Characterisation of *Moringa peregrina* Arabia seed oil

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RESUMEN

Caracterización de aceite de semilla *Moringa peregrina* de Arabia Saudí

El contenido de aceite de semilla *Moringa peregrina* (de Arabia Saudí) fue del 49.8%. Los resultados de algunas características físicas y químicas del aceite extraído fueron: índice de refracción (40 °C) 1.460, densidad (24 °C) 0.906, acidez (como oleico) 0.30%, índice de yodo 69.6, índice de saponificación 185 e índice de peróxido 0.4 meq/Kg. El aceite de semilla *Moringa peregrina* tuvo altos niveles de oleico (70.52%), seguido por el gadoleico (1.5%), mientras los ácidos saturados dominantes fueron palmítico (8.9%) y esteárico (3,82%). Los α- γ- y δ-tocoferoles fueron detectados a niveles de 145, 58 y 66 mg/Kg respectivamente. El período de inducción (a 120 °C) de aceite de semilla de tomate fue de 10.2 horas y se redujo a 8.1 horas después del desgomado. Las extinciones específicas a 232 y 270 nm fueron 1.66 y 0.19 respectivamente. El β-sitosterol fue el componente más predominante de la fracción esterólica del aceite. Otros esteroles encontrados en porcentajes mayores del 1.5% fueron 24-metilenecolesterol, campesterol, estigmasterol y Δ⁵-avenasterol. Además se encontraron trazos con componentes menores de brasicasterol, campestanol, Δ⁷- campestanol, clerosterol, $\Delta^{5,24}$-estigmastadienol, Δ^7-estigmastanol y Δ^7-avenasterol.

PALABRAS-CLAVE: Aceite de semilla Moringa peregrina – Arabia Saudí — Características físico-química.

SUMMARY

Characterisation of *Moringa peregrina* Saudi Arabia seed oil

Oil content of *Moringa peregrina* seeds (from Saudi Arabia) was 49.8%. Results of some physical and chemical characteristics of extracted oil were: refractive index (40 °C) 1.460, density (24 °C) 0.906, acidity (as oleic) 0.30%, iodine value 69.6, saponification number 185 and peroxide value 0.4 meq/kg. *Moringa peregrina* seed oil was found to contain high levels of oleic (70.52%), followed by gadoleic (1.5%), while the dominant saturated acids were palmitic (8.9%) and stearic (3.82%). α- γ- and δ-tocopherols were detected at levels of 145, 58 and 66 mg/kg respectively. The induction period (at 120 °C) of tomato seed oil was 10.2 hours and reduced to 8.1 hours after degumming. Specific extinctions at 232 and 270 nm were 1.66 and 0.19 respectively. β-sitosterol was found as the most predominant component of the sterolic fraction of the oil. Other sterols found in percentages higher than 1.5% were 24-methylenecholesterol, campesterol, stigmasterol and Δ⁵-avenasterol. In addition, trace to minor amounts of brassicasterol, campestanol, Δ⁷-campes'anol, clerosterol, $\Delta^{5,24}$-stigmastadienol, Δ^7-stigmastanol and Δ^7-avena sterol were found.

KEY-WORDS: Moringa peregrina seed oil — Physico-cher ical characteristics — Saudí Arabia.

1. INTRODUCTION

The Moringaceae family consists of 10 (Somali *et al.*, 1984) or 12 (Mohan *et al.*, 1981) species wich belong to only one genus called Moringa. All Moringa species are native to India from where they have been introduced into many warm countries (Sengupta et al., 1970). Morton (1991) reported that the most common species are *Moringa peregrina* (forsk) *fiori* (syn. *M. aptera Gaertns*; *M. arabica* (Lam.) Pers., *Moringa zeylanica Sieb*; *Balanus myrepsica* Blackm), *Moringa stenopetala Cufod*, *Moringa borziana Mattei*, *Moringa longituba Engl*, *Moringa concanensis Nimmo*, *Moringa ovalifolia Dinter* and *A. Berger*, *Moringa drouhardii*, *Moringa hildebrantii* (Bianchini *et al.*, 1981).

Until now a full characterisation and comparison of the oil produced from the seeds of *Moringa peregrina* has not been reported.

2. EXPERIMENTAL

Materials

The seeds of *Moringa peregrina* were obtained from Saudi Arabia. The virgin olive oil «Horio» was purchased from MINERVA S.A. (Athens, 14452, Greece).

Reagents

All the reagents (analytical and HPLC grade) were obtained from Sigma Chemicals Company Co. (St. Louis, MO 63178, USA) and the standard solutions for the determination of tocopherols were purchased by Merck Ltd (Darmstand, D-64271, Germany) (dl-α-tocopherol), Sigma ((+)-δ-tocopherol), British Greyhound Chromatography and Allied Chemicals (Birkenhead, Merseyside, L434X, UK) (Methyl ester standards) and Larodan AB (Malmö, S-21616, Sweden) (sterc I standards).

Oil extraction

The seeds of *Moringa peregrina* were divided into three portions and the oil was extracted using a 2L soxhlet extractors with n-hexane and analysed immediately.

Before the start of the measurements the oil was refined (degummed) apart from a small quantity of about 40 ml which was kept for the induction time determination (Rancimat) and other methods in order to compare the unrefined with the refined oil. The solvent was evaporated under reduced pressure, and the oil from different batches were combined and kept in sealed bottles under refrigeration (0-4 °C) for further processing and analysis.

Degumming

The oil was heated at 75 °C and 20% boiling water was added. The mixture was mixed for 10 minutes with the aid of a glass rod. After cooling, the oil was centrifuged for 10 minutes in 3,500 rpm in tubes of 200 cm³ in a Sorvall General-Purpose RC-3 Automatic Refrigerated Centrifuge (Ivan Sorvall INC., Newtown Connecticut, 06470, USA).

Determination of the physical characteristics

The determination of the physical characteristics was as follows: the density (relative density 40 °C/20 °C), refractive index (at 40 °C), colour (measured with a Lovibond tintometer (The tintometer Ltd., Salsbury, England) and smoke point (according to the method described by British Standards Methods of Analysis. BS 684: Section 1.8) were measured.

Determination of the chemical characteristics

The determination of the chemical characteristics was a follows: the acidity (measured according to the method described by IUPAC (1987), the saponification value (determined according to the method described by AOCS methods Cd 3-25, described in Bailey's Industrial Oil and Fat Products, the iodine value (measured according to the Wijs method as described by Pearsons (1981).

Determination of the fatty acid composition

The determination of the fatty acids composition was done by gas-liquid chromatography according to the method described by Tsaknis (1991).

The FAMES preparation was done using the following procedure: About 25 mg of oil were accurately weighed into a screw cap tube, and 1.5 cm³ methanolic sodium hydroxide was added, mixed and heated at 100 °C for 7 minutes. After cooling, 2 cm³ of boron trifluoride were added and heated at 100 °C for 5 minutes. The tube was cooled to 30 °C - 40 °C and 1 cm³ of iso-octane was added, capped and shaken using whirli mix for 30 seconds. 5 cm³ of satured sodium chloride solution was immediately added and the tube was shaken again. The tube contents were allowed to separate and the top (iso-octane containing fatty acid methyl esters) layer removed and the lower layer was extracted again with an addition of 1 cm³ iso-octane. The two iso-octane extracts were combined (dried over anhydrous sodium sulphate) and concentrated to approximately 1 cm³ with a stream of nitrogen.

Analysis of fatty acid methylesters was performed on a Varian 3600 Gas chromatograph (Varian, Palo Alto, California, USA) equipped a Carbowax 20M (Supelco, INC. Supelco Park, Bellefonte, PA 16283-0048) 10' x 1/8" (5% on Chromosorb W 80/100 mesh) column. The temperature program was 60 °C for 10 min and then 2 °C min^{-1} up to 220 °C. Injector and FID temperatures were set at 160 °C and 280 °C respectively, sample volume was 0.2 μl, the carrier gas was N$_2$ 30 ml min^{-1}, chart speed was set at 0.5 cm min^{-1} and the attenuation 10^{-10} x 32. In total three samples were prepared and measured separately.

Determination of the sterol composition

The identification and determination of sterols by GLC was done according to the method described by the Offical Journal of the European community, No. L248, 5.9.1991.

Analysis of sterols was performed on a Hewlett Packard 5890 Gas Chromatograph (Hewlett-Packard, San Diego, CA, USA) equipped with a DB-5 FSOT capillary column (30 m x 0.25 mm x 0.25 μm) (J & W, 91 Blue Ravine rd., Folson, 95630-4714, California, USA). The pressure of the carrier gas (H$_2$) was 75 kpa. Injector and FID temperatures were 280 °C and 300 °C respectively. The temperature program was isothermal 260 °C for 40 min at least.

Determination of the triglyceride composition

The determination was done using the standard method of the Official Journal of the European communities (O.J.E.U. (1991)).

A 5% solution of Moringa oil was prepared by weighing 0.5 ± 0.001 g of sample into a 10 ml graduated flask and making up with solvent (acetone: chloroform (1:1)).

A 10 μl sample was injected into the Waters 600E HPLC pump (Millipore Corporation, Waters Chromatography Division, Massachusetts, MA 01757, USA) fitted with a Jones Chromatography column Lichrosob RP18 Art 50333 (Merck Ltd., Darmstand, D-64271, Germany) with the following characteristics: dimensions 25 mm x 4.6 mm, particle size 10 μm. The column was held at 35 °C in an external oven.

Detection was with a Waters 410 Refractive Index detector set at 40 °C. Acetone: acetonitrile (50:50) at 1.5 ml/min was used as the mobile phase. A total of 60 min was necessary to assay the triglycerides. For the integration of chromatograms Waters Baseline 815 software was used.

In total three samples were prepared and measured separately.

Determination of the tocopherol composition

The method used for the determination of tocopherols was a modification of Carpenter's (1979) method as follows.

(a) 1 g of oil was accurately weighed into a 3 dram sample vial wrapped in foil paper to prevent oxidation. The oil was dissolved in a cm³ n-hexane before injection.

(b) A 20 μl sample was injected into the Waters 600E HPLC pump (Millipore Corporation, Waters Chromatography Division, Massachusetts, MA 01757, USA) fitted with a Waters μ-Polarsil, 125Å, 10 μm, 3.9x300 mm column.

Detection was performed with a Waters 4 3 Tunable Absorbance Detector set at 295 nm. Iso-propanol: n-hexane: absolute ethanol (2: 97.5: 0.5) at 1 cm³/min was used as the mobile phase. A total of 5 min was necessary to assay the tocopherols. In total three samples were prepared and measured separately.

Determination of the oxidative state

For the determination of the oxidative state the peroxide value as well as the evidence of purity and deterioration from ultraviolet spectrophotometry were measured. The peroxide value was measured using the method adapted from the one developed by Lea (1952). The evidence of purity and deterioration from ultraviolet spectrophotometry ($E_{1cm}^{1\%}$ at 232 nm, $E_{1cm}^{1\%}$ at 270 nm) was carried out by using the method of IUPAC(1987) and by the use of a Hitachi U-3210 Spectrophotometer (Hitachi Ltd. Tokyo, Japan).

Determination of the susceptibility to oxidation with the Rancimat method

Two and a half (2.5 g) of oil were accurately weighed into each of the six reaction vessels and the following procedure was carried out. The «Metrohm Rancimat 679» (Metrhom Ltd., CH-9101, Herisau, Switzerland) was switched on until the temperature of the oil batch reached the temperature of 120 °C. Then 50 cm³ of the distilled water was placed into each of the six conductivity cells and the air flow rate was set at 20 L h⁻¹. The temperature was checked to ensure it had a constant value. The air supply was connected to the tubes containing the oil samples and the chart recorder was started. The determination continued automatically until the conductivity reached the maximum value and the induction period was read.

3. RESULTS AND DISCUSSION

The results of the determinations of the oil produced from *Moringa peregrina* Saudi Arabia seeds were compared not only with those reported in the literature but also with olive oil because it has similar fatty acid composition.

The oil content of *Moringa peregrina* seeds was found to be 49.8% (CV 2.301), and fell in the range of previously reported data 54.3% (Sengupta and Gupta, 1970).

Due to the low free fatty acid content there was no need for neutralisation. However there was a need for degumming because the oil was cloudy. The degumming process produced a transparent pale yellow liquid at ambient temperature with characteristic odour... After the completion of the process the percentage of the oil recovered was measured. The recovery of oil was 98.9%.

Results of the physical characteristics of the oils are shown in table I. The obtained values for density and refractive index were in line with those reported in literature (Sengupta and Gupta, 1970). There were no previously reported data to compare colour and smoke point. The density and refractive index were lower than those of the olive oil. The smoke point of the oil under examination was about 10 °C higher from that of the olive oil.

Results of the chemical characteristics of the oil are shown in table II. The acidity of the Moringa oil was higher than that reported in literature (Sengupta and Gupta, 1970). The iodine and saponification value were in line with those reported in literature (Segunpta and Gupta, 1970). The *Moringa peregrina* seed oil was less unsaturated than the olive oil (see also fatty acid composition, Table III). The saponification value of *Moringa peregrina* oil was similar to that reported in literature (Sengupta and Gupta, 1970) and to olive oil.

Table I
Physical Characteristics of the degummed oils

DETERMINATION	Moringa peregrina	LITERATURE (Sengupta and Gupta, 1970)	Olive oil
density at 24 °C (mg/ml)	0.906 (0.006)	0.909 (15 °C)	0.915 (25 °C) (0.007)
refractive index (n_D 40 °C)	1.460 (0.002)	1.461	1.468 (20 °C) (0.005)
colour (red units, yellow units)	0.9 r. (0.20), 50.0 y. (3.90)	present work	— —
smoke point (°C)	199 (2.00)	present work	190 (1.9)

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

Table II
Chemical Characteristics

DETERMINATION	Moringa peregrina	LITERATURE (Sengupta and Gupta, 1970)	Olive oil
acidity * (% as oleic acid)	0.30 (0.005)	0.02	0.98 (0.02)
saponification value ** (mg of KOH/g of oil)	185 (3.9)	182.9	188 (5.0)
iodine value ** (g of I/100 g of oil)	69.6 (0.48)	69.5	80.0 (0.71)

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

* Not degummed oil.

** Degummed oil.

Table III
Fatty Acid Composition of the degummed oils

Fatty acid	% (GC)		
	Moringa peregrina	LITERATURE (Sengupta and Gupta, 1970)	Olive oil
C10:0	0.08 (0.03)	present work	not detected
C14:0	0.10 (0.05)	<0.01	<0.01
C16:0	8.90 (0.34)	9.3	11.2 (0.66)
C16:1	not detected	2.4	0.60 (0.09)
C17:0	not detected	present work	0.10 (0.01)
C18:0	3.82 (0.22)	3.5	2.80 (0.11)
C18:1	70.52 (0.37)	78.0	72.21 (0.78)
C18:2	0.62 (0.33)	0.6	4.20 (0.49)
C18:3	not detected	1.6	0.50 (0.10)
C20:0	1.94 (0.28)	1.8	0.60 (0.29)
C20:1	1.50 (0.05)	present work	0.20 (0.06)
C22:0	2.36 (0.41)	2.6	<0.01
C22:1	0.49 (0.03)	present work	not detected

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

The Table III shows the fatty acid composition of *Moringa peregrina* seed oil. Total unsaturated fatty acids were more than 70%, while the major fatty acid was oleic ($C_{18:1}$) in a concentration of 70.52%, followed by gadoleic ($C_{20:1}$), 1.5%. Palmitic acid ($C_{16:0}$) was found to be the dominant saturated fatty acid and was in lower concentration than that reported by Sengupta and Gupta (1970). The same authors has also reported lower concentrations for miristic ($C_{14:0}$), stearic acid ($C_{18:0}$) and relatively high concentrations of oleic ($C_{18:1}$) and behenic ($C_{22:0}$). The concentrations of $C_{18:2}$ and $C_{20:0}$ found in the present study were in agreement with those reported by Sengupta and Gupta (1970). $C_{16:1}$ cis ω9 and $C_{18:3}$ also reported by

the same authors were not detected by the present determination. Small to trace amounts of $C_{10:0}$, $C_{20:1}$ and $C_{22:1}$ cis were also found in *Moringa peregrina* seed oil. These are detected for the first time. Based on results obtained the fatty acid composition of *Moringa peregrina* seed oil showed that it falls in the linoleic-oleic acid oils category. Comparing physical and chemical properties of *Moringa peregrina* seed oil with those of other vegetable oils, it is similar to olive oil. Therefore the oil could be useful for edible purposes and for some industrial applications like hydrogenation, shortening production and others. The *Moringa peregrina* Saudi Arabia seed oil had more $C_{18:0}$, $C_{20:0}$, $C_{20:1}$ and $C_{22:0}$, about the same content of $C_{18:1}$ but much less $C_{18:2}$ and no $C_{18:3}$ compared to olive oil. *Moringa peregrina* oil was less unsaturated than the olive oil.

The composition of the sterol fraction, analysed by GLC, is shown in Table IV. The sterol fraction of the *Moringa peregrina* seed oil consisted mainly of campesterol, stigmaterol, β-sitosterol and Δ^5-avenasterol, among of wich β-sitosterol was the most predominant, accompanied with trace or minute amounts of 24-methylenecholesterol, 5,24-stigmastadienol, brassicasterol, clerosterol, Δ^7-stigmastanol, Δ^7-avenasterol and campestanol. There were no previously reported data to be compared with those of the present determination. The sterol composition of the olive oil was different from that of *Moringa peregrina*. The dominant sterol of the olive oil was also β-sitosterol but in a concentration of 68%. The sterol composition was determined for the first time in Moringa species.

The triglyceride composition is shown in table V. Triolein (OOO), in a concentration of 45.43%, was

Table IV
Sterol Composition of the degummed oils

Sterols by GC	%		
	Moringa peregrina	LITERATURE	Olive oil
Cholesterol	0.14 (0.036)	present work	not detected
Brassicasterol	0.38 (0.044)	present work	not detected
24, Methylene cholesterol	2.91 (0.161)	present work	not detected
Campesterol	25.47 (0.985)	present work	2.20 (0.098)
Campestanol	0.51 (0.176)	present work	not detected
Stigmasterol	26.79 (1.513)	present work	0.40 (0.036)
Δ^7, Campestanol	0.53 (0.130)	present work	not detected
5,23 Stigmastadienol	0.20 (0.091)	present work	not detected
Clerosterol	0.79 (0.115)	present work	1.00 (0.009)
β-Sitosterol	27.28 (3.546)	present work	68.00 (4.351)
Stigmastanol	0.63 (0.087)	present work	not detected
Δ^5-Avenasterol	10.18 (0.589)	present work	18.02 (1.235)
5,24 Stigmastadienol	2.42 (0.105)	present work	not detected
Δ^7, Stigmastanol	0.75 (0.314)	present work	not detected
Δ^7, Avenasterol	1.01 (0.121)	present work	not detected

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

Table V
Triglycerides determination of degummed oils

Triglyceride	%		
	Moringa peregrina	LITERATURE	Olive oil
LLnLn	0.23 (0.019)	present work	not detected
LLL	0.34 (0.026)	present work	0.34 (0.031)
OLLn	0.37 (0.029)	present work	0.27 (0.022)
OLL	not detected	present work	2.62 (0.201)
PLnO	not detected	present work	0.74 (0.056)
PLL	0.58 (0.041)	present work	1.08 (0.091)
OLO	4.94 (0.236)	present work	13.69 (0.899)
POL	1.28 (0.099)	present work	5.97 (0.556)
PPL	0.23 (0.018)	present work	0.85 (0.062)
OOO	45.43 (2.464)	present work	41.29 (2.313)
POO	28.54 (1.335)	present work	21.02 (1.122)
POP	0.42 (0.067)	present work	2.57 (0.241)
PPP	1.26 (0.101)	present work	0.86 (0.049)
SOO	9.18 (0.747)	present work	5.50 (0.267)
POS	0.21 (0.009)	present work	1.78 (0.078)
SOS	not detected	present work	0.88 (0.038)
PLSt	5.123 (0.230)	present work	not detected

Where: P: palmitic, S: stearic, L: linoleic, O: oleic, St: stearic, Ln: linolenic.
\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

found to be the dominant triglyceride, followed by POO (28.54%). The triglyceride composition could not be compared with the literature because there were no previously reported data. The content of LLL of *Moringa peregrina* was similar to that of the olive oil. *Moringa peregrina* had higher concentration of LLnLn, OLLn, OOO, OLLn, PPP, SOO and PLSt and lower of OLL, PLnO, PLL, OLO, POL, PPL, POP, POS and SOS comparing to olive oil. The triglyceride composition was determined for the first time in Moringa species.

The Table VI shows the tocopherol composition as determined by HPLC. A high tocopherol content was found in *Moringa peregrina* seed oil, consisting of α- γ- and δ-tocopherol, at concentrations of 145, 58 and 66 mg/kg, respectively. Most vegetable oils contain α-, β- and γ-tocopherols. δ-Tocopherol exists in few oils like cottonseed, peanut, wheat germ, soybean and castor oils. The antioxidant activity of δ-tocopherol exceeds that of γ-, β- and α-tocopherol. Thus, tocopherols present in high concentrations in *Moringa peregrina* seed oil are expected to offer some protection during storage and processing. There were no previously reported data to compare the tocopherol composition. The tocopherol content of the olive oil was much lower than that of the *Moringa peregrina* seed oil.

The oxidative state of *Moringa peregrina* seed oil was determined using the peroxide value, $E_{1cm}^{1\%}$ at 232 nm and 270 nm. The results are shown in Table VII. The peroxide value of *Moringa peregrina* seed oil was 0.4 meq/kg and fell in the range adopted as satisfactory. The peroxide values were lower than those reported in the lieterature and those of the olive oil. For the $E_{1cm}^{1\%}$ at 232 nm and 270 nm there were no available published results for comparison of the data of the present work.

The susceptibility to oxidation of the *Moringa peregrina* seed oil, as it was measured by the Rancimat method, is shown in Table VIII. A 20.5% reduction in induction was observed, which could be attributed to oil degummming. There were no available published results for comparison of the data of the present work. The induction period of *Moringa* oil was slightly longer than that of the olive oil before and after degumming. The oxidative stability of olive oil is related to some extent to the presence of α-tocopherol (Kiritsakis, 1989). Kiritsakis and Min (1989) reported that olive oil contains between 15-150 mg/kg α-tocopherol. α-Tocopherol is one of the most reactive naturally occurring singlet oxygen acceptors among the four tocopherols. However, the stability of olive oil could not be explained only on the basis of tocopherol action. It is known that the olive mesocarp contains phenolic compound, which though water soluble are present in the olive oil and considerably increase the oxidation stability of the oil (Kiritsakis and Min, 1989). Pokorny (1987) also reported that olive oil is a relatively stable oil owing to various phenolic substances present in virgin (unrefined)

oil. Tyrosol, hydroxytyrosol, oleuropeinaglycone which is an ester of olenonic acid and hydroxytyrosol, are among the most important phenolic substances in olive oil.

To the higher content of α-tocopherol of the *Moringa peregrina* seed oil can be attributed the higher resistance to oxidation. In addition, olive oil contains linolenic acid which is absent from *Moringa peregrina* seed oil and which is more easily undergone oxidation and degradation than $C_{18:2}$ and $C_{18:1}$. Furthermore, the higher resistance oxidation of *Moringa peregrina* seed oil as compared to that of olive oil could be attributed to its lower content of $C_{18:2}$ as well as to the significant higher content of tocopherols.

Table VI
Tocopherol Composition of the non degummed oils

DETERMINATION		mg/kg	
Tocopherols by HPLC	Moringa peregrina	LITERATURE	Olive oil
α-tocopherol	145 (8.1)	present work	88.5 (6.33)
γ-tocopherol	58 (6.4)	present work	9.9 (0.63)
δ-tocopherol	66 (4.3)	present work	1.6 (0.03)

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

Table VII
Determination of the oxidative stability of the degummed oils

DETERMINATION	Moringa peregrina	LITERATURE (Sengupta and Gupta, 1970)	Olive oil
Peroxide value –(meq O_2 /kg of oil)	0.4 (0.19)	2.3 (25)	14.6 (1.01)
$E_{1cm}^{1\%}$ at 232 nm,	1.66 (0.25)	present work	2.3 (0.1)
$E_{1cm}^{1\%}$ at 270 nm	0.19 (0.08)	present work	0.14 (0.07)

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

Table VIII

Determination of the susceptibility to oxidation of the degummed and non degummed oils

DETERMINATION	Moringa peregrina	LITERATURE	Olive oil
Rancimat method (h) at 120°C			
Before degumming	10.2 (0.23)	present work	7.88 (0.55)
After degumming	8.11 (0.19)	present work	—

\# Values are means of triplicate determinations and percentage coefficient of variation are given in parenthesis.

4. CONCLUSIONS

The oil from the seeds of *Moringa peregrina* contains high ratio of monounsaturated fatty acids to saturated fatty acids, and might be acceptable substitute for highly monounsatured oils such as olive oil in diets.

The induction period measurements demonstrated a great resistance to oxidative rancidity. The oxidative stability of the Moringa oil is related to some extent to α-, γ- and δ-tocopherols which are natural antioxidants.

Additional research on possible toxicity should be carried out.

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