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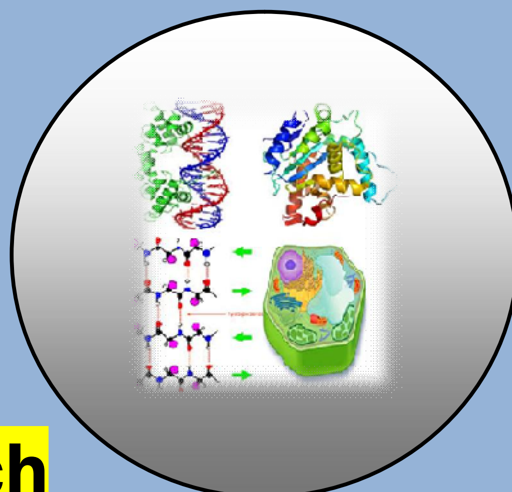

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Chemical Composition of the Seed Kernel Flour of Some Mango (*Mangifera indica* L.) Varieties

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ABSTRACT

Chemical analysis of seed kernel flour of three mango varieties namely: Saigon, Edward and Julie were carried out to determine alternative uses of mango seed kernels. The results revealed that percent moisture, protein, ash, crude fat, crude fibre, carbohydrate and energy value ranged from 7.39-8.63, 5.20-6.13, 5.99-6.23, 5.04-8.53, 1.98-2.75, 68.40-73.16 and 29.37-35.64; respectively. Crude fat, crude fibre and energy value were significantly higher ($p<0.05$) in Saigon than Edward and Julie. Edward had the highest protein and carbohydrate content while Julie had the highest ash content. Tannin which ranged from 5.78-7.41 g/100g was the most predominant anti-nutrient in seed kernels of the three mango varieties and was found to be highest in Saigon. However, Julie had the highest magnesium, potassium and copper contents. The major fatty acids in all the three mango varieties evaluated were stearic acid (37.57-38.80%), Palmitic acid (8.61-9.06%), oleic acid (43.71-44.91%), linoleic acid (5.87-7.00%) and linolenic acid (0.63-0.95%). Saigon had the highest stearic acid content while Edward had the highest palmitic, linoleic and linolenic acid contents. Generally, the high nutrient content and fatty acid profile of mango seed kernels shows that it has high potential as energy sources and can be utilized for industrial purposes and livestock feeds.

Keywords: Anti-Nutrients, Chemical Composition, Fatty Acids and Mango Seed Kernel.

INTRODUCTION

Mangoes (*Mangifera indica* L.) are one of the most economically important fruit which has been used as raw material for many packed fruit products (Kittiphoom and Sutasinee, 2013). Mango belongs to the genus *Mangifera* of the cashew family *Anacardiaceae.* The genus *Mangifera* contains several species that bear edible fruits known as *Mangifera indica*. The family contains 73 genera and about 600-700 species distinguished by their resinous bark and caustic oils in leaves, bark, and fruits (Akinyemi, 2012).

Much of the spread and naturalization has occurred in conjunction with the spread of human populations and as such, the mango plays an important part in the diet and cuisine of many diverse cultures. Alcorne *et al*., (1999) stated that the genus *Mangifera* originated from tropical Asia, while the most cultivated *Mangifera* species, *M. indica* (mango) has its origin in India. Mango is now cultivated throughout the tropical and subtropical world for commercial fruit production, as a garden tree and as a shade tree. A wide variety of processed products derived from mango pulp includes jam, sauce, chutney, mango juice, nectar and canned whole or sliced mango pulp in brine or in syrup or in tea (Singh, 1960; Campbell *et al*., 2002). Mango stone consists of a tenacious coat enclosing the kernel. The seed content of different varieties of mangoes ranges from 9% to 23% of the fruit weight (Palaniswamy *et al*., 1974) and the kernel content of the seed ranges from 45.7% to 72.8% (Hemavathy *et al*., 1988). Mango kernel contains almost 15% wt of oils (Nzikou *et al*., 2010). Unfortunately, only the mango flesh is utilized by factories, resulting in a vast amount of mango stones being discarded as waste. Seeds are important sources of nutrients and oil (Saiprabha and Goswami-Giri, 2011). A lot of work has been carried out on seeds of many crops such as *Solanum nigrum* L.var. virginicum (Akubugwo *et al.,* 2008)*, Colocynthus citrullus* (Akpambang *et al.,* 2008) and *Terminalia catappa* (Akpabio, 2012); because of their demands both for industrial applications and human consumptions. Certain industrial wastes such as fruits and vegetables seeds are rich and cheaper source of fats and oils (Saiprabha and Goswami-Giri, 2011). After consumption and industrial processing of mango pulp, considerable amount of the seeds are discarded as waste. The usefulness of whole mango seed kernel, the oil, in comparison with the fruit pulp, is yet to gain both cottage and industrial attention in Africa (Nzikou *et al*., 2010); particularly Nigeria which is rated the tenth mango producing country in the world (FAO, 2002; Akinyemi, 2012). D'Mello, (1992) stated that results of proximate analyses are extensively employed in research and industry for estimation of nutrient potentials of feedstuffs. Okoli *et al*., (2003) also stated that proximate analysis is specifically useful in screening the array of tropical plants utilized for ruminant feeding. It is believed that information on the chemical properties of mango seed kernel would help to identify the potential benefit of the seed kernel both for livestock and industry use; and reduce waste of these seeds in regions of production. This study was therefore carried out to evaluate the proximate, minerals, anti-nutrients and fatty acid compositions of the seed kernel of some mango varieties.

MATERIAL AND METHODS

Collection and preparation of samples

Healthy mango fruits were collected at maturity from the mango orchard of the National Horticultural Research Institute, Ibadan, Nigeria during the 2012 and 2013 fruiting season. The three different varieties collected were Saigon, Edward and Julie. The fresh juicy parts of the selected mangoes were removed. The stones were air dried and seed kernels were removed from their tenacious coat enclosing the kernel. The seed kernels were finely ground into flour and stored in a refrigerator at 4 ^{o}C prior to analysis.

Chemical analysis

Proximate Analysis

Proximate analysis was carried out on the milled samples to determine the moisture, crude fiber, protein, ash, carbohydrate and crude fat contents. The moisture, crude fibre and ash contents of the milled samples were determined by the method described by Pearson, (1976). The crude protein was determined using the Kjedahl method as described by AOAC, (2000). The protein was calculated using the general factor 6.25 to convert the Nitrogen to protein (AOAC, 2000). Crude fat was determined using Soxhlet apparatus (AOAC, 2000). The percentage total carbohydrate was estimated as the difference between 100 and the sum total of the proximate composition of each sample (Nzikou *et al*., 2010).

Mineral analysis

In determining the mineral elements, the milled samples were first ashed in a muffle furnace at 500^{o} C for 4hr and the resultant ash was digested and used in the determination of the individual metals. Calcium, Iron, Copper, Manganese, Magnesium and Zinc were determined by Atomic Absorption Spectrophotometer. Sodium and Potassium were determined by Flame Photometry and Phosphorus was determined using molybdate method (AOAC, 1990).

Anti-nutrient Analysis

Tannin was determined by the Folin-Denis spectrophotometric method as described by Pearson (1976). The absorbance was measured at 250 nm and the tannin content was given as, %Tannin = An/As x C x 100/W x $(V_f – V_a)$

Where:

An= absorbance of test sample; As= absorbance of standard solution

C= Concentration of standard solution; W= weight of sample used

Vf= total volume of extract; Va= volume of extract analysed.

Phytate was determined by the method of Wheeler and Ferrel, (1971) and absorbance was measured at 519 nm. Oxalate was determined using the modified method employed by Ukpabi and Ejidoh (1989). The procedure involves the digestion of sample containing oxalate, precipitation of the oxalate to remove ferrous ions on addition of NH_4OH solution and permanganate titration of the total filtrate resulting from digestion and oxalate precipitation. Hydrogen cyanide was determined using the alkaline picrate method of Wang and Filled as described by Onwuka (2005). Total phenolic content was determined by the method of Singleton *et al*., (1999) using the Folin-Ciocalteu reagent. Absorbance was measured at 765 nm using a spectrophotometer and results were expressed as gallic acid equivalent (mg GA/kg extract) in dry weight. Total flavonoid content was determined by the colorimetric method of Harborne, (2000). The absorbance was read at 415 nm using a spectrophotometer. Results were expressed as catechin equivalent (mg CE/kg extract) in dry weight.

Oil Extraction

For solvent extraction, 50g each of the mango seed flour was placed into a soxhlet apparatus and then extracted using light petroleum ether for 8 hours on a water bath (Pena *et al*., 1992). The solvent was removed under vacuum in a rotary evaporator Model N-1 (Eyela, Rikakikal Co., Ltd., Tokyo, Japan) and residual solvent was removed by drying in an oven at 60^{o}C for 1 hr and flushing with 99.9% nitrogen.

Fatty acid analysis

Fatty acid determination and separation was done using the chromatographic method (AOAC, 2000) in which a chromatographic tube approximately 2 x 40 cm was used. It involved preparation of the chromatographic column and separation of the fatty acids.

Statistical analysis

All analyses were carried out in triplicate and data were expressed as means ± standard deviation. Analysis of Variance (ANOVA) was performed to calculate significant differences in treatment means and multiple comparisons of means were done by LSD test (SAS, 2000). Significant differences between groups was considered at $p<0.05$.

RESULTS AND DISCUSSION

Proximate composition

Proximate composition of the seed kernels of the three mango varieties revealed that the moisture content, protein, ash, crude fat, crude fibre and energy values are significantly different ($p<0.05$) in all three varieties studied (Table 1). Saigon has the highest values for moisture content (8.63%), crude fat (8.53%), crude fibre (2.75%) and energy value (35.64%). Edward has the highest protein (6.13%) and carbohydrate (73.16%) contents and these are significantly higher ($p<0.05$) than that of Saigon and Julie. Edward has the lowest moisture (7.39%); ash (5.99%); crude fat (5.04%); crude fibre (1.98%) and energy value (29.37%). The moisture contents in this study ranged from 7.39 to 8.63%. This is similar to the moisture content (9.8%) obtained in mango seed kernel (Messay and Shimelis, 2012); and comparable to the moisture content (12.2%) obtained in maize (Cortez and Wild-Altamirano, 1972) and wheat (13.01%) (Messay and Shimelis, 2012). The moisture content obtained in this study is lower than values (45.20%) obtained for Congo mango seeds as reported by Nzikou *et al*, (2010) and 25.22% obtained for almond seed (Akpabio, 2012). The low moisture content depicts a long shelf life for the mango stones. Ash contents are indices of the presence of mineral contents. The ash content in this study ranged from 5.99-6.23% with Julie having significantly the highest ash content, this is similar to 5.1% obtained for barley bran and 5.0% obtained for chick pea hulls (Kassahun *et al*., 2012). The similarity in the ash content of mango seed kernels with barley and chick pea implies that mango kernels can be used as a cheaper substitute in livestock feeds for this nutrient. The ash content of the three varieties of mango seed kernels studied is higher than value (2.10%) obtained for a mango variety reported by Messay and Shimelis, (2012); 0.35-3.66% obtained for some mango varieties (Dhingra and Kapoor, 1985) and 3.3% obtained for cashew nuts (Fetuga *et al*; 1974); indicating differences in mineral content among fruits and even within fruit varieties. The protein (5.20-6.13%) and carbohydrate (68.40 to 73.16%) contents of the three varieties of mango seed kernels studied is similar to the protein (6%) and carbohydrate (70%) contents obtained by Sarkiyayai *et al*, (2013) for big seeded Durshea variety of *M. indica*. This is also similar to the protein (5.2-9.1%) and carbohydrate (66-73%) contents obtained in the kernel of some maize varieties (Cortez and Wild-Altamirano, 1972; FAO, 2012) and comparable to the protein (10.12%) and carbohydrate (73.53%) contents obtained in wheat as reported by Messay and Shimelis, (2012). The similarity in the protein and carbohydrate contents of mango seed kernels with maize and wheat implies that mango kernels which are normally discarded as waste can be used as a cheaper source of these nutrients in livestock feeds.

The protein content of the three varieties of mango seed kernels studied is also comparable with values (6.24-8.19%) obtained for ten varieties of mango seed kernel (Kayode *et al*., 2013) and 6.0% obtained for chick pea hulls (Kassahun *et al*., 2012); but lower than 21.2% obtained for cashew nuts (Fetuga *et al*; 1974) and 33.69% obtained for almond seeds (Akpabio, 2012). The dietary requirement for crude protein for broilers of 6-8 weeks old is 18g per day (NRC, 1994), though the protein content for mango seed may not be able to meet this daily dietary requirement, it may be useful as a good source of dietary supplement for poultry feeds when combined with other supplements. The carbohydrate contents of Edward and Julie are significantly higher ($p<0.05$) than that of Saigon. The carbohydrate contents (68.40-73.16%) of all three varieties is similar to 67.25% obtained in mango seed kernel (Messay and Shimelis, 2012); and 73.53% obtained for wheat (Messay and Shimelis, 2012). The carbohydrate content in this study is also higher than 25.47% obtained for almond seeds (Akpabio, 2012) and 29.47% obtained for melon seeds (Obasi *et al*, 2012). The high carbohydrate content depicts the potential use of mango seed kernel as high energy source when incorporated into animal feeds. The crude fibre in the kernel of the three mango varieties studied ranged from 1.98-2.75%, this is similar to the value (0.8-2.9%) obtained for some maize varieties (Cortez and Wild-Altamirano, 1972; FAO, 2012); and higher than value (0.75%) obtained for wheat (Messay and Shimelis, 2012). The crude fibre (2.75%) obtained for Saigon which had the highest value is similar to the crude fibre (1.98-2.95%) obtained for ten varieties of mango seed kernel (Kayode *et al*., 2013) and 0.14%-2.95% obtained for some mango varieties ((Dhingra and Kapoor, 1985). The crude fibre content is lower than 5-51% obtained for melon seeds (Obasi *et al*; 2012) and 3.11% obtained for almond seeds (Akpabio, 2012). The crude fat which ranged from 5.04-8.53% in this study is similar to values (12.8%) obtained for some mango varieties (Messay and Shimelis, 2012) and 13.0% obtained in Congo mango (Nzikou *et al*., 2010).

Anti-nutrient composition

The anti-nutrients content (Hydrogen cyanide, Oxalate, Tannin, Phytate, Phenol and Flavonoids) of the mango seed kernels evaluated are shown in Figure 1. Saigon has the highest values for Oxalate (4.88 mg/kg), Tannin (7.41 g/100g), Phytate (6.78 mg/kg), Phenol (0.63 mg/kg) and Flavonoids (0.35 mg/kg). Tannin is the most predominant anti-nutrient in the seed kernel of the three mango varieties studied, its value ranged from 5.78-7.41 g/100g and is similar to the report by Joseph and Abolaji (1987) in which they found tannin to be the most predominant anti-nutrient in Nigerian wild mango kernels. Tannin contents obtained in this study are lower than values (10.0-11.0 g/100g) obtained for the seed kernel of some mango varieties (Parmar *et al*., 1990); but higher than 4.28 g/100g obtained for mango seed kernel (Messay and Shimelis, 2012). The tannin contents obtained in this study are higher than 0.04 g/100g obtained for almond seeds (Akpabio, 2012); 5.02-5.17 g/100g obtained for *Dacryodes edulis* seeds (Iyawe, 2009), 4.0 g/100g obtained for cassava leaves (Ravindran, 1993) and 5.1 g/100g for forage legumes (Ologhobo, 1989). According to Diagayette and Huss (1981), the level of tannin which adversely affect digestibility in sheep and cattle is between 2-5 g/100g, whereas goats have a threshold capacity of about 9 g/100g dietary tannin (Nastis and Malachek, 1981; Fadiyimu *et al*., 2011). Therefore, all the three mango varieties studied has tannin content beyond the ideal level for sheep but at levels tolerable to ruminants.

Tannins are a group of polyphenols which form insoluble complexes with protein and inhibit several enzymes (Bressani *et al*., 1983). They interact with salivary proteins and glycoproteins in the mouth and render the tissues astringent to taste. Tannins also reduce palatability, due to a sour taste (Messay and Shimelis, 2012). The conversion of raw animal hides into leather has traditionally been carried out with plant derived tannins. Many different cultures have developed the process of tanning. In the tropics, mangroves are often used to make tannins. Several *Rhizophora* species (Rhizophoraceae) are especially important among these. Although these would seem to provide an almost limitless source of tannins, mangroves represent an unstable ecological community and their destruction has proven to be costly in terms of seafood (Seigler, 2005). Perhaps the use of mango seed kernels might be an alternative source. Hydrogen cyanide content obtained in this study ranged from 0.02-0.03 mg/kg and is lower than 0.21 mg/kg obtained for almond seed (Akpabio, 2012). The lethal dose for this toxicant is 50-60 mg/kg (Rention, 1971); values obtained in this study are low, implying that using the seed kernel flour as livestock feed poses no health risk. The Oxalate content of the mango seed kernels varied from 3.46-4.88 mg/kg and is much lower than 187.4–542.4 mg/kg obtained for ten mango varieties (Kayode *et al*., 2013), 264 mg/kg obtained for almond seeds (Akpabio, 2012) and 2400-3700 mg/kg obtained for *Dacryodes edulis* seeds (Iyawe, 2009). The low oxalate content in the mango varieties studied fell short of the lethal dose (4-5g) for adult (Ross *et al*., 1999). The major problem associated with excessive oxalate consumption is its ability to form complexes with some mono and divalent ions therefore making its bioavailability a challenge. Oxalate has been known to form complexes with calcium, magnesium and iron leading to the formation of insoluble oxalate salts and resulting in oxalate stones. The low oxalate content of the three mango seed kernels evaluated indicates that calcium, magnesium and iron absorption would not be inhibited by oxalate whenever the kernel of these mangos are used as feed supplements. The phytate content of the mango varieties in this study ranged from 3.90-6.78 mg/kg. This is higher than 0.002 mg/kg reported for cashew kernel (Ogungbenle, 2014); but much lower than 121300-133700 mg/kg reported for *Dacryodes edulis* seeds (Iyawe, 2009). The implication of high phytic acid consumption is the induction of mineral deficiency through the formation of insoluble salts with divalent metals particularly calcium, magnesium, iron and zinc, making these unavailable to the body. Phytic acid may also react with protein or any of these minerals to either form phytate-protein complex or phytate-cation-protein complex. In addition to these, antioxidant enzymes requiring zinc as cofactors are inhibited while erythropoiesis may become impaired due to non-iron availability (Iyawe, 2009). Total phenol and flavonoid contents ranged from 0.41-0.63 mg/kg and 0.30-0.35 mg/kg, respectively. The total phenolic content obtained in this study is much lower than values (117000 mg/kg and 53500 mg/kg) obtained in mango seed kernel oils by Nzikou *et al*., (2010) and Kittiphoom and Sustasinee, (2013), respectively. This is also lower than 88200 mg/kg obtained in Avocado seed, 62600 mg/kg obtained in Longan seed and 27700 mg/kg obtained in Jackfruit seed (Soong and Barlow, 2006). Total phenolic content varies considerably from one kind of fruit to another. Total phenolic compounds are the main component responsible for antioxidant activity; this is mainly due to their redox properties which plays an important role in absorbing free radicals and quenching singlet oxygen or decomposing peroxides (Osawa, 1994).

The low amounts suggest that mango seed kernel is not toxic and can be safely introduced as a supplement into livestock feeds (Agunbiade and Olanlokun, 2006).

Table 1. Proximate composition (%) of three mango varieties.

Variety	MC	Protein	Ash	Crude Fat	Crude Fibre	CHO	Energy
Saigon	8.63±0.01a	5.7±0.01b	6.12±0.01b	8.53±0.01a	2.75±0.01a	68.40±0.27b	35.64±0.63a
Edward	7.39±0.01c	6.13±0.01a	5.99±0.01c	5.04±0.01c	1.98±0.01c	73.16±0.26a	29.37±0.36c
Julie	8.33±0.01b	5.20±0.00c	6.23±0.01a	5.14±0.01b	2.34±0.01b	72.72±0.39a	31.92±0.20b

Mean separation with the same letter in a column are not significantly different at p<0.05

Table 2. Mineral composition (mg/kg) of the seed kernel flour of three mango varieties.

Variety	Ca	Mg	K	Na	P	Mn	Fe	Zn	Cu
Saigon	5800±0.02a	2800±0.00b	1800±0.01a	6.99±0.16a	475±0.03b	6.72±0.15c	9.84±0.10c	3.01±0.06a	0.63±0.01c
Edward	4300±0.02c	2400±0.02c	1600±0.00b	5.62±0.11c	494±0.13a	8.08±0.07a	11.09±0.06a	2.65±0.07b	0.71±0.01b
Julie	5500±0.02b	2900±0.02a	1800±0.02a	6.34±0.29b	494±0.07a	7.07±0.08b	9.92±0.08b	3.00±0.01a	0.84±0.03a

Mean separation with the same letter in a column are not significantly different at p<0.05

Mineral composition

Result of the mineral contents of the entire mango seed kernels in this study reveals that there is significant difference in the mineral content across all the three varieties (Table 2). Calcium is the most abundant element ranging from 4300-5800 mg/kg, this is higher than the daily dietary requirement of lactating cows (3100 mg/kg), dry cows (1800 mg/kg) and is similar to that of growing calves (5800 mg/kg); (NRC, 1989). Saigon has the highest calcium content, followed by Julie; these are higher than value (483 mg/kg) obtained in maize kernel (Bressani *et al*., 1989). Thus, the mango seed kernels of all the three varieties can be incorporated into livestock feeds as good sources of calcium. Calcium is one of the macronutrients required by beef cattle and it is a major mineral component of the skeleton. Ninety nine (99%) of total body calcium are stored in the bones and a long term deficiency of calcium can cause bone weakness and even breakage. Saigon also has the highest potassium (1800 mg/kg), sodium (6.99 mg/kg) and zinc (3.01 mg/kg) contents. The magnesium content of the kernels ranged from 2400-2900 mg/kg with Julie having the highest value. This is higher than the magnesium content (1079 mg/kg) obtained in maize (Bressani *et al*., 1989) and value (223.4 mg/kg) obtained in Congo mango seed kernel as reported by Nzikou *et al*., (2010). The magnesium content in this study can meet the daily dietary requirement (1000 mg/kg) for this mineral in lactating cows; (1200 mg/kg) in dry cows and (2000 mg/kg) in growing calves (NRC, 1989), making mango seed kernels suitable for use in cow feeds. Magnesium is essential for carbohydrate metabolism and nervous system function. Its deficiency is mostly uncommon except for cows grazing small grain pastures during late winter. Potassium content in this study ranged from 1600-1800 mg/kg and is higher than the value obtained in Congo mango (Nzikou *et al*., 2010). This is also lower than 3248 mg/kg obtained in maize (Bressani *et al*., 1989), 6000 mg/kg required by lactating and dry cows and 7000 mg/kg required by growing cows (NRC, 1989).

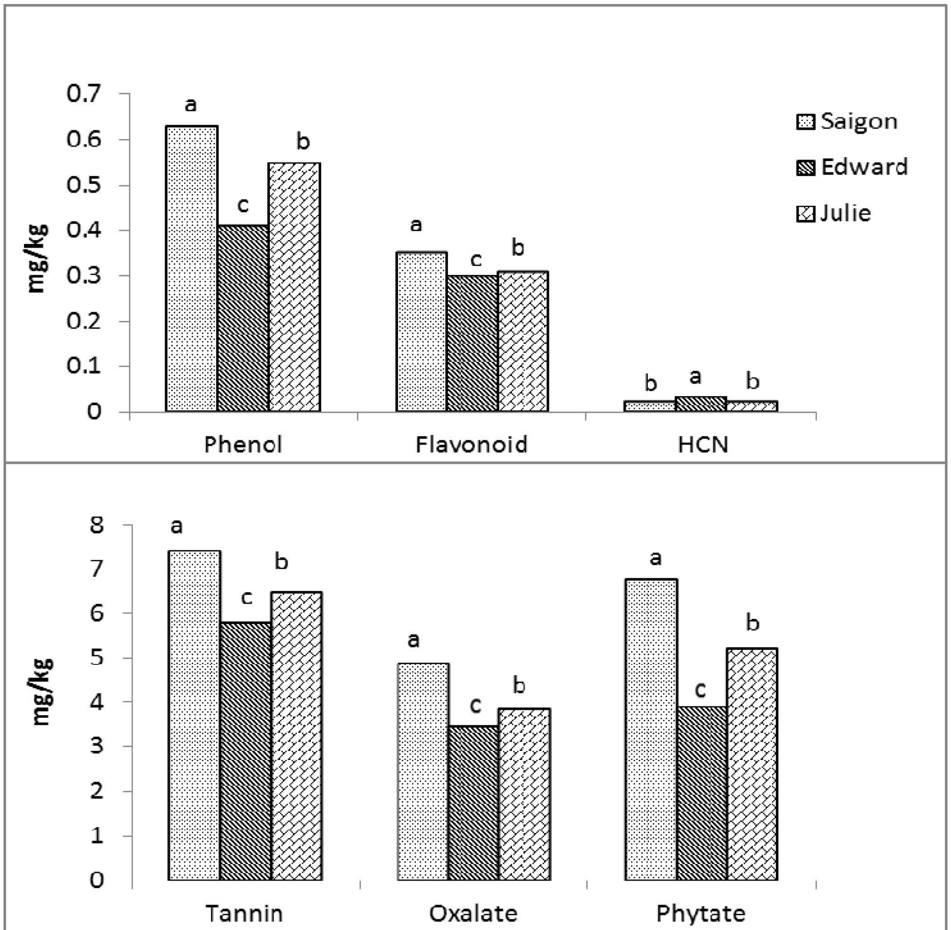

Figure 1: Phytochemical composition (mg/kg) of three Mango varieties

All phytochemicals in Figure 1 are expressed in mg/kg, except Tannin which is expressed in g/100g

Table 3. Fatty acid composition (%) of the seed kernel flour of three mango varieties.

Variety	Stearic acid (18:0)	Palmitic acid (16:0)	Oleic acid (18:1)	Linoleic acid (18:2)	Linolenic acid (18:3)
Saigon	38.80±0.48a	8.61±0.26b	43.71±0.72b	6.69±0.53a	0.63±0.12b
Edward	37.57±0.23b	9.06±0.16a	43.89±0.37b	7.00±0.254a	0.95±0.21a
Julie	37.93±0.35b	8.83±0.15a	44.91±0.41a	5.87±0.313b	0.72±0.22b

Means ± S.D. with same letter in same column are not significantly different at $p<0.05$
(C:D) - Carbon atoms:Double bonds ratio.

Potassium according to NRC, (1989) is really not needed in high concentration because its excess inhibits magnesium absorption in animals. Grasses, particularly early lush spring growth contains adequate amounts of potassium for grazing cattle and supplementation is rarely needed (NRC, 1989). Sodium ranged from 5.62-6.99 mg/kg in this study, this is lower than 592 mg/kg obtained in maize (Bressani *et al*., 1989) and 27 mg/kg obtained in Congo mango seed kernel (Nzikou *et al*., 2010). The requirement for sodium in lactating and dry cows is 700 mg/kg (NRC, 1989). The low amount of sodium in the mango seed kernels studied may not be adequate in meeting dietary needs but combination with other cereals rich in sodium can make it suitable for use in livestock feeds. Sodium provides for the proper functioning of the nervous and muscular systems and they regulate body pH and amount of water retained in the body, it is commonly deficient in diets and a constant daily source must be provided (NRC, 1989). Phosphorus content of mango seed kernel of the three varieties studied ranged from 475-494 mg/kg, this is higher than value (200 mg/kg) obtained for Congo mango (Nzikou *et al*., 2010); but lower than value (2996 mg/kg) obtained in maize (Bressani *et al*., 1989). Phosphorus is needed for bone growth, kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance (Fallon *et al*., 2001). The manganese and iron contents of Edward are significantly ($p<0.05$) higher than that of Saigon and Julie. Iron is essential for blood formation. The iron content of the mango seed kernel in this study ranged from 9.84-11.09 mg/kg, this is lower than the value (48 mg/kg) obtained in maize (Bressani *et al*., 1989).

Fatty acid composition

Fatty acid profile (Table 3) of the seed kernel oils of the three mango varieties is a main determinant of the oil quality. Fatty acids are also important as nutritional substances and metabolites in living organisms. Many kinds of fatty acids play an important role in the regulation of a variety of physiological and biological functions (Zhao *et al*., 2007). The seed kernel oils of the three mango varieties evaluated mainly consisted of stearic (37.57–38.80 mg/kg) and oleic (43.71–44.91 mg/kg) acids. This is similar to report of (Nzikou *et al*., 2010) in which stearic (37.73%) and oleic (46.22%) acids were the major fatty acids present in the mango seed kernels; but different from the maize oil composition which consists mainly of oleic and linoleic acids (Bressani *et al*., 1990). Stearic acid was the main saturated fatty acid, while oleic acid was the major unsaturated fatty acid in this study; this corresponds to the results of the study conducted by Kittiphoom and Sutasinee (2013). The stearic acid content obtained in this study is lower than value (42-48%) obtained for some mango seed kernels as reported by (Bringi, (1999); but higher than the value (2.40%) obtained in tropical white maize as reported by Bressani, 1990). Palmitic and Oleic acids which ranged from 5.1-8.0% and 35-42%, respectively; (Bringi, 1999) are comparable to values obtained in this study for the three mango varieties. Saigon significantly has the highest stearic acid than that of Edward and Julie, while Edward has the highest palmitic, linoleic and linolenic acid contents. Mango seed kernel oil and its derivatives are used in cosmetic as a preservative since it has high content of stearic acid. It melts at body temperature or upon contact with skin and disperses smoothly, providing a protective, emollient layer. It has a protective effect against harmful UV radiations from the sun and reduces degeneration of skin cells and restores elasticity (Saiprabha and Goswami-Giri, 2011).

Stearic acid is a long 18-carbon straight-chain saturated fatty acid and has been found to bind composites (Netravali, 2003), human serum albumin (Bhattacharya *et al.,* 2000) and α-helical sites in bio-molecules (Vila *et al*., 1998); indicating the usefulness of the kernels of these mangoes for those purposes. Julie has the highest oleic acid content (44.91%). Oleic acid is an 18-carbon monounsaturated fatty acid essential in human nutrition and helps reduce triglycerides, LDL-cholesterol, total cholesterol and glycemic index (Kittiphoom and Sutasinee, 2013). The increase in stability over oxidation of vegetable oil is attributed to oleic acid (Abdulkarim *et al*., 2007). Oleic acid is less susceptible to oxidation than polyunsaturated fatty acid from the n-6 series (Linoleic acid) (kittiphoom and Sutasinee, 2013). Linoleic acid which ranged from 5.87–7.00 mg/kg is an unsaturated essential fatty acid and is important for the stability of oils because of the chemical reactions occurring at the double bonds. It contributes to health benefits of human body and is preferred by industries when oil hydrogenation is required (Kittiphoom and Sutasinee, 2013). The high quality and nutritional value of mango kernel oil of these three varieties has potential application in human foods.

The results indicate that the mango seed kernel is comparable to most of the cereals in respect to carbohydrates, protein, fat and minerals. It has high potential as energy sources and may be better utilized as a source of important nutrients in livestock feeds. Mango seed kernel oil has been shown to be rich in stearic and oleic acids, indicating that they are stable and tolerant to rancidity. The high content of oleic and linoleic acids which are polyunsaturated fatty acids makes mango seed kernel oil a potential source of nutrient rich food oil. The study suggests that mango seeds should be further utilized rather than just discarded as waste.

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