of qualitative and quantitative examinations of different elements. The results are given in **Table 2** and **Figure 1**.

3.2.1. Phytochemical Qualitative Tests Results

The *P. thonningii* decoction before and after extraction shows that tannins, polyphenols, steroids, flavonoids, saponins and, terpenes are normally present in

Table 1. Oil extraction yield according to extraction mode

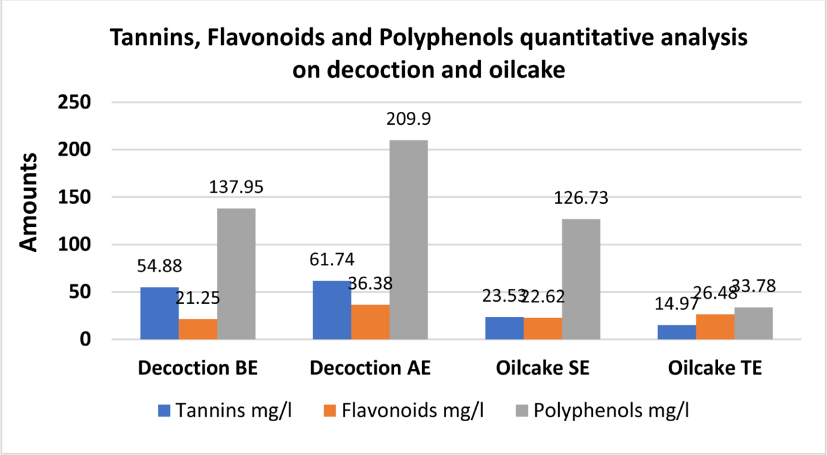
Extraction mode	Yields (%)
Soxlhet extraction	56.9[a]
TE with PT	6.12[b]
TE without PT	5.18[b]

*Same letter shows no significant differences; TE traditional extraction; PT *Pliostigma thonningii.*

Table 2. *Piliostigma* decoction qualitative phytochemical characterization

Compounds	*Pilliostigma* decoction before oil extraction	*Pilliostigma* decoction after oil extraction	Oilcake
Tannins	+	++	+
Polyphenols	+	++	ND
Steroids	+	++	ND
Saponins	+	+	+
Flavonoids	+	++	+
Terpenes	+	++	+

(−) absence; (+) presence; (++) presence in a higher level; (ND) not determined.



*BE: before extraction; AE: after extraction; SE: Soxhlet extraction; TE: traditional extraction.

Figure 1. Quantitative phytochemical coumponds of oilcake and *Pilliostigma* decoction before and after oil extraction.

the *Pilliostigma* leaves. This observation confirms previous results [22] [23] [24]. However, their a.mount increased after oil extraction. In fact, compounds move from the seeds to the water decoction during the oil extraction. Indeed, polyphenols [26], tannins [27], flavonoids [28], saponins [29] and terpenes [30] are usually extracted in the presence of water or a mixture of water with another solvent. In the oilcake, tannins, saponins, flavonoids and, terpenes are present but in lower intensity than in the decoction after extraction. This lower presence can be caused by the washing step noticed when doing the oil extraction. In fact, after oil extraction, oilcake is washed with water before its use as food [7]. Therefore, phytochemical compounds can be eliminated during these washing steps.

3.2.2. Phytochemical Quantitative Tests Results

The quantitative analysis of the tannins, flavonoids and polyphenols on the oilcake shows a significant difference in the content of tannins, flavonoids, and polyphenols between the oilcake obtained by Soxhlet and the oilcake obtained by traditional extraction (**Figure 1**). However, the polyphenol content difference is

much more significant with respective values of 126.73 mg/l and 33.78 mg/l. A better affinity of polyphenol compound to water instead of hexane can explain it [31]. So, it appears that with the traditional extraction, phenolic compounds tend to be lowered in the oilcake.

The *Pilliostigma* decoction analysis shows that the polyphenolics compounds, the tannins, and the flavonoids amount increase after oil extraction. It highlights that these compounds moved from the seed to the decoction during the oil extraction. However, the tannins' and flavonoids' amount present in the oilcake is higher than in the decoction (tannins 6.86 against 14.97 and flavonoids 15.13 against 26.48). On the contrary to the polyphenolic compound content which is higher in the decoction (71.95 against 33.78).

3.3. Physico-Chemical Parameters of *Q. undulata* Oil

According to the extract methods, *Q. undulata*'s oil present various characteristics summarisez in Table 3.

It appeared that *Q. undulata* oil extracted with and without PD presented almost same peroxide value, saponification value and refractive index. However, iodine value and acid value were quite different. The iodine value was more elevated in the oil extracted with PD and the acid value more elevated in the oil extracted without PD. Decrease in iodine value shows decrease in the number of double bonds and it indicates the oxidation of the oil [32] showing that *Q. undulata* oil is more oxidated when extracted without PD. The acid value is used as an indicator for the edibility of the oil. When the acid value exceeds 4 mg KOH/g, the oil is not suitable for edible purposes [33]. Therefore, oil obtained with TE without PD is not suitable for edible utilization because the acid value is about 7.333 mgKOH/g. Therefore, these results show that oil extraction with PD gives better physico-chemical characteristics. In the future, tests can be made to identify the mechanism of oil quality improvement by PD leaves.

3.4. Oilcake Nutritional Value

After oil extraction, cake is consumed. Thus, it seems necessary to evaluate its nutritional value summarized in Table 4.

The protein and mineral contents are higher in the sample from Ebarack

Table 3. Physicochemical parameters of *Q. undulata*'s oil traditionally extracted.

Parameters	Oil extracted with PD	Oil extracted without PD
Refraction value	1.46 ± 0.000	1.46 ± 0.000
Acid value (mg/g)	3.070 ± 0.554	7.33 ± 0.465
Saponification value (mg/g)	198.35 ± 2.267	198.17 ± 0.190
Peroxyde value (meq/kg)	4.45 ± 0.042	4.94 ± 0.523
Iodine value (g/100g)	30.04 ± 0.072	21.45 ± 2.440

PD: *Pliostigma* decoction.

Table 4. Oilcake nutritional value of *Q. undulate.*

Samples	Proteins %	Minerals				Total sugar (mg/100g)
		Na (mg/100g)	Mg (mg/100g)	Ca (mg/100g)	K (mg/100g)	
Sample 1	42.69	32.91	459.68	152.33	620.77	1.05
Sample 2	36.71	16.35	331.11	110.9	544.75	1.15

*Sample 1 comes from Ebarack village and sample 2 from Eganga village (these villages are located in Salemata department in the Region of Kedougou in southeastern Senegal).

Table 5. Comparison of mineral composition between sesame, peanut and *Quassia* seeds.

Minerals (mg/100g)	Peanut [40]	Sesame [40]	*Quassia undulata*
Ca^{2+}	73.8	962	110.9 - 152.33
Mg^{2+}	315	324	331.11 - 459.68
K^{+}	980	468	544.75 - 620.77

(sample 1). These differences could be due to the environmental factors [34] [35] or due to the quality of the seeds and storage parameters [36].

The protein content of the meal varies from 36.71% to 42.69%. These levels are comparable to those of soybean and peanut meal which are respectively 39.15 g/100g and 32.17 g/100g [37]. The sugar content on the other hand is very low (≈1 mg/100g). A rapid comparison between oil cakes from sesame and peanuts (**Table 5**) showed that the magnesium content of *Quassia* seeds is higher than those of sesame and peanuts. Thus, *Q. undulata* meal could also be used to feed poultry [38] or sheep [39].

The potassium content is also higher than that of sesame but however is much lower than that of peanuts. Regarding calcium, the values obtained for *Quassia* are higher than those for peanuts but much lower than those for sesame. These results show that Quassia seeds are a good source of protein and minerals. Their use as supplementation foods could indeed be considered. In fact, according to the FAO, the daily intakes of potassium [41], calcium, magnesium [42] and sodium [43] are respectively 3510 mg/day, 1000 mg/day, 200 mg/day and 2 g/day for adults; therefore, *Quassia* seeds could help to complete these daily intakes.

4. Conclusion

These results allow us to continue investigations on the role of *P.* during *Quassia undulata* oil's extraction. It appeared that traditional extraction gives a low extraction yield that needs to be optimised. On the other hand, it was noted that the oil obtained by traditional extraction with *Piliostigma thonnigii* leaves decoction has a better quality. However, *Piliostigma thonnigii* key role in Quassinoids elimination should be determined. Finally, cakes which are rich in protein and mineral elements such as magnesium and potassium are a good resource for animal feed as well as for supplementation in human food.

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Conflicts of Interest

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

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