

Physicochemical characteristics and fatty acid composition of kernels oil from four mangoes varieties (*Mangifera indica*) (Kent, Brooks, Keitt and Amelie) harvested, processed in North of Cote d'Ivoire

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Abstract

Mango seeds are discarded as waste after the extraction of mango juice. This study aims to valorise the kernels oils of mango (*Mangifera indica*). In this study, the kernel of four mango varieties (Amelie, Brooks, Kent and Keitt) that are grown and processing in north of Cote d'Ivoire investigated were used. The oils of these kernels were extracted by Soxhlet at 80 °C. Their physicochemical properties were determinate using standard methods. Physicochemical properties of the kernels oil were: specific gravity, 0.80±0.08 to 0.93±0.01; refractive index (50 °C), 1.43±0.07 to 1.47 ± 0.10; iodine value, 44.84 ± 0.05 to 59.41 ± 0.03 g I₂ /100 g; peroxide value, 0.50 ± 0.00 to 1.90 ± 0.00 meq.O₂/kg; acid value, 2.00 ± 0.00 to 7.65 ± 0.01 mg of KOH/g and saponification value, 167.53 ± 0.04 to 188.44 ± 0.04 mg KOH/g. Results revealed that these kernels oil contained a significant presence of oleic (31.14 ± 0.27 to 37.19c ± 0.23) and stearic (20.11 ± 0.12 to 40.43 ± 0.03) fatty acids. All these interesting characteristics confirm their usefulness for different nutritional and industrial applications.

Keywords: Mango varieties; Kernel oil; Physicochemical properties; Fatty composition

1. Introduction

The mango (*Mangifera indica*) is a fruit widely produced in tropical and subtropical regions [1]. Its global production is estimated at forty-five million tons in 2014 and is about 1,374,000 tons in 2010 in West Africa. In Côte d'Ivoire, the orchard is concentrated in the northern zone, in the savannah regions (Korhogo, Sinématiali, Ferkessédougou and Odienné) [3]. However, the country's mango industry is facing a conservation problem. Fruit processing is one of the main ways to overcome this problem. Thus, three new dried mango production units have been opened in the north of the country. Despite the importance of export, some of the mango, Kent, Keitt, Brooks and Amelie varieties are increasingly processed [4]. However, this processing generates by-products (epicarp and seed) that are considered waste and become a source of environmental pollution and loss of profit. There is therefore a need to treat these wastes. The recovery and valorisation of this food waste, hence, represents a major challenge, both from an economic and ecological point of view.

Mango kernel represents about 20 % of the whole fruit and 75 % of the stone [5]. Mango kernel oil may be defined as oil fraction extracted from stone of mango fruit. Mango kernel produces 12–15 % edible oil [6]. It can be utilized for the preservation of fats and oils, supplementation of sunflower oil and tallow, improved their oxidative stability [7, 8]. Chemical characterization of mango kernel revealed that oleic acid, palmitic and stearic are the major fatty acid, solid

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fat index of Mango kernel oil was zero at human body temperature, the melting point ranges from 32 to 36 °C, which offers wide range of applications in trans free options, without partial hydrogenation and as a cocoa butter substitute [9]. On account of abundant mango production, nutraceutical characteristics, Mango kernel oil has the potential to become a commercial source of edible oil [6].

A previous study has reported that the kernels oil of four varieties of mango (*M. indica* i.e., Amelie, Brooks, Kent and Keitt) contained considerable quantities of oil [10]. However, further research on the chemical composition and other properties of these almond's oil is necessary to evaluate their potential as sources of quality raw material for the industry. In this new study, it is about to extract and characterize the mangoes kernels oil of four varieties of mango.

2. Material and methods

2.1. Procurement of the material

Four popular varieties of mangoes (*Mangifera indica*) (Kent, Brooks, Keitt and Amelie) were selected and harvested at physiological maturity in the plantations of the Korhogo cooperative, located in the Poro region, 635 km from the city of Abidjan and between 9°27 north latitude and 5°38 west longitude. The *Amelie* variety represents the early variety, *Kent* and *Keith* represent the full season varieties and *Brooks* the late variety. The harvest was done during the 2019 and 2020 fruiting seasons in March to April for the *Amelie* variety; April to July for the *Kent* variety; June to August for the *Keith* variety and July to August for the *Brooks* variety.

The samples were brought to the Biocatalysis and Bioprocessing Laboratory of Nangui Abrogoua University. The fruits were thoroughly washed with double distilled deionized water to remove any pollutant, pesticide residues, dirt, and dust on the surface. They were then kept for ripening at room temperature within three (3) days for the *Amelie* variety and seven (7) days for the other three varieties [11].

All solvents and reagents used were of analytical grade (E. Merck, Darmstadt, Germany), unless otherwise stated and the solutions were prepared with distilled water.

2.2. Preparation of Mangoes Kernels flours

The mangoes were sorted, washed, wrung, and peeled with a stainless-steel knife. Almonds are then manually extracted after pitting the fruits with the same knife. The weighed samples of kernels were oven dried at 50 °C for 72 hours and then crushed in a blender to obtain flours, used as material

2.3. Oil kernel Extract

20.0 g of powder kernels were extracted with hexane by Soxhlet at 80 °C (3 x 200 ml, 8 h each). The solvent was dried over anhydrous sodium sulphate. The filtered solvent was evaporated under vacuum to afford a lipid pale yellow semisolid (1.4 g, 6.1% w/w) and a defatted part of the mango used (18.3 g, 91.6% w/w).

2.4. Analytical Methods

Determination of the fatty acid methyl esters Gas-liquid chromatography was used for fractionation and determination of fatty acid methyl esters according to the method described by Zygadlo *et al.* [12].

Determinations for peroxide, iodine, and saponification values and free fatty acid contents were carried out using standard analytical methods [13].

Physical properties included specific gravity, moisture, refractive index and melting point were determined according to AOCS. [14].

2.5. Statistical Analysis

All chemical analyses and assays were performed in triplicate, unless otherwise indicated. Results were expressed as mean values \pm standard deviation (SD).

Analysis of variance (ANOVA) followed by Duncan's test was performed to test for differences between means by employing Kyplot (version 2.0 beta 15, c1997-2001, Koichi Yoshioka) statistical software.

3. Results and discussion

3.1. Physical properties

The extraction yields and the physical properties of the four varieties of mangoes studied were showed in table 1.

The result of table 1 showed that the oil yields of mango kernel were between 9.51 ± 0.09 to $13.45 \pm 0.60\%$. These yields were low compared to those of oleaginous seeds [15]. The results showed that certain almonds of mango contain more oil than other. The oil yields of Brooks and Kent varieties were higher while Keitt and Amelie varieties were weaker.

Physical properties including specific gravity, moisture, refractive index and melting point of the four varieties of mango seed kernel oil were determined (Table 1). The moisture contents of oils of mango kernels is between 0.19 ± 0.01 and $0.45 \pm 0.4\%$. These values were higher than the maximum level recommended by the regulations for vegetable oils and butters (0.2%) [16] except the *Kent* ($0.19 \pm 0.01\%$) value. The high presence of water could promote enzymatic activity. This suggests that our oils (Amelie, Brooks and Keitt) were more likely to suffer the hydrolytic or enzymatic alteration that leads to the formation of secondary products such as monoglycerides and diglycerides. These high values could also reflect the hygroscopic nature of these oils in the presence of moisture in the air [17].

The density of the oils depends on its chemical composition. The densities of the oils of mango kernels were between 0.80 ± 0.08 and 0.93 ± 0.01 g/cm³ at 25 °C. These values were similar to those of butter and vegetable oils such as shea butter (0.9), cocoa butter (0.88-0.90), palm oil (0.89- 0.90) and cotton oil (0.91-0.92) [16].

The refractive index depends also on the chemical composition of the oil and the temperature. This index grows with the unsaturation or with the presence on the fatty chains of secondary functions. The refractive index values of oils of four varieties of mango kernels were between 1.43 ± 0.07 and 1.47 ± 0.010 at 50 °C. From these results, it could be noticed that these values were in agreement with those reported by other authors [18, 19]. The refractive index of the oil of the Kent variety (1.47 ± 0.010) was higher. This variety reflect a degree of insaturation higher than other varieties.

Data obtained showed these mangoes oils melt over a wide temperature range (17.64 ± 0.03 – 34.32 ± 0.03 °C).

Table 1 Physical characteristics of varieties mangoes kernel oils

Parameters	Mangoes varieties			
	Amelie	Brooks	Kent	Keitt
Fat content	9.51 ± 0.09^a	13.45 ± 0.60^d	11.87 ± 0.45^c	10.75 ± 0.90^b
Moisture (%)	0.45 ± 0.4^c	0.25 ± 0.03^b	0.19 ± 0.01^a	0.27 ± 0.02^b
Melting point (°C)	20.23 ± 0.03^c	26.42 ± 0.02^a	34.32 ± 0.03^d	17.64 ± 0.03^b
Refractive index at 50°C	1.46 ± 0.03^a	1.45 ± 0.05^a	1.47 ± 0.10^a	1.43 ± 0.07^a
Relative density of fat (g/cm ³) at 25 °C	0.87 ± 0.04^a	0.80 ± 0.08^a	0.93 ± 0.01^a	0.90 ± 0.06^a

Values are mean \pm standard deviation of three measurements (n = 3). For each line, identical script indicates no significant difference at $p < 0.05$ according to the Kruskal-Wallis test between mean values

3.2. Chemical properties

Chemical characteristics including free fatty acid, peroxide value, iodine number, saponification number and unsaponifiable matter of mango seed kernel oil were shown in table 2. The chemical properties of oil are amongst the most important properties that determines the present condition of the oil. The acid value and peroxide values are valuable measures of oil quality.

The acid value is an important index to evaluate the quality of oil since it measures the content of free fatty acids formed after the hydrolytic degradation of lipid molecules, and can be used to indicate the degree of rancidity in oil hydrolysis [20]. The acid value contents ranged from 2.00 ± 0.00 to 2.364 ± 0.00 mg KOH g⁻¹ fat for oils of three varieties of mango kernels (Brooks, Kent and Keitt). they were very low compared to the maximum limit of 5% for acids value in high grade palm oil in Nigeria [21]. The low acidity of these oils indicated that the mangos kernels oil, unlike the *Amelie* variety, was almost free from hydrolytic rancidity brought almost by lipases and enables the direct use of such oils in industries without further neutralization [22]. These mangoes kernels oils unlike the *Amelie* variety could be suitable for cooking as their acid values fall within the maximum limit of 3.00 mg KOH/g recommended for cooking oils [23].

An abundance of primary products, peroxides and hydroperoxides, were formed in oils via autoxidation during the oxidation process [24]. The peroxide values can be used as an oxidative index for the early stages of lipid oxidation, and a higher oxidative stability is usually accompanied by a slower increase in the peroxide values. The peroxide value of the oils of four varieties of mango kernels were between 0.50 ± 0.00 and 1.90 ± 0.00 meq de O₂ kg⁻¹ fat. The peroxide value of kernel mango oils and butters are lower than the allowed value for crude vegetable oils (≤ 15 meq / kg oil) [16].

The iodine value is a chemical parameter that presents the degree of unsaturation of a fat. The iodine value of oils of mango kernel are between 44.84 ± 0.05 and 59.41 ± 0.03 gI₂/100g. The obtained iodine values agreed with values reported for palm oil (50-55 gI₂/100g) [16].

As for the saponification value, oils of the four varieties mangoes kernels value ranged between 167.53 ± 0.04 to 188.44 ± 0.04 mg KOH/g. High saponification value indicated the presence of greater number of ester bonds, suggesting that the fat molecules were intact. Thereby, these mangoes kernels oils, especially mango kernel oil of the *Kent* variety (188.44 ± 0.04 mg KOH/g), could also be recommended in soap making regarding its higher saponification value close than that (187-193 mg KOH/g) of palm oil extensively used in soapmaking [25].

Unsaponifiable matter is component of an oily mixture which fails to form soap when blended with NaOH. The composition of unsaponifiable matter of vegetable oils including tocopherols, sterols and squalene is of great importance for oil characteristics and stability [26]. The results show that the various oils of mango kernels contain 0.94 ± 0.26 to 1.90 ± 0.22 % of unsaponifiables. Except *Kent* (0.94 ± 0.26) and *Brooks* (1.00 ± 0.16) varieties, these values are higher than those of vegetable oils in general ($\leq 1\%$) [16].

Table 2 Chemical characteristics of varieties mangoes kernel oils

Parameters	Mangoes varieties			
	Amelie	Brooks	Kent	Keitt
Acid value (mg KOH g ⁻¹ fat)	7.65 ± 0.01^b	2.20 ± 0.00^a	2.36 ± 0.00^a	2.00 ± 0.00^a
Iodine value (Wijs) gI ₂ /100g	57.63 ± 0.05^c	50.76 ± 0.04^b	59.41 ± 0.03^d	44.84 ± 0.05^a
Saponification number (mg KOH g ⁻¹ fat)	167.53 ± 0.04^a	179.90 ± 0.08^b	188.44 ± 0.04^c	168.08 ± 0.02^a
Unsaponifiable matter (% of total lipid)	1.74 ± 0.08^b	1.00 ± 0.16^a	0.94 ± 0.26^a	1.90 ± 0.22^b
Peroxide value (meq de O ₂ kg ⁻¹ fat)	0.50 ± 0.00^a	1.90 ± 0.00^b	0.63 ± 0.003^a	1.64 ± 0.00^b

Values are mean \pm standard deviation of three measurements (n = 3). For each line, identical script indicates no significant difference at $p < 0.05$ according to the Kruskal-Wallis test between mean values

3.3. Fatty acid composition

The fatty acid composition of the four varieties of mangoes kernel oils studied was showed in table 3. These results showed that the oils of the almonds mangoes were predominantly rich in oleic acid (31.14 ± 0.27 - $37.19 \pm 0.23\%$) followed by stearic acid (20.11 ± 0.12 - $40.43 \pm 0.03\%$). The predominance of oleic acid was also observed in nut oils like almond (43-75%), cashew (57-64.2%), hazelnut (76-82%), macadamia (34-75%) pecan (40.6-75%) and pistachio (52-70%) [27]. On the other hand, the minor amounts of fatty acids composition were found to be 3.70 ± 0.38 to $16.91 \pm 0.27\%$, 5.34 ± 0.13 to $14.27 \pm 0.33\%$, 2.26 ± 0.09 to $11.69 \pm 0.17\%$, 4.03 ± 0.23 to $9.83 \pm 0.15\%$, 1.85 ± 0.02 to $7.11 \pm 0.05\%$ and 0.54 ± 0.21 to $6.81 \pm 0.05\%$ for Linoleic acid, Linolenic acid, Arachidic acid, Lauric acid, Myristic acid and Palmitic acid respectively. These results confirmed those of Abdalla *et al.* [7] and Nzikou *et al.* [28]. The proportion of

unsaturated fatty acids was greater than the saturated fatty acids in two varieties of mangoes kernel oils (Kent and Amelie). The high unsaturated fatty acids content in these two varieties of mangoes kernel oils could be explained by the high iodine values. The abundances of unsaturated fatty acids in the oil are desirable from nutritional and health points of view as unsaturated fatty acids consumption will not lead to heart related diseases [29]. The consumption of polyunsaturated and monounsaturated fatty acids has been recommended to improve the lipid profile. Unlike, excessive consumption of saturated fatty acids is implicated to the increase of the plasmatic cholesterol, the obesity and certain cardiovascular disorders like atherosclerosis [30]. The major unsaturated fatty acids these two oils were oleic acid ($37.19 \pm 0.23\%$ for Amelie to $31.70 \pm 0.20\%$ for Kent), Linoleic acid ($8.01 \pm 0.24\%$ for Amelie to $16.91 \pm 0.27\%$ for Kent) and Linolenic acid ($5.34 \pm 0.13\%$ for Amelie to $8.96 \pm 0.25\%$ for Kent). Linoleic acid and Linolenic acid are an essential fatty acid, they required for growth, physiological functions and body maintenance [31]. Mono unsaturated fatty acids as oleic acid is increasingly recommended for consumption since it seems not to affect the HDL levels, and it may reduce the LDL and triacylglycerols blood levels, that make it more effective in prevention of heart diseases.

Table 3 Fatty acid composition of varieties mangoes kernel oils

Fatty acid (%)	Mangoes varieties			
	Amelie	Brooks	Kent	Keitt
Lauric Acid	4.03 ± 0.23^a	5.23 ± 0.04^b	$6.14^{c \pm 0.03^c}$	9.83 ± 0.15^d
Palmitic Acid	0.54 ± 0.21^a	5.67 ± 0.07^b	6.81 ± 0.05^c	5.52 ± 0.09^b
Stearic Acid	40.43 ± 0.03^d	23.63 ± 0.11^c	20.11 ± 0.12^a	22.90 ± 0.23^b
Arachidic Acid	2.61 ± 0.10^a	11.69 ± 0.17^c	2.26 ± 0.09^a	7.54 ± 0.22^b
Linolenic Acid	5.34 ± 0.13^a	8.58 ± 0.19^b	8.96 ± 0.25^b	14.27 ± 0.33^c
Linoleic Acid	8.01 ± 0.24^b	3.78 ± 0.20^a	16.91 ± 0.27^c	3.70 ± 0.38^a
Oleic Acid	37.19 ± 0.23^c	36.27 ± 0.25^b	31.70 ± 0.20^a	31.14 ± 0.27^a
Myristic Acid	1.85 ± 0.02^a	5.15 ± 0.09^b	7.11 ± 0.05^c	5.10 ± 0.01^b
Saturated	49.46 ± 0.08^b	51.67 ± 0.14^c	42.43 ± 0.08^a	50.89 ± 0.06^b
unsaturated	50.54 ± 0.12^b	48.33 ± 0.01^a	57.57 ± 0.31^d	49.11 ± 0.18^a

Values are mean \pm standard deviation of three measurements (n = 3). For each line, identical script indicates no significant difference at $p < 0.05$ according to the Kruskal-Wallis test between mean values.

4. Conclusion

The present study on the physicochemical properties and fatty acid composition of the kernels oil of four varieties of mango (*M. indica* i.e., Amelie, Brooks, Kent and Keitt) in order to contribute to their valuation, suggests that these kernels could be considered as edible oil sources. The study of these mangoes' almond has revealed the presence of about 10% oil. The study of their lipid compositions revealed a significant presence of oleic and stearic fatty acids, hence they potential use in dietetics and pharmacology. The kernels oils of the of mangoes especially the *Kent* variety can also be used in soapmaking, given their high saponification indices. The properties of oils extracted revealed that the almonds oil of four varieties of mango are a good source of oil which could be employed for industrial purposes.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest amongst the authors as all the authors contributed in one way or the other in conducting the research and in writing the manuscript which was eventually articulated and submitted for publication by the corresponding author.

Statement of ethical approval

This research is in full compliance with ethical standards and moreover, neither human nor animal subjects were used while conducting this research.

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