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Egyptian mango by-product 1. Compositional quality of mango seed kernel

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Abstract

Egyptian mango seeds were collected as wastes from local fruit processing units and the kernels were separated and dried. This study was carried out on mango seed kernels to clarify their proximate composition, amino acids, phenolic compounds and the characteristics of the extracted oil including unsaponifiable matter constituents, lipid classes and fatty acid composition. Mango seed kernels contained a considerable amount of total phenolic compounds, total lipid, unsaponifiable matter, and a low amount of crude protein, but the quality of protein was good because it was rich in all essential amino acids. Eight phenolic compounds were identified; tannin and vanillin were in highest amounts. Unsaponifiable matter showed the occurrence of high amounts of squaline followed by sterols and tocopherols. Stearic acid was the main saturated fatty acid, while oleic acid was the major unsaturated fatty acid in all lipid classes. The fatty acid composition of total lipid and neutral lipid was similar, while phospholipid had a high amount of palmitic, linoleic and linolenic acids.

Keywords: Mango seed kernel; Proximate composition; Amino acids; Phenolic compounds; Unsaponifiable matter; Lipid classes; Fatty acid composition

1. Introduction

In Egypt, mangos are the most popular fruits and are cultivated almost in the whole of the Nile valley and around the desert. There are several varieties grown in Egypt, the better known cultivars are alphonso, pairi, zebda, mabroka, balady, and succary (El-Soukkary, EL-Sahn, & Mohamed, 2000). In Egypt, more than four million tons of mango fruits were produced in 2004/2005 (Ministry of Agriculture, 2005).

After consumption or industrial processing of the fruits, considerable amounts of mango seeds are discarded as waste (Puravankara, Bohgra, & Sharma, 2000). According to mango varieties, the seed represents from 10% to 25 % of the whole fruit weight (Hemavathy, Prabhakar, & Sen, 1988). The kernel inside the seed represents from 45% to 75% of the seed and about 20% of the whole fruit (Arogba, 1997). However, more than one million tones of mango seeds are being annually produced as wastes so that if such seeds could be utilized in some way, hazards could be eliminated and probably valuable products could be produced.

Depending on their variety, mango seed kernels contain on a dry weight average 6.0% protein, 11% fat, 77% carbohydrate, 2.0% crude fiber and 2.0% ash (Zein, El-Bagoury, & Kassab, 2005). Although mango seed kernels have a low content of protein, the quality of protein is good (Seleim, Rashwan, & Ragab, 1999). The amino acid profile of different varieties of mango seed kernel protein contains the most of the essential amino acids, with highest values of leucine, valine and lysine (Diaz & Coto, 1983; Shahinaz, 2001). Mango seed kernels were shown to be a good source of polyphenols, phytosterols as campesterol, β-sitosterol and tocopherols (Soong, Barlow, & Perera, 2004). The lipid composition of mango seed kernels has attracted the attention of scientists in recent years because of their unique physical and chemical characteristics (Hemavathy et al.,

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1988; Helmy, 1998). Hemavathy, Prabhakar, and Sen (1987) extracted and fractionated total lipids from Alphonso mango kernel into three lipid classes. Total lipid (11.6% of dry kernel) consisted of 96.1% neutral and 3.9% polar lipids, which comprised 2.9% glycolipids and 1.0% phospholipids. Also, Rashwan (1990) extracted and fractionated total lipids from three different mango seed kernel varieties namely goleck, pairi and hindi. The neutral lipids varied from 95.2% to 96.2%, phospholipids from 2.7% to 3.3% and glycolipids from 1.1% to 1.4%. Triglycerides constituted the major fraction of the neutral lipids, for all varieties and accounted from 93.7% to 96.4%. The lipids of mango seed kernel consist of about 44–48% saturated fatty acids (majority stearic) and 52–56% unsaturated (majority oleic) (Ali, Gafur, Rahman, & Ahmed, 1985; Hemavathy et al., 1987; Mohamed & Girgis, 2005). On the nutritional and toxicological studies of the mango seed kernel, Rukmini and Vijayaraghavan (1984) indicated that mango seed kernel fat is promising and a safe source of edible oil and was found to be nutritious and non-toxic so that it could be substituted for any solid fat without adverse effects. Rashwan (1990) showed that the lipids extracted from different mango varieties were free from toxic material such as hydrocyanic acid. Arogba (1997) concluded that the Nigerian mango kernel has a good source of high quality fat and protein as well as tannin. When extracted, these components could be valuable commercially in the vegetable oil industry, in confectionery and in tanning. Similarly, the processed flour could be a principal ingredient in the diets of babies and adults in Nigeria. Soong et al. (2004) suggested that mango seed kernel could be used as a potential source for functional food ingredients due to its high quality of fat and protein as well as high levels of natural antioxidants. Moreover, Zein et al. (2005) published that soaking and boiling treatments had a great impact in reducing of the anti-nutritional factors. So the processed flour could be a principal ingredient for making products such as cakes and cookies for infants and adults and also other products such as bread and pastry. The present study attempted to estimate the compositional quality of the Egyptian mango seed kernel. Therefore, this study was designed to determine the proximate composition, amino acid pattern and phenolic compounds in mango seed kernel (MSK) flour, and unsaponifiable constituents, lipid classes and the fatty acid composition in mango seed kernel oil (MSKO).

2. Materials and methods

2.1. Materials

During the summer season of 2005, about 200 kg of mango seeds as by-products (waste) were collected from two different places (four individual samples) after the manufacture of mango juice from the mixed varieties of ripened mangoes such as zebda, balady and succary. Two individual samples (50 kg each) were obtained from Edfina Company for Food Preservation, Alexandria, Egypt. Two individual samples (50 kg each) were obtained from local fruit juice markets at Alexandria, Egypt. All chemicals used in this study were purchased from the El-Gamhouria Company for chemicals and medical requisites (Alexandria, Egypt) while the standards of fatty acid methyl esters (FAME), tocopherols and sterols were from Sigma (St. Louis, MO, USA).

2.2. Methods

2.2.1. Preparation of mango seed kernels

The seeds (four samples) were washed and air dried and the kernels were removed manually from seeds. The kernels were chopped and dried at 50 °C (Augustin & Ling, 1987). The dried material was ground in a hammer mill (Apex Wiley provided with a 100 mesh sieve) into a powdery form and kept in a closed dark glass bottle and stored at 4 °C until utilization.

2.2.2. Proximate composition and amino acid analysis of prepared mango seed kernels

Moisture content, ash, crude fiber and crude protein were determined in samples (two replicates per sample) according to AOAC (1990), while total lipids were extracted and determined according to Folch, Le, and Stanley (1957). Amino acid composition was determined according to the method described by Ozols (1990) using Beckman amino acid analyzer (Model 119 CL) at the Alexandria University. One hundred milligrams of ground samples were hydrolyzed, filtered through a Whatman No. 42 and diluted to 25 ml. Two milliliter of filtrate was placed in a vacuum dessicator until dryness. The dry residue was dissolved in a 5 ml sodium citrate buffer (pH 2.2) and used for amino acid analysis.

2.2.3. Determination and identification of phenolic compounds

Total phenols were extracted from mango seed kernels powder samples according to the methods of Rodriguez de sotillo, Hadley, and Holm, 1994 using methanol alcohol 95% under cooling (4 °C). Five grams of the powder sample was homogenized for 4 min with 29 ml of cold methanol, the resulting slurry were centrifuged at 3000*g* for 10 min. The supernatant liquid was filtered through filter paper (Whatman no. 4). The filtrate was collected for quantitative analysis. The total phenol content of methanol extract was assayed colorimetrically using the Folin-ciocalteu method where an aliquot (1 ml) of the extract was mixed with diluted Folin-ciocalteu (0.5 ml) and 2% ethanol amine (1 ml) at room temperature. After 5 min, the absorbance was measured at 750 nm using a Shimadzu UV-2101 spectrophotometer with a blank sample (water plus reagent) in the reference cell. The phenolic compounds of methanolic extracts from mango seed kernels were identified and determined using high performance liquid chromatography (HPLC, Dundee University, UK) according to

the method described by Anderson and Pederson (1983). HPLC (Hewlett Packard Serious HP 2100) consisting of a model P 4600 pump with a Waters R401 detector, a U6K injector, and a Waters Bondapak C-18 column (30 cm × 4 mm).

2.2.4. Characteristics of mango seed kernel oil (MSKO)

Physical properties included specific gravity, refractive index, melting point and colour were determined according to AOCS (1989).

Chemical characteristics including free fatty acids (FFA), peroxide value (PV), iodine value (IV) and saponification value (SV) were determined according to AOCS (1989).

2.2.5. Extraction and determination of unsaponifiable matter

Unsaponifiable matter of mango seed kernel oil was extracted and determined in oil samples according to Abdalla (1999). Twenty grams of MSK oil was refluxed with 40 ml of 10% ethanolic potassium hydroxide for 1 h. The reaction mixture was diluted with 40 ml of distilled water and the unsaponifiable matter was extracted three times with 20 ml portion of ether. The ether extracts were combined and washed three times with distilled water until they were alkali-free. The ether extract was evaporated and dried over anhydrous sodium sulphate. The unsaponifiable residues were weighed and analyzed for squalene, sterols and tocopherol contents. Squalene was determined in the unsapoifiable matter using GC (Pye-Unicam, Dundee University, UK) equipped with a capillary silica column (25 m × 0.5 mm) packed with *SE* 52 (Carlo Ebra). Sterols and tocopherols were analyzed in the unsaponifiable matter using GC (Pye-Unicam, Dundee University, UK) equipped with a glass column (25 m × 0.4 mm) packed with 3% *OV*-1 as recommended by Ghosh and Bhattacharyya (1996).

2.2.6. Lipid classes

The total lipids were fractionated into neutral lipid (NL), glycolipids (GL) and phospholipids (PL) on a silicic acid column (Rouser, Kritchewsky, & Yamamato, 1967) using chloroform, acetone and methanol successively. The eluted fractions were collected in pre-weighed flasks; the solvents were removed at 40 °C in a rotary evaporator. Each eluted fraction was determined gravimetrically as a weight percentage of the total lipids. Individual components of neutral lipids and phospholipids were separated on thin layer chromatography (TLC) of silica gel G plate using hexane: diethyl ether: acetic acid (80:20:1, v/v) and chloroform: methanol: water (85:10:5, v/v), respectively, as described by Radwan (1978).

2.2.7. Fatty acid composition

The fatty acid composition of total lipids extracted from mango seed kernels as well as neutral lipids and phospholipids classes were estimated. Fatty acid methyl esters was determined using a gas chromatograph [GC-4C Shimadzu CM (PFE)] equipped with flame ionization detector (FID) and a glass column (3 m × 3 mm i.d.) packed with 5% DEGC on 80/100 chromosorb. The column temperature was 180 °C isothermal and detector temperature was 270 °C. The gas flow rates were 20 ml/min for N_2, 75 ml/min for H_2 and 0.5 ml/min for air. The standard mixture of FAME was analyzed under identical conditions prior to running the sample. The concentration of FAME was calculated by triangulation method.

3. Results and discussion

3.1. Proximate composition, amino acids and phenolic compounds of mango seed kernels (MSK)

The moisture content of fresh mango seed samples was on average 50.7% while the moisture content of dried MSK powder samples was on average 8.5%. Crude protein, total lipid, crude fiber and ash contents of MSK were found to be 6.7%, 12.3%, 2.7%, and 2.5% on a dry weight basis, respectively. These results were in agreement with the data obtained by El-Soukkary et al. (2000), Seleim et al. (1999), and Zein et al. (2005). The total lipid content was high in level than that showed by many other publications such as Youssef (1999), may be due to different mango varieties.

The protein content of the MSK was compared to jackfruit seeds (Puwastien, Burlingame, Raroengwichit, & Sungpuag, 2000). Their results showed that jackfruit seeds (Thai variety) contained moisture on average 60.7% and protein 5.5 g protein per 100 g dry seeds, while jackfruit seeds (Malaysian varieties) contained moisture from 57.2 to 63.7% and protein from 6.6 to 4.7 g per 100 g dry seeds. Accordingly, the protein content of the MSK determined in this study was similar or higher than that of jackfruit seeds.

The amino acid composition of mango seed kernels is presented in Table 1. All the essential amino acids except for methionine, threonine and tyrosin occurred at higher levels in the MSK than those of the FAO/WHO reference protein (FAO, 1993). Augustin and Ling (1987) found that MSK flour protein contained the most of the essential amino acids in higher levels than in the FAO reference. Glutamic acid was the most predominant amino acid followed by aspartic, arginine and leucine. The values of amino acids showed that methionine and tyrosin were in the lowest levels in Egyptian MSK. These results were paralleled with those reported by Arogba (1997), Lasztity, EL-Shtel, Abdel-Samei, Hatour, and Labib (1988) and Zein et al. (2005) who found that amino acids presented in a greater amount in MSK protein were glutamic and aspartic. Different investigations indicated that amino acid composition of mango seed kernel depends on mango varieties (Elegbede, Achoba, & Richard, 1996).

Mango seed kernels (MSK) contained 112 mg total polyphenols per 100 g dry seed kernel powder. High performance liquid chromatography (HPLC) was used for separation and identification of phenolic compounds extracted

Table 1
Amino acid composition of mango seed kernels (Mean ± SD, $n = 4$) compared with FAO/WHO reference protein (g amino acid per 100 g protein)

Amino acids	Mango seed kernel	FAO/WHO reference protein
Leucine	6.9 ± 0.2	4.8
Isoleucine	4.4 ± 0.2	4.2
Methionine	1.2 ± 0.1	2.2
Phenylalanine	3.4 ± 0.1	2.8
Lysine	4.3 ± 0.2	4.2
Threonine	3.4 ± 0.2	4.0
Tyrosine	2.7 ± 0.1	4.1
Valine	5.8 ± 0.3	4.2
Total essential amino acids	32.1 ± 2.2	
Aspartic	6.5 ± 0.4	
Glutamic	18.2 ± 0.8	
Serine	3.3 ± 0.1	
Proline	3.5 ± 0.2	
Glycine	4.0 ± 0.4	
Alanine	4.2 ± 0.4	
Histidine	5.5 ± 0.6	
Arginine	7.3 ± 0.8	
Total non-essential amino acids	52.2 ± 2.1	

MSK contains crude protein, 6.7% per 100 g dry seed kernel powder.

from mango seed kernels as shown in Table 2. The results indicated that MSK contained different phenolic compounds such as tannin which represented 20.7% of total polyphenols, followed by 20.2% of vanillin. MSK also contained high amounts of coumarin, cinammic and ferulic acids, while gallic and caffeic acids and mangiferin were found in lower amounts than other phenolic compounds. These results somewhat agree with those reported by Mohamed and Girgis (2005) and Puravankara et al. (2000). Puravankara et al. (2000) separated six major phenolic compounds (mainly, gallic acid, ellagic acid and gallates) and isolated eight different phospholipid fractions from mango seed kernel powder. Their results showed that phenolics were more effective than the phospholipids in increasing the induction period of buffalo ghee. They concluded that besides two major classes of phenolic compounds and phospholipids, other factors such as tocopherols, carotenoids and sugar/amino acid browning reaction products may also be involved in the effectiveness of mango seed kernel powder in extending the shelf-life of buffalo ghee. Also, Mohamed and Girgis (2005) separated six phenolic compounds, mainly coumaric, vanillin and ferulic acid. They concluded that mango seed kernel extract can be used as a new natural antioxidant to improve the oxidative stability of both sunflower and soybean oils. Moreover, Nunez-Selles (2005) reported that phenolic compounds found in mango seed kernel and bark are responsible for antioxidant activity and concluded that mango seed extract could be useful in preventing the production of reactive oxygen species and oxidative tissue damage in vivo.

Table 2
Phenolic compounds in mango seed kernel extract (Mean ± SD, $n = 4$)

Phenolic compounds	Values (% of total compounds)
Tannin	20.7 ± 1.3
Gallic acid	6.0 ± 0.5
Coumarin	12.6 ± 0.9
Caffic acid	7.7 ± 0.8
Vanillin	20.2 ± 2.1
Mangiferin	4.2 ± 0.4
Ferulic acid	10.4 ± 1.1
Cinammic acid	11.2 ± 1.0
Unknown compounds	7.1 ± 0.9

MSK contains total polyphenols, 112 mg per 100 g dry seed kernel powder.

3.2. Characteristics of mango seed kernel oil (MSKO) and composition of unsaponifiable matter

Physical properties including specific gravity, refractive index, melting point and colour as well as chemical characteristics including free fatty acid, peroxide value, iodine number, saponification number and unsaponifiable matter of MSKO were determined (Table 3). From these results, it can be noticed that the values of specific gravity, refractive index and melting point in MSKO are in agreement with those mentioned by Bahaa El-Din (1979) and Mohamed and Girgis (2005). Moreover, the crude fat of mango seed kernel was creamy in colour and had a total lovibond colour value of 25 (30Y+10R). The low acidity of MSKO indicated that the mango seed was almost free from hydrolytic rancidity brought almost by lipases and enables the direct use of such an oil in industries without further neutralization as described by Arogba (1997). On the other hand, MSKO had a high quality due to the low level of peroxide value. The iodine number of MSKO, which indicates the unsaturation of fatty acids, was found to be 53.15. The earlier study by Bahaa El-Din (1979) found that iodine number was less than 40, while recent studies (Mohamed & Girgis, 2005) found that iodine number ranged from 49 to 53, which is in agreement with our results.

The results of saponification number were comparable with literature values (El-Soukkary et al., 2000; Hug, Mondal, Ahmed, & Gafur, 1985). Unsaponifiable matter

Table 3
Some physical properties and chemical characteristics of mango seed kernel oil (Mean ± SD, $n = 8$)

	Values
Physical properties	
Specific gravity at 40 °C	0.900 ± 0.03
Refractive index at 40 °C	1.459 ± 0.10
Melting point (°C)	30.50 ± 1.25
Total Lovibond colour (30Y+10R)	25.00 ± 1.50
Chemical characteristics	
FFA (as oleic acid%)	1.22 ± 0.20
Peroxide value (milliequivalent O_2 per kilogram oil)	0.96 ± 0.25
Iodine number	53.15 ± 2.20
Saponification number	192.16 ± 6.50
Unsaponifiable matter (% of total lipid)	2.78 ± 0.15

MSK contains total lipids, 12.3 g lipid per 100 g dry seed kernel powder.

determined in this study was higher than many other publications which represented 2.78% of total lipids.

The composition of unsaponifiable matter of vegetable oils including tocopherols, sterols, and squalene is of great importance for oil characteristics and stability (Sims, Fioriti, & Kanuk, 1972). Unsaponifiable matter extracted from mango seed kernel oil was analyzed for squalene, sterol fractions and tocopherol fractions as described in Table 4. These three important components constituted about 75% of unsaponifiable matter of MSKO. β-Sitosterol was the most abundant sterol fraction followed by Δ-avenasterol, while campesterol and stigmasterols were in lowest levels. α-tocopherol was the most predominant tocopherol fraction (about 80% of total tocopherols), followed by γ-tocopherol (about 20% of total tocopherols).

Unsaponifiable fractions data obtained from the recent research work are valuable so that attention should be paid to these important compounds.

3.3. Lipid classes and fatty acid composition of MSKO

The neutral lipids represented 94.7% of the total lipids of MSKO (Table 5). The phospholipids followed by glycolipids were 3.6% and 1.7% of total lipids. These values were very close to those previously reported by Ali et al. (1985), Rashwan (1990) and Van Pee et al. (1981) for mango kernel lipids. The neutral lipids revealed the presence of six fractions. Triglycerides constituted the major percentage of the neutral lipids, and accounted for 88.4% of total lipid and 93.4% of neutral lipids. Free fatty acids of MSKO were in lowest levels (0.50% of total lipid), indicating that the lipid was of a high quality. The phospholipid classes showed six identified fractions. The data indicated that the main component of phospholipids was phosphatidyl choline (1.5% of total lipid and 40.4% of total phospholipids), followed by phosphatidyl ethanolamine (1.1% of total lipid and 30.2% of total phospholipids), while phosphatidyl serine, phosphatidic acid and phosphatidyl inositol were in the lowest levels. These results coincide with those outlined by Ali et al. (1985) and Hemavathy et al. (1987).

Table 5
Lipid classes of mango seed kernel oils (Mean ± SD, $n = 8$)

Lipid classes	Values (% of total lipids)
Neutral lipids	94.7 ± 2.6
Monoglycerides	0.8 ± 0.1
Diglycerides	3.1 ± 0.4
Sterols	1.3 ± 0.2
Free fatty acids	0.5 ± 0.1
Triglycerides	88.4 ± 2.2
Hydrocarbons	0.6 ± 0.1
Phospholipids	3.6 ± 0.5
Phosphatidyl serine	0.2 ± 0.1
Phosphatidyl inositol	0.2 ± 0.1
Phosphatidyl choline	1.5 ± 0.4
Phosphatidyl ethanolamine	1.1 ± 0.2
Phosphatidic acid	0.2 ± 0.1
Unknown compounds	0.4 ± 0.2
Glycolipids	1.7 ± 0.3

MSK contains total lipids, 12.3 g lipid per 100 g dry seed kernel powder.

The fatty acid composition of total lipids, neutral lipids and phospholipids of MSKO is presented in Table 6. The results revealed that total saturated fatty acids of total lipids and neutral lipids of MSKO were 44.6% and 46.5%, respectively, and the ratio of unsaturated to saturated fatty acids were 1.3 and 1.2, respectively. This ratio indicated that MSKO was highly stable to oxidation (Hemavathy et al., 1987). Unsaturated fatty acids were higher in phospholipids fraction than in total lipids or neutral lipids fraction, so that the ratio of unsaturated to saturated fatty acids increased to 1.4. In general, stearic acid was the main saturated fatty acid, while oleic acid was the major unsaturated fatty acid, followed by linoleic acid. Linolenic acid was found in trace amounts in total lipids and neutral lipids (1.2%, 1.1% of total fatty acids, respectively). In the phospholipid fraction, stearic acid decreased followed by oleic acid while palmitic and both linoleic and linolenic acids contents increased. Hemavathy et al. (1987) fractionated the total lipids of mango seed kernel of alphonso variety to neutral lipids, glycolipids and phospholipids and studied their fatty acid patterns.

Table 4
Unsaponifiable matter constituents of mango seed kernel (Mean ± SD, $n = 4$)

Unsaponifiable fractions	Values (% of total unsaponifiable matter)
Squalene	38.2 ± 2.2
Sterol fractions	
Campesterol	2.1 ± 0.2
Stigmasterol	1.4 ± 0.2
β-sitosterol	12.6 ± 2.1
Δ-avenasterol	6.4 ± 0.9
Tocopherol fractions	
α-tocopherol	8.8 ± 1.5
γ-tocopherol	3.1 ± 0.4

MSK contains total lipids, 12.3 g lipid per 100 g dry seed kernel powder.
MSK contains unsaponifiable matter, 2.78% of total lipids.

Table 6
Fatty acid composition of mango seed kernel lipid classes (Mean ± SD, $n = 4$)

Fatty acids	Lipid fractions (% of total fatty acids)		
	Total lipids	Neutral lipids	Polar lipids
Myristic $C_{14:0}$	0.5 ± 0.1	0.4 ± 0.1	0.3 ± 0.1
Palmitic $C_{16:0}$	5.8 ± 0.3	6.2 ± 0.2	11.6 ± 0.3
Stearic $C_{18:0}$	38.3 ± 1.2	39.9 ± 1.1	29.2 ± 0.6
Oleic $C_{18:1}$	46.1 ± 2.3	46.3 ± 1.4	41.3 ± 0.7
Linoleic $C_{18:2}$	8.2 ± 0.6	6.1 ± 0.3	15.4 ± 0.4
Linolenic $C_{18:3}$	1.2 ± 0.2	1.1 ± 0.1	2.3 ± 0.2
Saturated fatty acids	44.6 ± 1.3	46.5 ± 1.3	41.1 ± 0.9
Unsaturated fatty acids	55.5 ± 1.6	53.5 ± 1.5	59.0 ± 1.6
Unsaturated/Saturated	1.3 ± 0.1	1.2 ± 0.1	1.4 ± 0.2

MSK contains total lipids, 12.3 g lipid per 100 g dry seed kernel powder.

They found that the fatty acid composition of total lipids and neutral lipids was similar, while glycolipids and phospholipids had higher palmitic, linoleic and linolenic acids compared to total and neutral lipids. These findings are in agreement with the results obtained in this research work. Helmy (1998) and El-Soukkary et al. (2000) studied the fatty acid composition of mango seed kernel oil. Their data showed that the main fatty acids of total lipids were stearic (40–42%) and oleic (47–48% of total fatty acids), and they together constituted 87–88% of total fatty acids. These results are in agreement with the data obtained in this work where stearic and oleic acids of total lipids and neutral lipids constituted 84.4%, 86.2% of total fatty acids, respectively. Accordingly, MSKO is more stable than many other vegetable oils rich in polyunsaturated fatty acids. Such oils seem to be suitable for blending with vegetable oils, stearin manufacturing, confectionery industry or/and in the soap industry.

4. Conclusion

Egyptian mango seed kernels contain considerable amounts of total phenolic compounds and total lipids with high levels of unsaponifiable matter. Although mango seed kernels have a low content of protein, the quality of protein was good because it was rich in all essential amino acids. All the essential amino acids except for methionine, threonine and tyrosin occurred at higher levels in the MSK than those of the FAO reference protein. Eight phenolic compounds were identified in which tannin and vanillin represented about 40% of the total phenolic constituents. Unsaponifiable matter showed the occurrence of high amounts of squaline followed by sterols (β-sitosterol and Δ-avenasterol), tocopherols (α-tocopherol and γ-tocopherol). Neutral lipid class represented about 95% of total lipids and revealed the presence of six fractions, triglycerides constituted as one with a major percentage. The phospholipids class showed six identified fraction. The main component was the phosphatidyl choline followed by phosphatidyl ethanolamine. Stearic acid was the main saturated fatty acid, while oleic acid was the major unsaturated fatty acid for all lipid classes. Unsaturated fatty acids were higher in polar lipids than in total or neutral lipids. This baseline information would assist potential commercial handlers of mango seed kernels. Although more research is needed, the Egyptian mango seed kernel as waste seems promising as a food additive for extending the shelf-life of a variety of food products.

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