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Characterization of Egyptian *Moringa oleifera* Lipids (Whole Seeds and Kernels)

Salama, M. A.[1]; M. A. Owon[2]; M. F. Osman[2]; Awatif I. Esmail[1] and B. Matthäus[3]

[1] Food Technology Research Institute, Agriculture Research Center, Egypt.

[2] Food Technology Department, Faculty of Agriculture, Kafrelsheikh University, Egypt.

[3] Max Rubner-Institut (MRI) Bundesforschungsinstitut für Ernährung und Lebensmittel, Institut für Sicherheit und Qualität bei GetreideSchützenberg, Detmold, Germany

ABSTRACT

Moringa seeds (*Moringa oleifera*) are rich in oil contents, the purpose of this study is to extract the oil from the whole seeds and kernels of the Egyptian Moringa by cold and hot extraction methods and to study the effect of extraction method on the composition of fatty acids, tocopherols and triglycerides in extracted oil. The results indicated that the amount of extracted oil by hot extraction were 28.85% and 39.23% and by cold extraction were 21.39% and 29.34% for whole seeds and kernels, respectively. The main saturated and unsaturated fatty acids in both were behenic (6.76 – 6.49%) and oleic (66.22 – 65.78%) acids. Palmitic acid was higher in the kernels than in the whole seeds (5.90 – 5.55%), while vaccenic acid was higher in the whole seeds than in the kernels (6.33 – 6.15%), respectively. After cold extraction, stearic and behenic acids increased in whole seeds (4.55 to 5.51%), (6.76 to 7.67%) and kernels (4.45 to 5.52%), (6.49 to 7.85%), respectively. While, oleic, vaccenic, linoleic and gondoic acids decreased by cold extraction in whole seeds and kernels. Tocopherols obtained from kernels were more than whole seeds. α-Tocopherol by hot extraction in the kernels and the whole seeds was 20.92 and 14.61 mg/100g, respectively. Using cold extraction in kernels caused significant decrease in α-Tocopherol (20.92 – 16.82 mg/100g). A significant difference appeared between whole seeds and kernels in the triglycerides (2,3-dioleyl-1-palmitoylglycerol) "POO" (15.64% and 15.86%) and (1,2,3 trioleylglycerol) "OOO" (34.22 and 34.32%). After cold extraction in both, triglycerides (1,3-distearoyl-2-oleylglycerol) "SOS" and (2,3-dioleyl-1- stearoyl) "SOO" increased (1.77 – 2.17% and 9.82 – 11.25% whole seeds) and (1.80 – 2.07% and 9.86 – 11.38% kernels).

Keywords: *Moringa oleifera*, Oil extraction, Fatty acids, Tocopherols, triglycerides.

INTRODUCTION

Moringa oleifera is a member of family Moringaceae. It is the most famous and utilized species in this family (Morton, 1991). It is wide spread in the western and sub-Himalayan tracts, India, pakistain, Africa (Mughal *et al*., 1999). Also it is found in central America, Caribbean Islands and North and South of America (Morton, 1991).

It has many traditional names such as horseradish or drumstick. In Egypt they called it "Shagara al Rauwaq" the tree of purification (Von, 1986). Due to its coagulating properties, it is used for water purification (Kalogo *et al.*, 2000; Anwar *et al.*, 2007). The shape of the seeds is triangle or round. These seeds are present inside pods. The kernels surrounded by coat which is easy to remove (Abdulkarim *et al*., 2005). 400 – 1000 pods and 15000 – 25000 seeds could be taken from each tree per year. The ratio of the kernels to the coat is 75-25% (Jahn, 1988).

Moringa oleifera considers as a vegetable food in some countries (Siddhuraju and Becker, 2003). The young pods are eaten in Indonesia like vegetables and it taste like asparagus (TANCN, 2003). The fried seeds have a taste like peanuts (Qaiser, 1973). The leaves are used by Philippine women mixed with chicken or shellfish soup to increase the production of milk for women (Siddhuraju and Becker, 2003). Oduro *et al*., (2008) reported that the leaves contained a good amount of iron and calcium. Also, it can be used as an external application for wounds (The Wealth of India, 1962). Sodamade *et al.,* (2013); Gowrishankar *et al.,* (2010) reported that the leaves were a good source of Na, Fe, Cu, Zn and Mg. Marrufo *et al.*, (2013) reported that *Moringa oleifera* leaves contained essential oil which had antimicrobial activities

Many parts of Moringa tree contain a good amount of amino acids – especially essential amino acids (Amagloh and Benang, 2009). *Moringa oleifera* root, seeds and leaf protein are characterized of good quality and as such are suitable for animal feeds and human diets (Okereke and Akaninwor, 2013). Anwar *et al.*, (2007) reported that Moringa is an important source of minerals, protein, vitamins, phenolic compounds and beta-carotene.

All parts of this tree have medicinal properties. The Wealth of India, (1962) and Dahot, (1988) reported that it can be used in the treatment of rheumatism, venomous bites and ascites. Also, it has an effect as antiepileptic, antipyretic, anti-inflammatory, antiulcer effects and antitumor (Cáceres *et al.,* 1992; Singh and Kumar 1999; Morimitsu *et al.*, 2000; Siddhuraju and Becker, 2003).

Ben oil the common name of the oil extracted from Moringa contains high amount of oleic acid. As known mono unsaturated fatty acids (oleic acid) has more oxidative stability than polyunsaturated fatty acids at frying processes and storage. Moringa oil (Ben oil) has more stability during frying than canola, soybean and palm olein oils (Abdulkarim *et al.*, 2007). It smells like peanut (Kleiman *et al.*, 2008). All the main fatty acids in olive oil are found in moringa oil, so it can be used as an alternative to olive oil after some modification (Dahot and Memon, 1985). Tsaknis *et al*., (1999) said that Moringa oil was used in making perfume and products for hair protection. The most prominent polyunsaturated triglycerides (TAG) in Moringa oil was triolein "OOO" 36.7% (Abdulkarim *et al.*, 2005). Several studies used different methods to extract Moringa oil. Abdulkarim *et al.*, (2005) used hot extraction with different solvents and aqueous enzymatic methods. They found the oil amount extracted by solvent was higher than enzymatic methods. Oleic acid was higher in enzymatic methods than in the solvents (70.00 – 67. 90%). Other study (Tsaknis *et al.,* 1999) extracted the oil from Moringa seeds using three different procedures including cold press, extraction with n-hexane and extraction with a mixture of chloroform/methanol (50:50). Using hexane extracted the highest amount of the oil was 35.70%. Oleic acid by using cold press reached to 75.39% followed by 73.91% by chloroform/methanol (50:50). The properties and the content of the oil can be changed and this may be due to the environmental condition and the species (Ibrahim *et al.,* 1974).

This research aims to study the difference between the oil extracted from *Moringa oleifera* whole seeds and kernels by two methods "hot and cold extraction" by studying fatty acids, tocopherols and triglycerides.

MATERIALS AND METHODS

1. Materials:

The materials used in this investigation were *Moringa oleifera* seeds. These seeds were purchased from Agriculture research center, Sakha, Kafrelsheikh City, Egypt.

Preparation of *Moringa oleifera* for analysis:

Mature *Moringa oleifera* dried pods were collected from Agriculture research center – Sakha - Kafrelsheikh– Egypt. The pods were opened to collect the seeds from inside. The seeds were dried in the sun. After that the seeds were divided to two portions. The first one we grinded it with the coat, this one called "Whole seeds". The second one the coat was removed from the seeds before grinding and called it "Kernels".

Chemicals:

Petroleum ether (40–60) was of analytical grade (>98%; Merck, Darmstadt, Germany). Heptane and tert-butyl methyl ether were of HPLC grade (Merck, Darmstadt, Germany). Tocopherol, tocotrienol standard compounds and Folin-Ciocalteau reagent were purchased from, Merck, (Darmstadt, Germany). Standards fatty acids methyl esters were obtained from, Restek, (Bad Homburg, Germany). Beta carotene was obtained from (Fluka, Germany).

2. Methods

Chemical composition

The methods of the Association of Official Analytical Chemists (AOAC, 2010) were used for proximate analysis.

Oil extraction:

The oil content was determined according to method DGF-B-I-5, (2013) by hot extraction using a Twisselmann apparatus. In brief, five gram of the dried seeds were grinded in a mill (IKA, model A11 BS000, Germany) and extracted using 75 mL petroleum ether in a Twisselmann apparatus for 6 hrs. For cold extraction, 20 g from the seeds were soaked in 200 ml of petroleum ether for 48 hours at room temperature. The obtained solvent from hot and cold extraction methods was removed by a rotary evaporator at 40°C and 25 Torr (model RV 10 C S93, IKA-Werke GmbH & Co. KG, Stauffen, Germany). For the determination of fatty acids, tocopherols and triacylglycerols the oil was dried by a stream of nitrogen after removing the solvent by a rotary evaporator to avoid the formation of degradation products during drying in the oven.

Fatty acids composition:

The fatty acids composition were determined following the DGF-C-VI 10, (2013) in combination with DGF-C-VI 11d, (2013). The prepared sample was injected in a HP5890 gas chromotograph (Agilent Technologies Sales & Services GmbH & Co. KG, Waldbronn, Germany), with a capillary column, CP-Sil 88 (100 m long, 0.25 mm ID, film thickness 0.2 µm). The temperature program was as follows: From 155 °C; heated to 220 °C (1.5 °C/min), 10 min isotherm; injector 250 °C, detector 250 °C; carrier gas 36 cm/s hydrogen; split ratio 1:50; detector gas 30 mL/min hydrogen; 300 mL/min air and 30 mL/min nitrogen; manual injection volume less than 1 µL. The peak areas were computed by the integration software, and percentages of fatty acid methyl esters (FAME) were obtained as weight percent by direct internal normalization.

Tocopherols composition:

Tocopherols composition (tocopherols, tocotrienols and plastochromanol-8) were determined according to method DGF-F-II 4a, (2013). 20 µL from the sample were injected by a Merck 655-A40 autosampler (Merck-Hitachi, Darmstadt, Germany) onto a Diol phase HPLC column 25 cm × 4.6 mm ID (Merck, Darmstadt, Germany) with a flow rate of 1.3 mL/min. The mobile phase was n-heptane and tert-butyl methyl ether

Triglycerides composition:

The triacylglycerol composition was determined by gas chromatography according to method DGF-C-VI 14, (2013).

Statistical analysis:

The data were statistically analyzed by paired samples T test analysis of variance (ANOVA) procedure with SPSS software (Version 16.0, SPSS Inc., Chicago, IL) software (Steel and Torrie, 1980).

3. Results and discussion

Chemical composition:

From Tables (1 and 2), the kernels of *Moringa oleifera* had more amount of protein (40.18%) and ether extract (39.23%) by hot extraction than the whole seeds were (31.30%) and (28.85%), respectively. While by cold extraction the oil amount was 21.39% - 29.34% from the whole seeds and kernels, respectively.

Ash, fibers and carbohydrates were higher in the whole seeds (4.22%, 26.71% and 8.92%) than the kernels (4.04%, 13.96% and 2.59%), respectively. This is due to the presence of the coat with the whole seeds.

This finding is nearly similar with Abiodun *et al*., (2012) and Rahman *et al*., (2009) they reported that the moisture, protein and ash from the whole seeds were (4.70 – 7.10%), (28.04 – 31.80%) and (4.10 – 6.30%), respectively. Also, Anwar and Bhangers, (2003) and Compaoré *et al*., (2011) reported that the protein was 29.36% and 35.37% in the kernels of *Moringa olifera*.

Table 1. Chemical composition of *Moringa oleifera* (whole seeds and kernels) (on dry weight basis):

Composition	*Moringa oleifera*	
	Whole seeds (%)	Kernels (%)
Moisture	6.70	5.90
Protein	31.30	40.18
Ether extract*	28.85	39.23
Ash	4.22	4.04
Fibers	26.71	13.96
Carbohydrates	8.92	2.58

***Hot extraction**

Table 2. Effect of extraction methods on the oil amount of *Moringa oleifera*:

Extraction methods	*Moringa oleifera*	
	Whole seeds (%)	Kernels (%)
Hot	28.85±1.708	39.23±1.758
Cold	21.39±1.346	29.34±1.180

The results of the oil amount are in agreement with the results obtained by Bhutada *et al*., (2016) who reported that the oil yield from Moringa whole seeds using petroleum ether (hot extraction) was 28.60%. According to

Kibazohi and Sangwan, (2011), the oil was (24.80%) using hexane (hot extraction) from the Moringa whole seeds. While from Moringa kernels, Rahman *et al*., (2009) reported that the oil amount was (35.60%) using petroleum ether and (37.50%) using hexane (hot extraction). Also, Anwar and Rashid, (2007) and Da Porto *et al*., (2016) used hexane (hot extraction) and found the amount from Moringa kernels were 34.80% and 36.33%, respectively. Extraction method and solvent used, climate, time of harvest and plant variety are reasons for the difference in the amount of extracted oil (Abdulkarim *et al*., 2005).

Fatty acids composition:

Table (3) showed that the oil extracted by hot extraction in Moringa whole seeds and kernels contained palmitic acid (5.55% and 5.90%), respectively. While by using cold extraction stearic was (5.51% - 5.52%) and behenic acid was (7.76% - 7.85%) in Moringa whole seeds and kernels, respectively.

The content of the extracted oil by cold extraction for saturated fatty acids was 23.43% and 23.68%, respectively for whole seeds and kernels. While in the case of hot extraction the content of saturated fatty acids was 21.80% and 21.64%, respectively for both whole seeds and kernels. The content of unsaturated fatty acids was 75.15% - 75.42% by using cold extraction in whole seeds and kernels and was 77.54% - 76.81% in whole seeds and kernels, respectively (Table 3).

Using cold extraction caused a slight decrease in palmitic acid in whole seeds and kernels, it reached to 5.15% and 5.16%, respectively. Also, the same effect had happened in the unsaturated fatty acid gondoic (1.88% - 1.91%), respectively. While an increased had happened in stearic acid in both. No significant differences appeared in margric acid between whole seeds and kernels also by using hot and cold extraction. Between the oil extracted from whole seeds and kernels by hot extraction a differences had appeared in myristic, plamitic and vaccenic acids. Myristic and plamitic were higher in kernels than whole seeds (0.12 – 0.15%), (5.55 – 5.90%), respectively, while vaccenic was high in whole seeds (6.33 – 6.15%) (Table 3).

Also the results in Table (3) showed that the content of oleic acid from the oil extracted by hot extraction was 66.22% and 65.78% in whole seeds and kernels, respectively and vaccenic acid was 6.33% and 6.15% in both in comparison with cold extraction. This high amount of oleic acids makes Moringa oil preferable in nutrition and cooking (Abdulkarim *et al*., 2005). Also, it can be used in frying due to its oxidative stability (Petukhov *et al*., 1999). This finding is in agreement with the results obtained by Abdulkarim *et al*., (2005), Nzikou *et al*., (2009) and Tsaknis *et al*., (1999) they found that the oleic acid in Moringa oil was 70.00%, 74.93% and 73.60%, respectively.

Table 3. Fatty acids composition of *Moringa oleifera* (whole seeds and kernels) by hot and cold extraction (%):

Fatty acids	*Moringa oleifera*			
	Whole seeds		Kernels	
	Hot	Cold	Hot	Cold
Myristic $C_{14:0}$	0.12±0.021*	0.09±0.006	0.15±0.023*^{b}	0.09±0.000^{b}
Palmitic $C_{16:0}$	5.55±0.255*	5.15±0.046	5.90±0.139*^{b}	5.16±0.030^{b}
Margaric $C_{17:0}$	0.08±0.012	0.09±0.000	0.08±0.010	0.08±0.006
Stearic $C_{18:0}$	4.55±0.066^{a}	5.51±0.066^{a}	4.45±0.112^{b}	5.52±0.010^{b}
Arachidic $C_{20:0}$	3.35±0.119	3.63±0.036	3.21±0.046^{b}	3.72±0.020^{b}
Behenic $C_{22:0}$	6.76±0.419^{a}	7.67±0.139^{a}	6.49±0.082^{b}	7.85±0.030^{b}
Lignoceric $C_{24:0}$	1.39±0.060	1.29±0.015	1.36±0.023^{b}	1.26±0.006^{b}
TSFA	21.80	23.43	21.64	23.68
Palmitoleic $C_{16:1\ cis}$	1.42±0.066	1.36±0.006	1.42±0.040	1.43±0.015
Elaidic $C_{18:1\ D9\ tr}$	0.24±0.050^{a}	0.16±0.020^{a}	0.26±0.029^{b}	0.37±0.000^{b}
Oleic $C_{18:1\ D9}$ cis	66.22±0.172^{a}	65.16±0.016^{a}	65.78±1.054	64.84±0.172
Vaccenic $C_{18:1\ D11\ tr}$	6.33±0.031*^{a}	5.78±0.010^{a}	6.15±0.045*^{b}	6.07±0.015^{b}
Linoleic $C_{18:2\ D9.12\ cis}$	0.63±0.006^{a}	0.56±0.010^{a}	0.62±0.010^{b}	0.55±0.006^{b}
Linolenic $C_{18:3\ D9.12.15\ cis}$	0.18±0.032	0.16±0.000	0.17±0.000	0.16±0.006
Gondoic $C_{20:1\ D11\ cis}$	2.37±0.075^{a}	1.88±0.025^{a}	2.29±0.012^{b}	1.91±0.010^{b}
Erucic $C_{22:1\ D13\ cis}$	0.15±0.029	0.09±0.006	0.12±0.015	0.09±0.000
TUSFA	77.54	75.15	76.81	75.42
The sum	99.34	98.58	98.45	99.10

(*) Means that there are significant differences between whole seeds and kernels (hot extraction) at ≤0.05.
(a) Means that there are significant differences between whole seeds (hot and cold extraction) at ≤0.05.
(b) Means that there are significant differences between kernels (hot and cold extraction) at ≤0.05.

Moringa oleifera whole seeds and kernels contained a good amount of behenic acid (6.76 – 6.49%), respectively. Behenic acid using hot extraction of whole seeds and kernels (6.76 – 7.67%) increased in cold extraction of kernels (7.85%) and whole seeds (7.67%). Behenic acid result was similar to the once which reported by Abdulkarim *et al*., (2005), Rashid *et al*., (2008) and Nguyen *et al*., (2011) which reached (5.80%), (7.00%), (7.01%) and (6.71%), respectively. In skincare, behenic acid is most commonly used to provide soothing relief for dry and sensitive skin (Banov *et al*., 2014). The obtained results of vaccenic acid was in similar to the result reported Al Juhaimi *et al*., (2016) who found vaccenic acid was (6.00%) in Moringa seeds. Some health benefits for vaccenic acid were reported by Field *et al*., (2009). Significant difference occurred in myristic and plametic acids between whole seeds and kernels (0.12 – 0.15%) and (5.55 – 5.90%), respectively.

Tocopherols:

Moringa oleifera (whole seeds and kernels) has a good amount of tocopherols and this give more protection and stability during storage and manufacturing processes for Moringa oil (Tsaknis *et al*., 1999). The kernels had more amounts of tocopherols by hot extraction than the whole seeds 20.92 – 14.61 mg/100g α-tocopherol, 1.01 –

0.94 mg/100g β-tocopherol, 5.77 – 5.31 mg/100g γ-tocopherol and 1.10 – 1.01 mg/100 g δ- tocopherol, respectively (Table 4).

Almost these results were near to Rahman *et al*., (2009) who used light petroleum ether for extracting the oil form the Moringa kernels and found that α-tocopherol, γ-tocopherol and δ- tocopherol were 12.1, 6.4, 5.77 mg/100g, respectively. Also, Anwar and Bhanger, (2003) determined α-tocopherol, γ-tocopherol and δ- tocopherol from Moringa kernels but they used n-hexane and they found the results were 13.44, 9.37 and 4.80 mg/100g, respectively. However, from whole seeds and by using n-hexane, Tsaknis *et al*., (1999) reported that α-tocopherol, γ-tocopherol and δ-tocopherol were (9.82, 2.79 and 7.11 mg/kg), respectively.

Table 4. Tocopherols composition of *Moringa oleifera* (whole seeds and kernels) by hot and cold extraction mg/100g:

Tocopherols	*Moringa oleifera* Whole seeds		*Moringa oleifera* Kernels	
	Hot	Cold	Hot	Cold
α-Tocopherol	14.61±1.497*	14.15±0.035	20.92±0.710*[b]	16.82±0.840[b]
α-Tocotrienol	0.18±0.015*	0.37±0.120	0.22±0.029*	0.27±0.44
β-Tocopherol	0.94±0.076	0.77±0.031	1.01±0.035	0.85±0.067
γ-Tocopherol	5.31±0.235[a]	3.35±0.171[a]	5.77±0.278[b]	4.27±0.578[b]
Plastochromanol 8	0.20±0.171[a]	0.91±0.015[a]	0.25±0.223[b]	1.05±0.265[b]
δ- Tocopherol	1.01±0.092[a]	0.41±0.065[a]	1.10±0.174	0.52±0.035[b]

(*) Means that there are significant differences between whole seeds and kernels (hot extraction) at ≤0.05.
(a) Means that there are significant differences between whole seeds (hot and cold extraction) at ≤0.05.
(b) Means that there are significant differences between kernels (hot and cold extraction) at ≤0.05.

The results of γ-Tocopherol, Plastochromanol 8 (Plastochromanol-8 is an analogue of γ-tocotrienol with a much longer side-chain). Plastochromanol-8 was first found in leaves of the rubber tree (*Hevea brasiliensis*) from 50 years ago (Whittle *et al.,* 1965). It has been found in many other plants including rapeseed and maize (Dunphy *et al.,* 1966), but usually at lower levels than of the tocopherols) and δ- tocopherol in whole seeds and kernels after cold extraction changed. Data in Table (4) indicated that a decreasing happened to γ-tocopherol and δ- tocopherol in whole seeds and kernels (5.31 – 3.35 mg/100g), (5.77 – 4.27 mg/100g) and (1.01 – 0.41 mg/100g), (1.10 – 0.52 mg/100g), respectively, while plastochromanol 8 increased in cold extraction (0.91 – 0.1.05 mg/100g) than hot extraction (0.20 – 0.25 mg/100g), respectively. No significant differences occurred in α-tocopherol between hot and cold extraction of the whole seeds, while in the kernels a differences occurred in α-tocopherol (20.92 – 16.82 mg/100g) in hot and cold extraction, respectively (Table 4).

Triglycerides profile:

As shown in the Table (5) eleven triglycerides were detected in the order of (OOO, POO, SLO, SOO, PLS, PLO, LLL, POS, POP, SOS and PLP) (O = oleic acid, L = linoleic acid, P = palmitic acid and S = stearic acid). and those accounts for 85% of total triglycerides. The highest triglyceride was (OOO) in the whole seeds and kernels (34.22 – 34.32%) followed by "POO" (15.64 – 15.86%), "SLO" (10.25 – 10.45%) and "SOO" (9.82 – 9.86%). A difference occurred in the triglycerides "POO" and "OOO" between whole seeds and kernels . These results were near to Abdulkarim *et al*., (2005) who reported that "OOO" and "SOO" were (36.70 – 11.40%) in the whole seeds.

Using cold extraction (whole seeds) made a difference in the triglycerides "SOS" and "SOO" (1.77 – 2.17%) and (9.82 – 11.25%), respectively. This increase may be due to the increase of stearic acid in the whole seeds after cold extraction (4.55 - 5.51%). Also, due to the increase reported in stearic acid after cold extraction in kernels , the triglycerides "POS" and "SOO" increased (2.07 – 2.32%) and (9.87 – 11.38%), respectively. However the decreasing occurred in "PLP" (1.38 – 0.83%) was due to the decrease in palmitic acids after cold extraction in the kernels (5.90 – 5.16%).

Table 5. Triglycerides profile of *Moringa oleifera* (whole seeds and kernels) by hot and cold extraction (%):

Triglycerides	*Moringa oleifera* Whole seeds		*Moringa oleifera* Kernels	
	Hot	Cold	Hot	Cold
POP	1.79±0.167	1.51±0.035	1.92±0.140	1.64±0.167
PLP	1.03±0.302	0.74±0.035	1.38±0.020[b]	0.83±0.056[b]
POS	2.05±0.139	2.30±0.035	2.07±0.126[b]	2.32±0.113[b]
POO	15.64±1.311*	14.50±0.349	15.86±1.316*	14.73±0.936
PLS	2.94±0.132	2.83±0.353	3.05±0.102	2.85±0.120
PLO	2.88±0.373	3.05±0.383	2.95±0.373	2.83±0.317
SOS	1.77±0.075[a]	2.17±0.045[a]	1.80±0.095	2.07±0.060
SOO	9.82±0.389[a]	11.25±0.120[a]	9.86±0.260[b]	11.38±0.236[b]
OOO	34.22±1.038*	34.81±0.467	34.32±1.059*	33.75±0.906
SLO	10.25±0.616	10.16±1.141	10.45±0.595	9.42±0.310
LLL	2.21±0.046	2.38±0.122	2.22±0.095	2.25±0.070
Others	15.40	14.30	14.12	15.93

POP, 1,3-dipalmitoyl-2-oleylglycerol; PLP, 1,3-dipalmitoyl-2-linoleylglycerol; POS: palmitoyl-oleoyl-stearoyl glycerol; POO, 2,3-dioleyl-1-palmitoylglycerol; PLS,1-palmitoyl-2-linoley-3-stearoylglycerol; PLO: 1-palmitoyl-2-linoleoyl-3-oleoylglycerol; SOS, 1,3-distearoyl-2-oleylglycerol; SOO, 2,3-dioleyl-1- stearoylglycerol; OOO, 1,2,3 trioleylglycerol; SLO 1-stearoyl-2-linoleyl-3- oleoylglycerol and LLL, 1,2,3-trilinoleylglycerol.
(*) Means significant differences between whole seeds and kernels (hot extraction) at ≤0.05.
(a) Means significant differences between whole seeds (hot and cold extraction) at ≤0.05.
(b) Means significant differences between kernels (hot and cold extraction) at ≤0.05.

CONCLUSION

Removing the coat from the whole seeds and extracting oil from the kernels increased the oil amount. This coat can be used in several uses. Cold extraction method caused an increase in the TSFA in the whole seeds and kernels, while the TUSFA decreased in both. Tocopherols were higher in the kernels oil than the whole seeds oil but cold extraction caused a decrease in tocopherol in both. Also, triolien "OOO" and "POO" were higher in the kernels oil. Due to the increase of stearic acid after cold extraction in whole seeds and kernels this makes an increase in the triglycerides "SOO and SOS".

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صفات الليبيدات في البذور الكاملة ولب المورينجا المصرية

محمد عبد الباسط سلامة[1]، مصطفى أحمد عون[2]، محمد فوزي عثمان[2]، عواطف إبراهيم إسماعيل[1] و بيرتراند ماتيوس[3]

[1] معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – جيزة – مصر

[2] قسم الصناعات الغذائية – كلية الزراعة – جامعة كفرالشيخ – مصر

[3] قسم جودة وسلامة الحبوب (مجموعة بحوث الزيت) – معهد ماكس روبنر – ديتمولد – ألمانيا

تعتبر بذور المورينجا *Moringa oleifera* من البذور الغنية في محتواها من الزيت وكان هدف هذه الدراسة هو استخلاص الزيت من البذور ولب المورينجا المصرية بطريقتى الاستخلاص على البارد والاستخلاص الساخن ودراسة تأثير طريقة الاستخلاص على تركيب الأحماض الدهنية والتوكوفيرولات والجلسريدات الثلاثية في الزيت المستخلص. أوضحت النتائج أن كمية الزيت المستخلص باستخدام طريقة الاستخلاص الساخن كانت 28.85% ، 39.23% وبالاستخلاص على البارد كانت 21.39% ، 29.34% على التوالي لكل من البذور الكاملة واللب على التوالي. وكان الحامض الدهني المشبع "البهينك" والحامض الدهني الغير مشبع "الأوليك" هما الحامضين الأساسين في كلا منهما. وكان حامض البالمتيك أعلى في زيت اللب عن زيت البذور (5.90 - 5.55%)، بينما كان حامض الفاكسنيك أعلى في البذور (6.33 - 6.15%). أدى الاستخلاص البارد إلى زيادة حامضي الاستياريك والبهينك في زيت البذور (4.55 - 5.51%)، (6.76 - 7.67%) وفي اللب (4.45 - 5.52%) ، (6.49 - 7.85%)، على التوالي. بينما انخفض كل من الأوليك والفاكسينك واللينوليك والجوندويك بالاستخلاص البارد في كلا من البذور واللب. وكانت كمية التوكوفيرولات المتحصل عليها من اللب أعلى من البذور. وكمية α-Tocopherol المتحصل عليها اللب والبذور بطريقة الاستخلاص الساخن 20.92 – 14.61 ملجم/100 جم ، على التوالي. كما أدت طريقة الاستخلاص البارد للزيت من اللب إلى انخفاض في كمية α-Tocopherol (20.92 – 16.82 ملجم/100 جم). كما ظهرت فروق معنوية بين البذور واللب في الجلسريد الثلاثي (2,3 ثنائي أوليو – 1 بالميتيل جليسرول 15.86 - 15.64%) (POO) والجلسريد الثلاثي (1,2,3 ثلاثي أوليوجليسرول 34.32 - 34.22%) (OOO). كما أدى الاستخلاص البارد إلى زيادة الجلسريد الثلاثي (3،1 ثنائي استيرويل – 2- أوليل جليسرول SOS) والجلسريد الثلاثي (3،2 ثنائي أوليل – 1 – ستيرويل SOO) في البذور (1.77 - 2.17% و 9.82 - 11.25%) وفي اللب (1.80 - 2.07% و 9.87 - 11.38%).