

Mango Seed Kernel Starch and Fat as Potential Substitutes for Food and Non-Food Applications

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Abstract The major by-products from mango processing are peels and seeds which represent 35–60% of the total weight of the fruit. This study aimed to assess the physicochemical and functional properties of starch and fat extracted from mangoes seeds kernels for their use as alternative ingredients or additives in the food and non-food industries. Three cultivars of ripe mangoes (Kent, Keitt, Amelie) were collected in two orchards in Northern part of Côte d'Ivoire and starches and fats were extracted using sodium chloride solution and hexane, respectively. The starches granules had spherical and oval shapes with following sizes: $10.71 \pm 1.19 \mu\text{m}$ (Kent); $16.34 \pm 1.03 \mu\text{m}$ (Keitt) and $12.65 \pm 1.02 \mu\text{m}$ (Amelie). The amylose content of mango kernel starches ranged from $23.01 \pm 1.17\%$ (Kent) to $27.31 \pm 3.64\%$ (Keitt). The swelling power (SP) ranged from 2.8 to 20.27 g/g for all varieties from 50 to 95°C while the solubility increased rapidly at 80°C, with Keitt mango kernel starch exhibiting the highest solubility (12.6%). The syneresis rate at 4°C increases from week 1 (W1) to week 3 (W3), rising from 13.4% to 16.7% for Kent variety, from 16.7% to 20.3% for Keitt variety, and from 12.7% to 15.8% for Amelie variety. Saponification value (SV) of oils extracted from mango seed kernel oils (MKOs) ranged from 179.00 to 189.33 mg KOH/g while iodine value (IV) of MKOs varied from 22.87 to 23.85 g/100 g with no significant differences ($p > 0.05$) between varieties. The results of the GC-FID analysis showed that palmitic (26.17 – 25.78%), stearic acid (48.05 – 51.93%) and oleic acid (14.49 – 21.22%) were the major fatty acids. All these findings support the potential applications of starches and fats extracted from mangoes (cv Kent, Keitt, Amelie) seeds kernels for edible purposes, for cosmetics, pharmaceutical and chemical industries.

Keywords: Mango seed kernel, Starch, Fat, Physicochemical properties, Functional properties

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1. Introduction

Mango (*Mangifera indica* L.) is one of the most important tropical fruits in the world due to its taste, aroma and high nutritional value [1]. Indeed, mango fruits provide energy, dietary fibre, carbohydrates, proteins, fats and phenolic compounds which are vital for human health [2]. The annual production of mango fruit reached about 52 million tons according to FAO in 2020 with India, Indonesia and China as the third major producing countries with more than 50% of the total production. In Côte d'Ivoire, mango fruit plays an important economic role as the third major exported fruit after banana and pineapple. The main producing regions (Korhogo, Ferkessedougou, Sinematiali, Boundiali, Odienne) of mango fruits are located in Northern part of Côte d'Ivoire and the most cultivated varieties are Kent, Keitt and Amelie. Mango fruit is eaten fresh, and a wide range of foods can be processed by using the pulp. Indeed, mango puree, nectar, slices in syrup, pickles, canned slices,

chutney and dried slices are the main industrial products obtained from mango fruits [3,4]. The major by-products from mango processing are peels and seeds which represent 35–60% of the total weight of the fruit [5]. The peels accounts approximately for 7–24% of the total weight of mango fruit and these by-products have been reported as source of dietary fibre, cellulose, hemicellulose, lipids, proteins, enzymes and pectin [6]. Moreover, mango peels flour can be used for various food applications as functional ingredients in food products such as cakes, bread, biscuits and other bakery products [7]. As concern the seeds, more than one million tons of mango seeds are annually produced as wastes, and these are often underutilized [8,9]. The seed kernels represent 45–85% of the seed and approximately 20% of the whole fruit [10]. Some studies have reported mango seeds as biowastes with high content of bioactive compounds (phenolic compounds, carotenoids, vitamin C, and dietary fibre) [11]. Mango seeds are also good source of carbohydrates (58–80%), proteins (6–13%) and fats (6–16%) [12]. It has been reported that mango seeds were characterized by anticancer and antimicrobial activities

attributed to high antioxidant capacity [13,14]. Therefore, the proper use of mango seed as raw material for food and non-food applications could generate economic benefit for industries, promote health, and reduce environmental pollution. In this context, this study aims to assess the physicochemical and functional properties of starches and fats extracted from mangoes seeds kernels for their use as alternative ingredients or additives in the food and non-food industries.

2. Materials and Methods

2.1. Samples Collection and Treatment

Three cultivars of ripe mangoes (Kent, Keitt, Amelie) were collected in two orchards in the city of Korhogo (9°27'41" North, 5°38'19" West, Côte d'Ivoire), during 2021-2022 harvest season. Mangoes were washed with potable water, peeled, and the pulp was removed from the seeds. Mango seeds were dried at 50 °C/24h in oven and knife-opened to obtain the kernels. Afterwards mango seed kernels (MSKKn, MSKKt, MSKAm) were ground to obtain powder that passed through a 100-mesh sieve. The powder was stored at 4 °C after oven-drying to 6% to 8% moisture for subsequent starch and fat extraction.

2.2. Mango Seed Kernels Starch and Fat Extraction

2.2.1. Starch Extraction

Starch from mango seed kernels was obtained by using sodium chloride solution [15]. The kernels were washed and cut into small pieces, crushed in a blender for 10 min with 4% (w/v) sodium chloride solution. The suspension obtained was filtered on Whatman filter paper and the residue was washed several times with 4% (w/v) sodium chloride solution to remove starch. Then, the filtrate was subjected to overnight decantation under refrigeration. The supernatant was discarded and the starch residue was dried in a oven at 50 °C for 24 h, ground using mortar and passed through a 100-mesh sieve. The starch yield was determined and hermetically stored at 4°C until further analyses.

2.2.2. Fat Extraction

The soxhlet method was used for kernel fat extraction [16]. Thirty (30) g of kernel flour were weighed into cellulose extraction cartridges plugged with cotton. These cartridges were introduced into the Soxhlet system and fat was extracted using 300 mL of n-hexane. After two extraction cycles of 7 h each, the solvent was recovered using a HEIDOLPH HEI-VAP rotary evaporator. The flask containing fat was weighed to determine the extraction yield. Mango kernels fats were stored in dark bottles at -15°C for future use.

2.3. Determination of Physicochemical and Functional Properties of Mango Seed Kernel Starch

2.3.1. Characterization of Starch Granules Morphology and Size

The morphology of starch granules was observed using a scanning electron microscope (HIROX, SH-4000 M, Japan). The samples in powder form were coated with palladium and observed under the following conditions: 15 to 20 nm, 30x to 60,000x magnification and 5 to 30 kV accelerating voltage. Particle size of starch granules was determined by a lazer particle size analyzer, (HORIBA, LA-350, Germany). Starches slurry 0.032–0.055% (w/v) was taken in a small glass vial then vortexed and finally sonicated for 1 h before analysis.

2.3.2. Determination of Proximate Composition

The proximate composition of mango seed kernel starches was assessed by determinig the moisture, ash, fat, and proteins according to AOAC methods [17]. Carbohydrates were calculated by difference.

2.3.3. Determination of Amylose and Amylopectin content

Amylose and amylopectin contents were determined following a colorimetric method [18] with modification. Defatted starch (0.1g) was dissolved in 5 mL of potassium hydroxide (1N) solution. The suspension was thoroughly mixed and 5 mL of HCl (1N) solution were added. The mixture was boiled in water bath for 15 min and the volume was adjusted to 10 mL. After centrifugation at 1000 rpm for 10 min, a volume (0.05 mL) of the supernatant was introduced in test tube and 4.85 mL of distilled water, following by 0.1 mL of iodine reagent. The mixture was left to stand for 10 min and absorbance was read at 620 nm by using a spectrophotometer (THERMO SCIENTIFIQUE Helios Omega, USA). The amylose content was determined using a standard curve obtained from amylose standard solution (5 mg/mL). Amylopectin was determined by the following equation:

$$\text{Amylopectin}(\%) = 100 - \text{Amylose}(\%)$$

2.3.4. Determination of Swelling Power and Solubility

The swelling power (SP) and solubility (S) were performed according to a gravimetric method [19]. Suspensions of 10 mL of 1% (w/v) starch in centrifuge tubes were placed in water bath at various temperatures ranging from 50°C to 95°C under agitation for 1 h. After cooling at room temperature, suspensions were centrifuged at 5000 rpm for 15 min. The sediments and supernatants were collected in different test tubes and placed in a ventilated oven at 105°C for 24 h for the supernatants and 48 h for the sediments. The swelling power (SP) and solubility (S) for 1 g of dry starch were estimated using the following formula:

$$SP(g/g) = \frac{\text{weight of wet sediment}}{\text{weight of dry starch}}$$

$$S(\%) = \frac{\text{weight of dry supernatant}}{\text{weight of dry starch}} \times 100$$

2.3.5. Determination of Syneresis

The starch syneresis was carried out following a gravimetric method [20,21]. Briefly, starch suspensions were prepared at 4% w/w into 12 test tubes and heated until 95°C for 15 minutes in a shaking water bath. Afterwards, the gels were stored at 4°C for 4 weeks. After cooling at ambient temperature (25°C), the amounts of gel before the centrifugation (gel mass) and water exudate (supernatant mass) was gravimetrically determined each week and the percentage of syneresis was calculated as follows:

$$\text{Syneresis}(\%) = \frac{\text{weight of supernatant}}{\text{weight of gel}} \times 100$$

2.4. Determination of Physicochemical Properties and Fatty Acid Composition of Mango Seed Kernel Fat

2.4.1. Determination of Physicochemical Properties

The physicochemical characteristics: acid value - AV (mg KOH/g), saponification value - SV (mg KOH/g), iodine value - IV (g/100g), peroxide value - PV (meqO₂/kg), and unsaponifiable matter - UM (%) were determined according to standard AOAC methods [17].

2.4.2. Determination of Fatty Acid Composition

Fatty acids from the extracted mango seed kernels fats were converted into their respective fatty acid methyl esters (FAMES) and analyzed by gas chromatography coupled with flame ionisation detector (FID). In brief, 100 mg of fat was taken in a vial, then 2 mL of heptane was added and shaken vigorously to dissolve the fat, and mixed with 0.2 mL of 2N methanolic KOH. The mixture was shaken and divided into two clear layers. Afterwards, the upper layer of each sample containing the FAMES was transferred into a separate vial for fatty acid analysis. FAMES were analyzed using the Perkin Elmer Clarus 580 GC-FID system. The machine was equipped with a Elite 5MS capillary column of length 30 m and an internal diameter of 0.25 mm (film thickness, 0.25 µm). The carrier gas used was helium, and the flow rate was 1 mL/min. The injector temperature with split mode was 200°C. A sample volume of 1 µL was injected into the column with the initial temperature set to 50°C and held for 2 min; then, the temperature was increased up to 170°C and further increased to 190°C at a rate of 1.5°C/min and finally held for 10 min. The calculation of FAMES content was done by using an internal standard (C19) at 2 µg/mL.

2.5. Data Analysis

All measurements were carried out in triplicate and the results expressed as mean ± standard deviation. Analysis

of variance (1-way ANOVA) was performed to analyze significant differences of means among the selected mango varieties at $p < 0.05$. All statistical analyses were performed by using XLSTAT software version 2024.

3. Results and Discussion

3.1. Morphology and Particle Size of Mango Seed Kernels Starch Granules

The morphology of starch granules extracted from Kent Keitt and Amelie mango varieties was evaluated by scanning electron microscopy, and the images are presented in Figure 1.

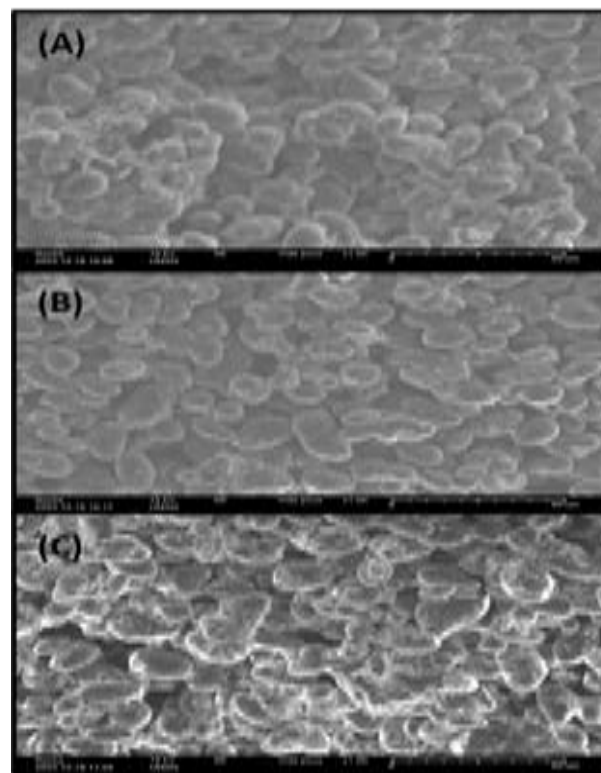


Figure 1. Morphology of mango seed kernel starch granules from Kent (A), Keitt (B) and Amelie (C) varieties

The scanning electron microscopy (SEM) images of mango seed kernel starch granules revealed a heterogeneous morphology, consisting predominantly of oval, round, and irregularly shaped granules. Most granules had smooth surfaces with few fissures or surface indentations. The absence of significant agglomeration suggests minimal starch damage during extraction and drying. Granule surface features and shape varied depending on the mango cultivar, which supports earlier findings that starch morphology is influenced by both genetic and environmental factors [22,23]. Unlike cassava or potato starches, mango starch showed less uniformity in granule shape, indicating a mixed amylose-amylopectin distribution and moderate crystallinity [24]. The distribution of starch grain sizes (Figure 2) showed variability depending on the variety, with values of $10.71 \pm 1.19 \mu\text{m}$ (Kent); $16.34 \pm 1.03 \mu\text{m}$ (Keitt) and $12.65 \pm 1.02 \mu\text{m}$ (Amelie).

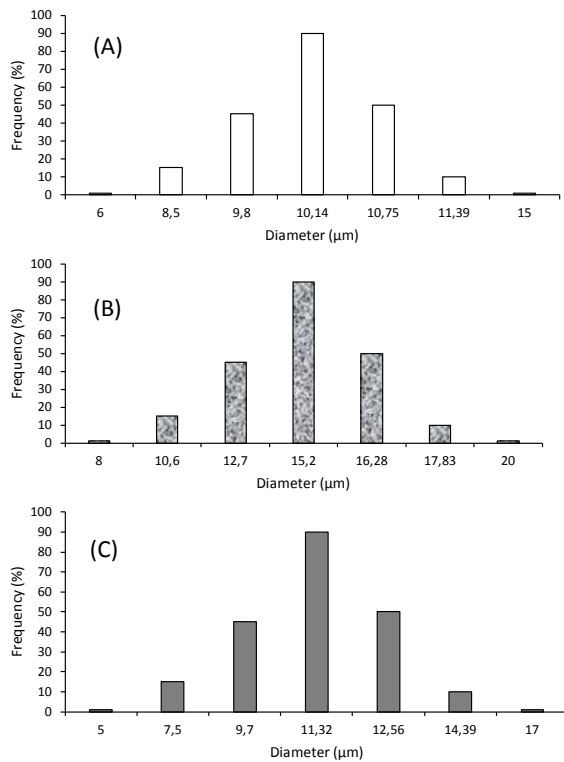


Figure 2. Particle size distribution of mango seed kernel starch granules from Kent (A); Keitt (B) and Amelie (C) varieties

The distribution curve indicated a unimodal pattern, with a narrow span of granule sizes, suggesting relative homogeneity in the extracted starch fractions. Granules size is an important factor during the starch gelatinization process. Indeed, larger granules generally exhibit higher swelling capacity and lower gelatinization temperatures, attributes that align with the functional data reported by some authors [25,26]. Furthermore, larger and smoother granules tend to have lower enzymatic hydrolysis rates, potentially contributing to lower glycemic index (GI) food formulations [27]. The morphological characteristics and particle size of mango seed kernel starch granules support their use in a variety of food and non-food applications. The moderately large, smooth granules of mango seed kernel starch indicate good potential for food and non food applications like thickeners and puddings and biodegradable packaging materials.

3.2. Proximate Composition of Mango Seed Kernels Starch

The results related to yield and physicochemical composition of mango seed starches from different cultivars are presented in Table 1. The starch extraction process indicated a yield ranging from 41.20 to 47.40%, showing significant differences ($p < 0.05$) between the varieties. The starch from the Kent variety ($47.40 \pm 0.25\%$) showed the highest yield ($p < 0.05$), highlighting industrial potential for exploitation as non-conventional starch source. Overall, the results obtained are within the range (27 to 59%) of those reported for mango seed starches from the Sindhoori, Tommy Atkins, Corazon, Uba, and Totapuri cultivars [28,29].

Table 1. Proximate composition of mango seed kernel starches from Kent (MSKKn), Keitt (MSKKt) and Amelie (MSKAm) varieties.

	MSKKn	MSKKt	MSKAm
Yield (%)	47.40 ± 0.25^a	41.20 ± 0.30^b	42.70 ± 0.50^b
Moisture (%)	4.54 ± 0.30^b	5.20 ± 0.20^a	4.20 ± 0.20^b
Ash (%)	0.18 ± 0.01^b	0.19 ± 0.00^b	0.23 ± 0.01^a
Fat (%)	0.26 ± 0.03^b	0.31 ± 0.01^a	0.28 ± 0.02^b
Proteins (%)	0.06 ± 0.01^a	0.07 ± 0.02^a	0.07 ± 0.01^a
Carbohydrates (%)	94.96 ± 0.25^b	94.23 ± 0.30^b	95.22 ± 0.30^a
Amylose (%)	23.01 ± 1.17^b	27.31 ± 3.64^a	26.41 ± 2.42^a
Amylopectin (%)	76.99 ± 2.41^a	72.69 ± 3.36^c	73.59 ± 0.51^b

Means in the same row with different superscripts differ significantly at $p < 0.05$.

Moisture contents ranged from 4.20 to 5.20%. These results are lower than those reported (6–10%) for starches from Tommy and Herein mango seed cultivars [30]. The relatively low moisture contents would inhibit the growth of microorganisms that degrade starch during storage [31]. The starches from the kernels of mango varieties also showed negligible differences in terms of ash (0.18–0.23%), fat (0.26–0.31%), and protein contents (0.06–0.07%). These results are consistent with those of previous studies on different mango varieties [32,33]. The low ash, fat, and protein contents could have positive impact on starch purity, potentially affecting its physicochemical properties [34].

The high carbohydrate content (94.23 - 95.22%), primarily due to starch, aligns with earlier reports indicating mango seed kernels are rich in starch granules with high amylopectin content [22]. The amylose content of mango seed kernel starches ranged from $23.01 \pm 1.17\%$ (Kent) to $27.31 \pm 3.64\%$ (Keitt), exceeding the values obtained (11.9–16.74%) by other authors [30]. The amylose content was similar to that of corn starch (22.20%) and potato starch (25.2%) [35,36]. Thus, these starches could be used in industries that produce thickeners and binders [33].

3.3. Functional Properties of Mango Seed Kernels Starch

3.3.1. Swelling Power and Solubility Index

Most starch applications are determined by amylose and amylopectin content, particularly gel producing, thickening, and water retention capacity. Figure 3 shows the swelling power (SP) and solubility percentage (S) of mango seed kernel starches from the Kent, Keitt, and Amelie varieties. Both properties are directly correlated with increases in temperature. The SP values ranged from 2.8 to 20.27 g/g for all varieties from 50 to 95°C. These values are higher than the value reported (1.90 g/g) for Tommy Atkins mango starch at 65°C [30]. Swelling power is the ability of starch to expand when heated to a certain temperature and also expresses the volume/dry weight ratio of the starch paste [37]. The difference in swelling power between different types of starch can be

explained by differences in the amylose/amylopectin ratio. In fact, Keitt mango kernel starch has the highest amylose content (27.31%), which is correlated to its swelling power (20.27 g/g).

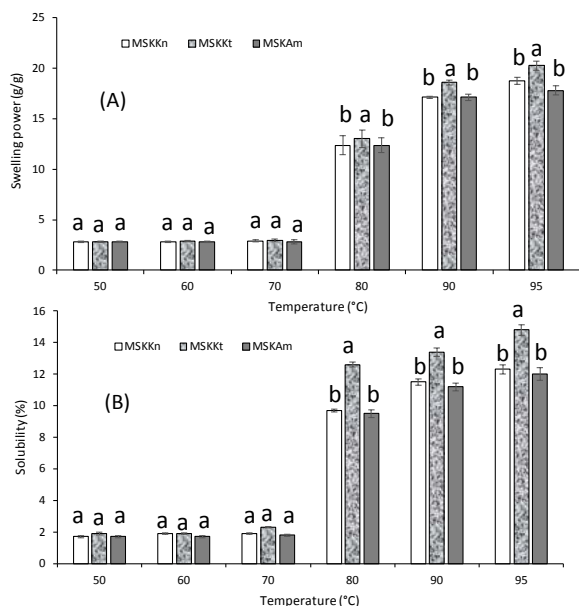


Figure 3. Swelling power (A) and Solubility (B) of mango seed kernel starches from Kent (MSKKn); Keitt (MSKKt) and Amelie (MSKAm) varieties. Values with different superscripts differ significantly at $p < 0.05$

Figure 3B shows the solubility of mango seed kernel starches evaluated at different temperatures. Solubility values increased from 1.7 to 2.3% between 50 and 70°C. However, at 80°C, the solubility increased rapidly, with Keitt mango kernel starch exhibiting the highest solubility (12.6%). The percentage solubility of starches is related to the level of structural degradation of the granules. In addition, it can be influenced by several factors, such as particle size, amylose content, and the degree of the amylopectin chains [38]. High swelling power is beneficial in soup thickeners, pie fillings, and gravies, where viscosity and gel strength are critical. Moderate solubility suggests controlled leaching of amylose, useful for textural stability in processed foods [39].

3.3.2. Syneresis Index

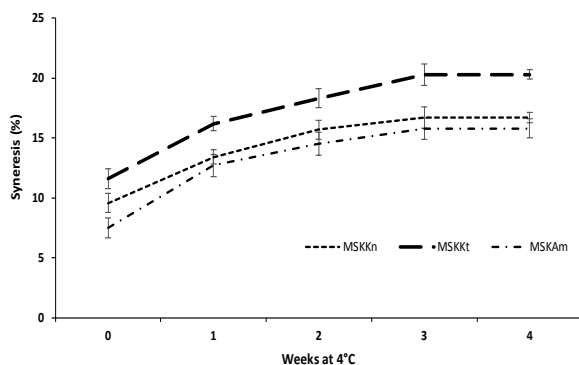


Figure 4. Syneresis of mango seed kernel starches from Kent (MSKKn); Keitt (MSKKt) and Amelie (MSKAm) varieties

The evolution of syneresis in mango seed kernel starches from the Kent, Keitt, and Amelie varieties is

shown in Figure 4.

The syneresis rate at 4°C increases from week 1 (W1) to week 3 (W3), rising from 13.4% to 16.7% (Kent variety), from 16.7% to 20.3% (Keitt variety), and from 12.7% to 15.8% (Amelie variety). During cold storage, the reorganization of starch molecules can lead to water release (or syneresis), which can affect functional properties in terms of viscosity or gel behavior [40]. These syneresis indicate that Keitt mango kernel starch may be more stable for use in the manufacture of refrigerated food products. On the other hand, Kent and Amelie mango kernel starches, which are less stable at refrigeration temperatures, could be used in the manufacture of salad dressings and sauces [41].

3.4. Physicochemical Properties and Fatty Acid Composition of Mango Seed Kernel Fat

The physicochemical properties and fatty acid composition of mango seed kernel oils from Kent, Keitt and Amelie varieties are shown in Table 2.

Table 2. Physicochemical properties and fatty acid composition of mango seed kernel oils from Kent (MSKKn), Keitt (MSKKt) and Amelie (MSKAm) varieties

	MSKKn	MSKKt	MSKAm
Yield (%)	9.60 ± 0.41 ^a	8.03 ± 0.34 ^b	6.91 ± 0.76 ^c
AV (mg KOH/g)	3.16 ± 0.78 ^b	4.03 ± 0.22 ^a	3.0 ± 0.54 ^b
PV (meq O ₂ /kg)	6.54 ± 0.06 ^a	4.56 ± 0.08 ^c	5.40 ± 0.25 ^b
IV (g I ₂ /100g)	22.87 ± 1.13 ^a	23.26 ± 1.09 ^a	23.85 ± 1.60 ^a
SV (mg KOH/g)	189.33 ± 3.06 ^a	177.67 ± 2.89 ^b	179.00 ± 2.00 ^c
UM (%)	1.45 ± 0.04 ^b	1.40 ± 0.05 ^b	1.55 ± 0.07 ^a
SFA (%)	78.10 ± 0.52 ^a	71.61 ± 0.04 ^b	76.64 ± 0.12 ^c
UFA (%)	21.14 ± 0.50 ^c	27.48 ± 0.21 ^b	23.23 ± 0.77 ^a
C16:0 (%)	26.17 ± 1.15 ^a	23.56 ± 0.34 ^c	25.78 ± 0.34 ^b
C18:0 (%)	51.93 ± 0.12 ^a	48.05 ± 0.19 ^c	50.86 ± 1.50 ^b
C18:1 (%)	14.49 ± 2.06 ^c	21.22 ± 0.46 ^a	16.78 ± 0.70 ^b
C18:2 (%)	6.65 ± 0.04 ^a	6.26 ± 0.01 ^c	6.45 ± 0.02 ^a

Means in the same row with different superscripts differ significantly at $p < 0.05$.

The yield of oil from different mango seed kernels (MKOs) varied in the range of 6.91 - 9.60% with the maximum yield (9.60%) for Kent variety while the minimum (6.91%) was obtained for Amelie variety. The differences in oil yields may be due to some factors such as ripening stage and harvesting times [42]. The mango seed kernel may be considered as potential source of oils for industry purposes considering the fact that these oils are derived from under-utilized and available waste material [43].

Saponification value (SV) of MKOs ranged from 179.00 to 189.33 mg KOH/g. The highest value was obtained for Kent variety (186.33 ± 3.06 mg KOH/g). The SV values of MKOs are comparable to those of oils and fats used for industrial purposes, such as shea butter

(178–193), cocoa butter (188 – 200), peanut oil (187–196) and cottonseed oil (189–198). The SV of MKOs suggest a predominance of medium to long-chain fatty acids, which enhances the oil's suitability for soap, cosmetics, and biodiesel applications [44,45]. The iodine value (IV) of MKOs varied from 22.87 to 23.85 g/100 g with no significant differences ($p > 0.05$) between varieties. Also, MKOs had lower iodine values (g/100 g) than shea butter (57 - 66), cottonseed oil (100 - 105), palm oil (50 - 55), and cocoa butter (33 – 42). The relatively low iodine values of the MKOs indicates their resistance to oxidation and longer shelf-life with regard to peroxide (4.56 – 6.54 meq O₂/kg) and acid values (3 – 4.03 mg KOH/g). Based on the lower iodine values, MKOs may be used in the manufacture of lubricants, soaps, leather and candles [46].

The unsaponifiable matter of the MKOs ranged from 1.40 to 1.55%, with the highest values observed for Amelie variety ($1.55 \pm 0.07\%$). These values are lower than those reported for Indian mangoes [47]. The unsaponifiable matter in oil can be used to assess the magnitude of minor components such as tocopherols, phytosterols, carotenoids, and other non-lipidic fractions [48].

The fatty acids profiles of MKOs are presented in the Figure 5.

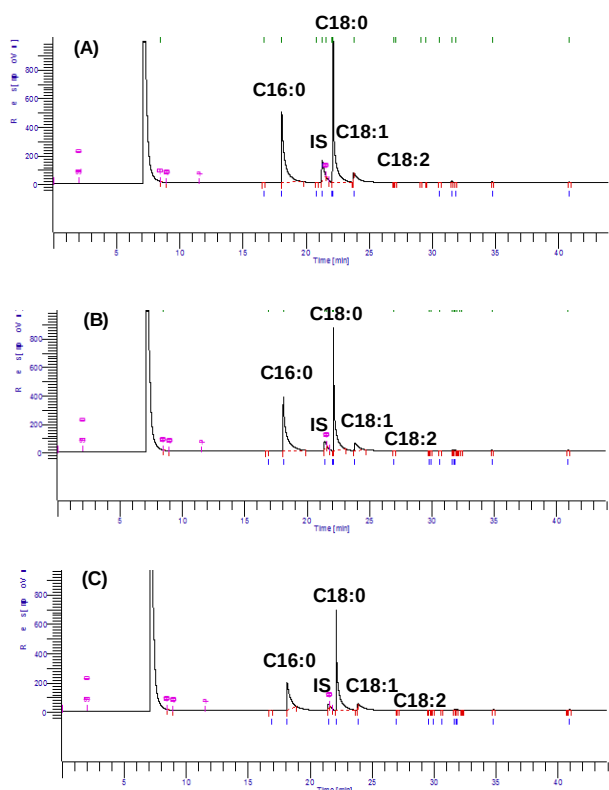


Figure 5. Fatty acids chromatograms of mango seed kernel oils (MKOs) from Kent (A); Keitt (B) and Amelie (C) varieties

The results of the GC-FID analysis showed the presence of 4 major fatty acids in the MKOs, namely, palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C18:2). The total saturated fatty acids (SFA) content of MKOs ranged from 71.61 to 78.10, with the highest value ($78.10 \pm 0.52\%$) for Kent variety. Total unsaturated fatty acids (TUSFAs) are in the range of 21.14 – 27.48%. Analysis of MKOs showed that palmitic (26.17 – 25.78%) and stearic acid (48.05 – 51.93%) were the

dominant fatty acids. Also MKOs contained a considerable amount of one of essential fatty acids, (C18:2) which cannot be synthesized by the human body and needs to be provided by the diet. The presence of some important fatty acids, especially C18:1 and C18:2, makes MKOs fit for edible purposes as well as for industrial applications such as the manufacture of candles, soaps, detergents, cosmetics, shaving soaps, lubricants, and pharmaceuticals [46].

4. Conclusion

The overall objective of this study was to assess the potential use of starches and fats from mango seed kernels (cv Kent, Keitt and Amelie) in agro-industry by determining their physicochemical, biochemical, and functional properties. The results of this research showed that starches from the kernels of mango varieties had interesting characteristics (granulometry, amylose content, swelling power, solubility) that could be exploited in food industries as thickeners and binders and also in chemical industries for adhesives products. The findings also showed variations in the physicochemical properties, and fatty acid compositions of MKOs of the selected varieties of mangoes. Saponification and iodine values with palmitic, stearic and oleic acid contents support the potential applications of MKOs for edible purposes and for cosmetics and pharmaceutical industries. However, it would be interesting to evaluate some valuable parameters of the starches, such as enzymatic and chemical digestion and the unsaponifiable fraction composition of fats before their application in food and non food industries.

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