



Research Article

Fatty Acid Profiles and Physicochemical Properties of Kernels from Four Senegalese Varieties of *Mangifera indica* L

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Abstract

The mango (*Mangifera indica*), belonging to the genus *Mangifera* of the family Anacardiaceae, is cultivated worldwide as an economically important fruit crop. It is also widely used in traditional medicine, which has stimulated growing interest in investigating and evaluating the therapeutic potential of its bioactive compounds. This study was carried out to assess physicochemical parameters and fatty acid composition of *Mangifera indica* seed oil collected from four Senegalese varieties. The oil contents obtained for the four varieties were 7.08%, 7.5%, 7.3 and 7.11% respectively for Sewe, Bouka, Palmer and Dieg bou gate. The oils, which were characterized by Gas Chromatography (GC) with Flame Ionization Detector (FID), were mainly composed of stearic acid, ranging from 41.849 ± 0.048 to $47.793 \pm 0.071\%$, and oleic acid from 31.085 ± 0.153 to $39.053 \pm 0.050\%$. Among the four Senegalese mango cultivars, Palmer has the highest oleic acid content ($39.053 \pm 0.050\%$). Significant amounts of palmitic, linoleic, and arachidonic acids were also detected, while the remaining fatty acids in the mango kernel were present only in trace amounts. The saponification values were identified to be in the range of 212.9 - 234.2 mg KOH/g of oil, and the iodine values ranging from 50.4 to 59.7 g I₂ /100 g of oil. The study showed that oils from different Senegalese cultivars of *Mangifera indica* have potential for various industrial applications.

Keywords

Oil, Fatty Acids Profile, Saponification Value, Iodine Value, GC/FID

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1. Introduction

Commonly known as mango, *Mangifera indica* belongs to the genus *Mangifera* of the family Anacardiaceae. Native to South Asia, *Mangifera indica* was introduced into East Africa between the 10th and 12th centuries through Arab trade routes and later disseminated to West Africa during the 15th and 16th centuries by Portuguese explorers. It is one of the oldest cultivated fruit trees [1, 2]. Apart from its very famous and appreciated fruits, various parts of *Mangifera indica* (bark, leaves, roots, fruits, and flowers) have traditionally been used to treat a wide range of health conditions, including anemia, malaria, diarrhea, gastrointestinal, genitourinary, ophthalmic, and respiratory conditions [3-5].

Numerous studies have investigated the pharmacological potential of *Mangifera indica*. Different parts of *M. indica* have been reported to exhibit antioxidant, anti-inflammatory, anti-diabetic, antibacterial, antifungal, anthelmintic, gastro-protective, hepatoprotective, antiplasmodial, and anticancer properties [6, 7].

A wide range of chemical compounds has been identified in *Mangifera indica*, among which polyphenols such as flavonoids, xanthenes, and phenolic acids are the most abundant [8]. Long-chain hydrocarbons and fatty acids identified in the kernel include stearic, eicosanoic, linoleic, linolenic, oleic, arachidonic, and palmitic acids [9]. The fat has numerous applications in both the cosmetic and food industries, particularly as a cocoa butter equivalent. Its incorporation into edible lipids and dairy products, such as sunflower oil, butter, and Gouda cheese, significantly enhances their oxidative stability [10].

Senegal is one of the largest mango producers in West Af-

rica. However, after consuming the pulp, the seeds are discarded, leading to environmental pollution, even though the mango kernel holds significant potential that could be exploited. Based on this context, this study focused on estimating the fatty acid composition of the oil extracted from four mango seed varieties.

2. Materials and Methods

2.1. Sample Collection

Kernels from four *Mangifera indica* varieties (Sewe, Bouka, Palmer, and Dieg bou gate) were collected from cultivated trees in Diender (14°52'28.0"N 17°05'09.0"W), Thies, Senegal. A voucher specimen of each plant part studied was deposited in the herbarium of the Laboratory of Pharmacognosy, Faculty of Medicine, Pharmacy and Odontology, Cheikh Anta Diop University of Dakar, Senegal. The plant material was shade-dried under ventilation for six weeks and then ground into a fine powder using a Brabender mechanical grinder.

2.2. Oil Extraction

To extract the oil from mango kernels, 50 g of powder were macerated in 350 mL of hexane four times for 2 hours each. After extraction, the solution was filtered and solvent evaporated of the solvent using a rotary evaporator. The yields of total fat were determined on a dry matter basis using the following equation:

$$\text{Total fat yield} = \frac{\text{Weight of fat extracted (g)}}{\text{Weight of mango kernel powder (g)}} \times 100$$

(for quantification of minor fatty acids) or a 25 mL flask (for quantification of major fatty acids) and brought up to the mark with hexane.

2.3. Methyl Esterification of the Fatty Acids

Methyl esters were prepared according to a general method standardized by the French Association for Standardization (AFNOR) [11]. In a 50 mL flask, 100 mg of oil (hexane extract) and 20 mg (or 1 mg for the quantification of minor fatty acids) of methyl heptadecanoate (internal standard) were introduced. To carry out saponification, 4 mL of methanolic KOH solution was added to the flask, which was then heated under reflux in an oil bath at 105°C for 10 minutes. After cooling to room temperature, 4 mL of boron trifluoride in excess methanol (BF₃/MeOH, 12% w/w) were added. The flask was returned to the oil bath and heated under reflux at the same temperature and the same duration as before. The methyl esters were extracted with 3 x 10 mL of hexane. The organic phase was then washed with 30 mL of distilled water and dried over magnesium sulfate. After filtration, the hexane solution containing the methyl esters was concentrated under reduced pressure. The residue was transferred into a 5 mL flask

2.4. Determination of Fatty Acid Composition by Gas Chromatography (GC) with Flame Ionization Detector (FID)

The resulting methyl esters were analyzed by Agilent 7820A gas chromatography equipped with flame ionization detector (FID) and a BPX70 capillary column (30 m x 0.22 mm; film thickness 0.25 µm) was used. The analysis was performed with helium (1.0 mL/min) as a carrier gas at the following temperature program: 160°C held for 15 min, after which the temperature was increased to 200°C at a rate of 10°C/min and the temperature was kept for the subsequent 10 min. The injector temperature was set at 270°C. For identification of fatty acids, retention times were compared to fatty acid methyl ester standards. Quantification was performed using peak area normalization.

Each sample was analyzed in triplicate. Comparisons with standards allowed the identification and quantification of the compounds.

2.5. Physicochemical Characteristics of the Extracted Oil

Saponification value and iodine value were determined according to the French Association for Standardization (AFNOR) [12].

2.5.1. Determination of Saponification Value (SV)

In a conical flask containing 2 g of mango kernel sample, 25 mL of alcoholic potassium hydroxide was added, and then the mixture was heated under reflux for 60 minutes. Immediately, few drops of phenolphthalein were added, and the hot solution was titrated with hydrochloric acid solution 0.5 N. A blank test was carried out. The following formula was used to calculate saponification value:

$$\text{Saponification Value} = \frac{(V_A - V_B) \times N \times 56.1}{W}$$

W = sample weight, V_A = Volume of KOH used for the blank (mL), V_B = Volume of KOH used for the sample (mL), and N = normality of hydrochloric acid used.

2.5.2. Determination of Iodine Value (IV)

Into a conical flask, 0.15 g of the sample, and followed by the addition of 25 mL of cyclohexane and a slow addition of 10 mL of Wijs reagent (iodine monochloride in glacial acetic acid). The conical flask was closed and kept in the dark for 45 minutes, with frequent shaking. Then, 100 mL of distilled water and 15 mL of 100 g/L potassium iodide solution were added. The whole was shaken and kept in the dark for a few minutes. The solution was titrated with 0.1 N sodium thiosulphate, using the starch solution as an indicator, which was added near the end of the titration. A blank test was performed in parallel. IV was calculated using the equation:

$$IV = \frac{(V_A - V_B) \times 1.269}{W}$$

W = the sample weight, V_A = the volume of 0.1 M sodium thiosulphate solution used for titration blank sample, and V_B = the volume of 0.1 M sodium thiosulphate solution used for titration of the sample.

3. Results and Discussion

3.1. Fatty Acid Composition

The profiles (GC chromatogram) of the fixed oils extracted from the kernels of the four *M. indica* varieties were shown in Figures 1-4.

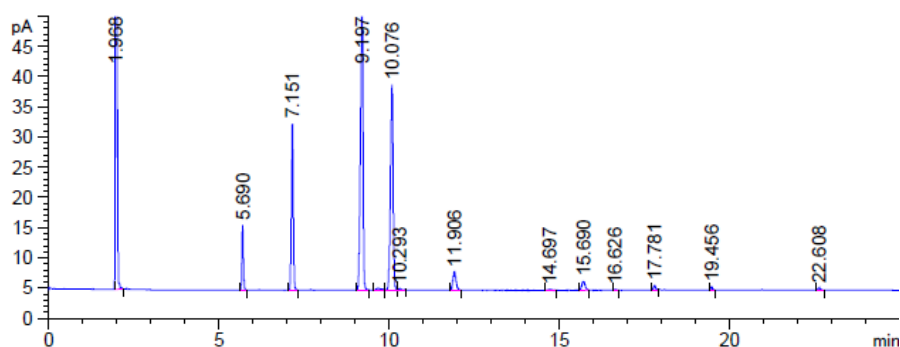


Figure 1. GC chromatogram for fatty acid methyl esters of Sewe variety.

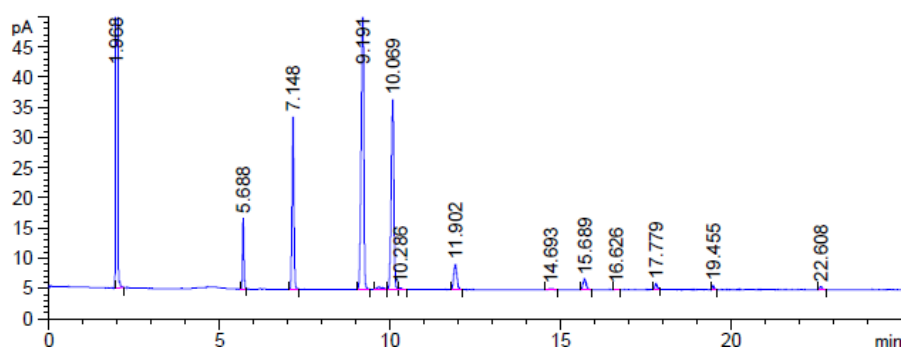


Figure 2. GC chromatogram for fatty acid methyl esters of Bouka variety.

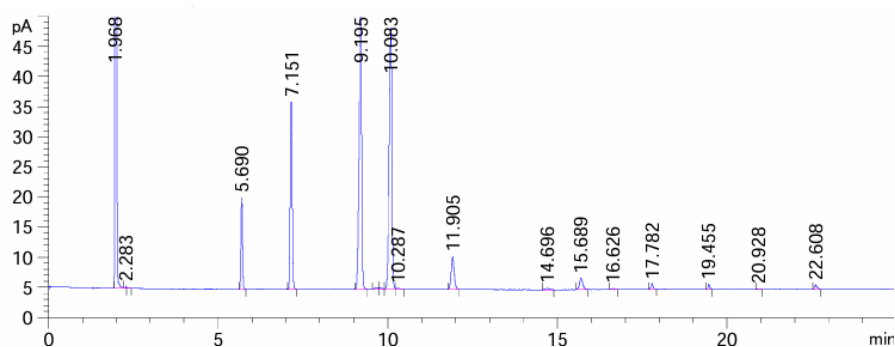


Figure 3. GC chromatogram for fatty acid methyl esters of Palmer variety.

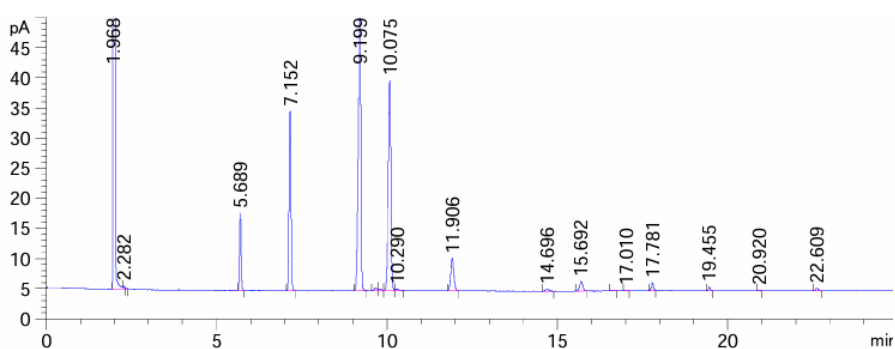


Figure 4. GC chromatogram for fatty acid methyl esters of Dieg bou gate variety.

Several compounds were identified, and the fatty acid composition was expressed as a percentage of the total fatty acid content of each oil (Table 1).

Table 1. Fatty acid profiles (%) of seed oil of Sewe, Bouka, Palmer and Dieg bou gate cultivars.

Fatty acids	Retention time (min)	Sewe	Bouka	Palmer	Dieg bou gate
Palmitic acid	5.73	9.977 ± 0.009	10.309 ± 0.011	11.369 ± 0.008	10.592 ± 0.005
Stearic acid	9.22	46.298 ± 0.082	46.046 ± 0.223	41.849 ± 0.048	47.793 ± 0.071
Oleic acid	10.23	33.815 ± 1.021	31.085 ± 0.153	39.053 ± 0.050	32.458 ± 0.049
linoleic acid	11.99	3.970 ± 0.005	5.338 ± 0.035	6.112 ± 0.007	6.403 ± 0.003
Palmitoleic acid	6.32	0.074 ± 0.002	0.0768 ± 0.001	0.0633 ± 0.001	0.073 ± 0.001
Vaccenic acid	10.36	0.251 ± 0.001	0.168 ± 0.003	0.116 ± 0.003	0.213 ± 0.006
Linolenic acid	14.74	0.244 ± 0.001	0.275 ± 0.001	0.151 ± 0.002	0.339 ± 0.001
Arachidonic acid	15.73	1.709 ± 0.005	1.667 ± 0.009	1.084 ± 0.013	1.348 ± 0.007
Gadoleic acid	16.65	0.146 ± 0.001	0.152 ± 0.006	0.084 ± 0.002	0.137 ± 0.008
Eicosadienoic acid	17.94	0.144 ± 0.001	0.085 ± 0.004	0.111 ± 0.001	0.094 ± 0.001
Behenic acid	19.47	0.358 ± 0.002	0.360 ± 0.001	0.248 ± 0.002	0.314 ± 0.001
Lignoceric acid	22.62	0.361 ± 0.003	0.429 ± 0.003	0.300 ± 0.002	0.305 ± 0.002

Over the past few decades, the mango kernel has attracted particular interest because it is a suitable source of

fats beneficial to human health and nutrition [13]. The chromatographic profiles obtained from the quantitative

and qualitative analyses of the analyses show that these four kernels have almost identical fatty acid compositions (Figures 1-4). Table 1 presents the main fatty acids found in the kernel of *M. indica*. We note that oils of the four *M. indica* varieties are predominantly composed of stearic acid ranging from 41.849 ± 0.048 to $47.793 \pm 0.071\%$ and oleic acid from 31.085 ± 0.153 to $39.053 \pm 0.050\%$. According to the literature, the main fatty acids of mango seed kernel are oleic acid and stearic acid [14-16]. It is worth noting that among the four mango varieties, Palmer cultivar exhibits the highest oleic acid content ($39.053 \pm 0.050\%$). Palmitic, linoleic, and arachidonic acids were also detected in significant quantities. The other fatty acids in the mango kernel were detected in trace amounts. The values found for stearic acid are within the range reported in the literature (38 to 46%), while except Palmer variety, oleic acid falls slightly outside the range reported in the literature review (37 to 55%) [17]. The qualitative and quantitative fatty acid composition of mango kernels shows that mango butter is like other major natural fats, such as cocoa butter widely used in food processing [17]. Another important advantage of mango kernel lipids is that they do not contain "trans" fatty acids, which are responsible for the development of various diseases and have several adverse effects on human health [13].

3.2. Physicochemical Properties

The physicochemical properties of oil from mango kernels are presented in the Table 2. *Mangifera indica* kernel oil was pale yellow in color and solid at room temperature. The oil contents obtained for the four varieties were 7.08%, 7.5%, 7.3 and 7.11% for Sewe, Bouka, Palmer and Dieg bou gate, respectively. The four mango samples displayed closely similar yield values. Our findings were consistent with the total lipid contents reported for five different regions of Nepal (6.88-7.2%) [18] and for 11 China-specific mango varieties (5.65-11.14%) [19]. Furthermore, according to the literature, the oil content of mango kernel varies from 7.81 to 13.6% by dry weight, depending on the mango varieties [14].

The saponification value corresponds to the amount of potassium hydroxide (in mg) required to neutralize the free acids and saponify the esters present in 1 g of lipid. The saponification value reflects the average chain length of the fatty acids contained in a fat or oil sample [20]. A lower saponification value indicates a higher molecular weight of the fatty acids present in the glycerides, and conversely. The saponification values 212.9, 228.7, 234.2 and 225.8 mg KOH/g of oil obtained respectively for Sewe, Bouka, Palmer and Dieg bou gate were higher than those of Sonwai *et al.* [21] whose saponification values of four mango oils were between 183 - 191 mg KOH/g of oil. These results are also higher than those reported by Zahoor *et al.* [22]. The results of this study show good agreement with the data (121.7-233.8 mg KOH/g of oil) compiled by Solís-fuentes *et al.* [13].

The iodine value, which measures the degree of unsaturation of fats, corresponds to the amount of iodine absorbed by 100 g of fat. A high iodine value indicates a high proportion of unsaturated fatty acids, which corresponds to greater nutritional value but lower oxidative stability. In this study, the seed oil had iodine values ranging from 50.4 to 59.7 g I₂ / 100 g of oil (Table 2) which were attributed to the presence of a moderate level of unsaturated fatty acid, probably linked to the significant presence of monounsaturated fatty acids, particularly oleic acid (Table 1). These average values correspond to a semi-solid or fat-like oil with good stability.

Moreover, Palmer variety, which has the highest oleic acid content, exhibits the greatest iodine value (59.7 g I₂ / 100 g of oil). Iodine values of the Senegal four mango varieties exhibited here were higher than that those of Thai varieties related by Sonwai *et al.* [21]. However, the iodine values of the four varieties studied were comparable to those of Malaysian cultivars (Apple, Arumanis, Chokonan, Elephant, Sala, and Waterlily) which showed iodine value in the range of 42.9 to 52.69 g I₂ / 100 g on dry weight basis [23]. In the literature, mango kernel oil generally exhibits iodine value ranging from 22.9 to 60.6 g I₂/100 g) depending on the mango variety under consideration [13]. The physicochemical properties of mango oil are highly variable and depend on methods of extraction and variety of mango [14].

Table 2. Physicochemical properties of Sewe, Bouka, Palmer and Dieg bou gate cultivars seed oil extract.

Parameter	Sewe	Bouka	Palmer	Dieg bou gate
Color	pale yellow	pale yellow	pale yellow	pale yellow
State at room temperature	Solid	Solid	Solid	Solid
Yield (%)	7.08	7.5	7.3	7.1
Saponification Value (mg KOH/g of oil)	212.9	228.7	234.2	225.8
Iodine value (g I ₂ / 100 g of oil)	52	50.4	59.7	54.7

4. Conclusion

The present study describes the physicochemical parameters and fatty acid profiles of four Senegalese cultivars of *Mangifera indica* L. The analysis of fatty acid composition demonstrated that these varieties are predominantly composed of stearic and oleic acids. The physicochemical parameters of the four investigated *M. indica* cultivar such as saponification and iodine values were found to be within the ranges reported in the literature. These findings indicate that mango kernel fat could serve as a promising raw material for the cosmetic industry.

Abbreviations

GC	Gas Chromatography
FID	Flame Ionization Detector
AFNOR	French Association for Standardization
SV	Saponification Value
IV	Iodine Value

Author Contributions

Samba Fama Ndoeye: Conceptualization, Formal Analysis, Investigation, Validation, Writing – original draft

Lalla Aicha Ba: Conceptualization, Investigation, Validation, Writing – original draft

Dan Eugene Bernardi: Conceptualization, Investigation, Validation, Writing – original draft

Mbaye Diaw Dioum: Conceptualization, Investigation, Methodology, Formal Analysis, Writing – original draft

Insa Seck: Validation

Seydou Ka: Validation

Ismaila Ciss: Validation

Abda Ba: Validation

Seynabou Sokhna: Validation

Moussa Ndao: Validation

Illa Tea: Conceptualization, Supervision, Investigation, Writing – review & editing

Matar Seck: Conceptualization, Supervision, Investigation, Writing – review & editing

Conflicts of Interest

The authors declare that there is no conflicts of interest.

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