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Physico Chemical Properties and Chemical Constituent Characterization of *Moringa oleifera* Seed Oil from Benue State, Nigeria, Extracted Using Cold and Soxhlet Method

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Authors' contributions

This work was carried out in collaboration between both authors. Author OOO designed the study, performed the statistical analysis, wrote the protocol, carried out the bench work and wrote the first draft of the manuscript. Author REK was the supervisors of the work. Both authors read and approved the final manuscript.

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ABSTRACT

The extraction and characterization of both cold press and hexane solvent extracted *Moringa oleifera* oil found in North central (Makurdi, Benue State) Ecological Zone of Nigeria has been carried out. The moringa seed was milled into flour and then divided into two portions. The first portion was used for the cold press extraction while the second portion was defatted using soxhlet extraction method. Normal hexane was used as solvent for the extraction process. The characterization breakdown revealed that tested parameters, which include specific gravity, refractive index, acid value, free fatty acid and moisture content were not significantly different ($p<0.05$) from each other. While, viscosity, colour, pH, percentage yield, saponification value, peroxide value and iodine value for both cold press and hexane solvent extracted Moringa oil produced, were significantly different ($p<0.05$) from each other. The oil was analysed using Gas

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Chromatography Mass Spectrometer method showing the composition and components (quantitative and qualitative) of the oil. Seven compounds were identified from oil derived from cold press extraction method with 5, 5-Dimethyl-1, 3-dioxane-2-ethanol and 12-Methyl-E, E-2, 13-Octadecadien-1-ol as the major component obtained. For the hexane solvent extraction method, only three compounds were identified with 9, 12-Octadecadienoic acid (Z, Z), (Linoleic acid) having highest abundance with respect to retention time as displayed by the highest peaks in the graphs. The seed oil of *M oleifera* showed good physio-chemical properties and could be utilized successfully as a source of edible oil for human consumption and for industrial applications. Also, we found oil derived from cold press extraction method as most enriched than that hexane solvent extraction method and can be used for the treatment of various hazardous diseases.

Keywords: Extraction; characterization; Moringa oleifera; cold press; GC-MS analysis and solvent.

1. INTRODUCTION

Moringa oleifera is acclaimed to be the most widely cultivated species of a *Moringaceae* family and is commonly known as the horseradish or drumstick tree*,* which is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan [1]. *Moringa* is known by these popular different names according to Adegbe et al*.,* [2] in Nigeria; it is "*Zogale*" in the north, "*Ewe Igbale*" and "*Idagba Manoye* in the southern part and *"Odudu Oyinbo*" in the eastern part of Nigeria. *M. oleifera* fruit has 10-50 seeds inside when mature. Fully mature dry seeds are round or triangular in shape and the kernel is surrounded by a light woody shell with three papery wings [3]. The fruits and seeds have been reported as a rich source of protein, essential elements (Ca, Mg, K and Fe) and vitamins (A, C, and E). The percentage yield of oil extracted from its seeds (Known as ben or behen oil due to the high behenic acid content) ranges from 38-40% and can be used as a food, a cosmetic, and a lubricant [4]. The oil has been used for cooking purposes in African and some parts of Asia, Particularly India, [5]. Dietz, et al., [5] reported that the use of unconventional oilseeds as a source of vegetable oils has become important considering the gap between demand and production of vegetable oils in many developing countries. In countries like India, Kenya, Malawi, Malaysia, Pakistan, and lately Nigeria reports on the composition and characteristics of *M. oleifera* seed oil varieties have been reported [3], [6-8] considering its prospect as an alternative vegetable oil source. According to Abdulkarim et al*.,* [3], the oil is relatively easy to extract using simple household technology, solvent method and screw press oil expeller method. The refined oil is clear, odourless and rancid-resistant. Seed biomass remaining after the oil extraction can be used as a fertilizer or flocculating agent for water purification [9]. The seeds of *Moringa* yield 38-40% edible oil known as Ben Oil [10]. *M. oleifera* seed oil is one of the most stable oil in nature and has a shelf life of up to five years. Therefore, extracting oil from *M. oleifera* seeds has a lot of commercial potentials for communities in developing countries. The oil extracted from *M. oleifera* seeds is regarded as having a good commercial interest due to its physical, chemical and pharmacological characteristics [11].

The objectives of this study were to determine physico-chemical properties, qualitative and quantitative composition (using GC-MS) of oil, extracted from *Moringa oleifera* using simple household technology (Cold press) and hexane solvent (soxhlex) method.

2. MATERIALS AND METHODS

2.1 Materials

Moringa oleifera Seed oil (MSO) harvested from the agricultural farm of federal university of Agriculture Makurdi, Nigeria was used for the study. They were authenticated by Prof. N.I. Odiaka of Department of Crop Production, College of Agronomy, University of Agriculture Makurdi, Nigeria.

2.2 Methods

2.2.1 Seed preparing stages

The seeds after harvesting were separated from the membranes and broken to remove the kernel from the hard shell. The kernels were cleaned and sun-dried so as to reduce the moisture content. The dried kernels were then crushed into fine particles with blender to make extraction (cold-press and hexane solvent) easier. The sample was stored in a safe place until ready for cold-press and hexane solvent extraction [12].

2.3 Determination of Moisture Content

The determination of moisture was carried out using the air-oven method as described in AOAC [13]. The petri dishes were washed, dried in the oven, allowed to cool in a desiccator and the weight noted. The samples 5 g was weighed into the petri dishes and dried in the oven at 105°C for 4 h. The sample was finally dried to a constant weight and the moisture content was calculated.

Moisture content = $\frac{weight\ loss\ x100}{weight\ of\ sample\ (g)}$

2.4 Oil Extraction

Oil extracted via cold-press and hexane solvent.

2.4.1 Cold-press extraction

The cold press extraction of Moringa seed oil was done using the local extraction method as described by Kate et al., [14] with slight modifications. The process involved dry milling, mixing, kneading, sprinkling of warm water intermittently and pressing to remove the oil without using any chemicals. The oil was then allowed to settle (water and dirt's settle below and the oil float at the top) for about two days before it was decanted into a container. The oil was filtered through filter paper (whatman No. 1), then centrifuged at 3000 rpm (2,431 x g) for 3 min to separate the water and residues from the oil. The oil was then stored in an amber bottles/plastic at 4°C until analyzed.

2.4.2 Hexane extraction

The n-hexane extract was obtained by complete extraction using soxhlet extractor. 10g of the powdered seeds sample was put into a porous thimble and placed in a soxhlet extractor, using 300ml of n-Hexane (with boiling point of about 40-60°C.) as extracting solvent for six (6) hours repeatedly until the required quantity was obtained. The oil was obtained after evaporation using a water bath at 70°C to remove the excess solvent from the extracted oil. The oil was kept in the refrigerator without further treatment until needed for further analysis [13].

2.5 Quantitative and Qualitative Characteristics

The GC and GC-MS analysis of the seed oil of *M. oleifera* was performed at the chemistry laboratory of Ahmadu Bello University (ABU), Zaria, Nigeria, as described by Adegbe et al., [2] using a multi-dimensional gas chromatography coupled with gas chromatography-mass spectrophotometer. (Shimadzu Japan) equipped with non-polar and polar double capillary columns (25.0 m×0.25 µm i.d., 0.25 µm df). High purity helium was used as the carrier gas at a constant flow rate of 0.99 ml/min. 1 µl sample was injected (split ratio 100:1) into GC and GCMS using AOC-2Oi; auto injector for analysis. The initial temperature was set at 60°C, heated at a rate of 3°C/min to 280°C and held isothermally for 6 minutes. Ion source temperature was set to 200°C while the interface was set at 250°C, solvent cut time was 3 minutes. Electron impact (EI) ionization mode was 70ev and the linear velocity of the column was 36.8 cm/sec. The identification of the various components was based on comparison of their mass spectra with those of Nist Library mass Spectra data base and mass spectra from Literature.

2.6 Determination of Physical Properties

2.6.1 Determination of the percentage of sesame oil

The crude and the refined oil were weighed separately and their percentage yield was calculated on dry matter basis as shown in equation below [15].

$$\%\ oil\ yield = \frac{weight\ of\ oil}{weight\ of\ sample\ on\ dry\ matter\ basis}$$

2.6.2 Determination density and specific gravity

The density and specific gravity were determined by the method described by Garba et al., [15]. An empty washed and dried beaker was weighed on the top load weighing balance. The weight of the beaker was recorded. Exactly 50 cm^3 of each of the oil sample were measured and poured into the beaker and weighed. The weights of the 50 cm^3 of the samples were recorded. The procedure was repeated with water and the weight of 50 cm^3 of water was obtained. The density and the specific gravity were calculated thus;

$$Density = \frac{Weight\ of\ oil\ sample}{volume\ of\ the\ oil\ sample}$$

$$Specific\ gravity\ of\ oil\ sample = \frac{weight\ of\ oil\ sample}{weight\ of\ equal\ volume\ of\ water}$$

2.6.3 Determination of refractive index

Refractometer was used in this determination. Few drops of the samples were transferred into the glass slide of the refractometer. Water at 40°C was circulated round the glass slide to keep its temperature uniform. Through the eyepiece of the refractometer, the dark portion viewed was adjusted to be in line with the intersection of the cross. At no parallax error, the pointer on the scale pointed to the refractive index. This was repeated and the mean value noted and recorded as the refractive index [15].

2.6.4 Determination of viscosity

A clean, dried viscometer with a flow time above 200 seconds for the fluid to be tested was selected. The samples were filtered through a sintered glass (fine mesh screen) to eliminate dust and other solid material in the liquid samples. The viscosity meter was charged with each of the samples by inverting the tube's thinner arm into the liquid samples and suction force was drawn up to the upper timing mark of the viscometer, after which the instrument was turned to its normal vertical position. The viscometer was placed into a holder and inserted to a constant temperature bath set at 40°C and allowed approximately 10 minutes for the sample to come to the bath temperature at 40°C. The suction force was then applied to the thinner arm to draw the samples slightly above the upper timing mark. The efflux time by timing the flow of the samples as it flows freely from the upper timing mark to the lower timing mark was recorded [15].

2.6.5 Colour

Colour of the oils was measured with a Minolta CR-300 colorimeter (Minolta. Co. Ltd., Tokyo, Japan) in the CIE L*a*b* mode CIELAB colour space. The parameters determined were:

L (L=0 [black] and L = 100 [white]),
a (a = greenness and +a = redness),
b (b = blueness and + b = yellowness).

2.6.6 pH determination

pH was determined using [13] procedure. Each oil samples (25 ml) was poured into a beaker and pH probe of the pH meter was inserted into it after the pH meter has been standardised in buffer 4 and 7 solution at 25°C.

2.7 Determination of Chemical Properties

2.7.1 Determination acid value

About 1g of the crude and refined oil was weighed separately in 250 ml conical flasks. 5

Table 1. Physico-chemical properties of *Moringa oleifera* seed oil extracted via cold-press and hexane solvent

Properties	Cold-press	Hexane solvent	Variation
Chemical properties			
Iodine value (g I2/100 gr oil)	64.84±0.02[a]	67.59±0.00[b]	2.75
Acid value (mg KOH/gr oil)	6.49±0.33[a]	6.35±0.12[a]	0.14
Peroxide value (meqO2/ kg oil)	5.42±0.03[b]	5.00±0.02[a]	0.42
Saponification value (mg KOH/ g oil)	215.82±0.22[a]	218.21±0.63[b]	0.98
Free fatty acid	3.24±0.17[a]	3.16±0.05[a]	0.08
Moisture content (%)	7.51±0.03[a]	7.51±0.03[a]	0.00
Physical properties			
Percentage yield (%)	12.26±0.08[a]	38.92±0.11[b]	26.66
Specific gravity (gr/cm3)	0.896±0.01[a]	0.887±0.01[a]	0.09
Refractive Index	1.467±0.01[a]	1.457±0.01[a]	0.010
pH	4.58±0.01[a]	5.27±0.01[b]	0.69
Colour			
L	24.37±0.54[b]	20.26±0.10[a]	4.11
a	3.76±0.48[a]	5.57±0.08[b]	1.81
b	45.99±1.96[b]	1.78±1.97[a]	4.21
Viscosity (mpa.s)	81.50±0.01[b]	57.20±0.01[a]	24.30
Organoleptic properties			
Odour	Agreeable	Agreeable	
Colour	Light Cream yellow	Cream yellow	

cm^3 of isopropyl alcohol was added into the conical flasks containing the oil samples with thorough stirring. Three drops of phenolphthalein indicator was added and titrated against 0.1 N of KOH solution while shaking constantly until a faint pink persist for 30s. The endpoint was recorded and the acid value was calculated [15] as;

$$A.V = \frac{Titre\ value + Molar\ Conc + 56.1}{Weight\ of\ Sample}$$

$$\%FFA = \frac{Titre\ value + Molar\ conc\ of\ KOH + 28.2}{Weight\ of\ sample}$$

2.7.2 Determination of saponification value

About 2 g of the samples were weighed separately in 250 ml conical flasks. 50 cm^3 of ethanolic potassium hydroxide was added into the conical flasks containing the oil samples with thorough stirring. The resulting mixtures were boiled until the oil dissolves. Three drops of phenolphthalein indicator were added and titrated against 0.1 N of KOH solution while shaking constantly until a faint pink persist for 30s [15].

$$S.V. = \frac{(B - R) + Molar\ Conc\ of\ HCL + 56.1}{Weight\ of\ sample}$$

2.7.3 Determination of Iodine Value

The method specified by AOCS, [12] and reported by Garba et al., [15] was used. 0.4g of the samples was weighed into a conical flasks and 20 ml of carbon tetra chloride was added to dissolve the oil samples. Then 25 ml of Dam's reagent was added to the flasks using a safety pipette in fume chamber. Stoppers were then inserted and the content of the flasks were vigorously swirled. The flasks were then placed in the dark for 2 hours 30 minutes. At the end of this period, 20 ml of 10% aqueous potassium iodide and 125 ml of water were added to each sample using a measuring cylinder. The contents were titrated with 0.1 M sodium-thiosulphate solutions until the yellow colour almost disappeared. Few drops of 1% starch indicator were added and the titration continued by adding thiosulphate drop wise until blue coloration disappeared after vigorous shaking. The same procedure was used for blank test and other samples. The iodine value (I.V) is given by the expression:

$$I.V. = 12.69\frac{C(V1 - V2)}{M}$$

Where C = Concentration of sodium thiosulphate used; V1 = Volume of sodium thiosulphate used for blank; V2 = Volume of sodium thiosulphate used for determination, M = Mass of the sample.

2.7.4 Determination of peroxide value

One gram (1 g) of oil sample was added with 1 g of potassium iodide and 20ml glacial acetic acid chloroform 2:1. It was then boiled for 1 min. The hot solution was transferred into a flask containing 20 ml of 5% potassium iodide solution. And few drops of the starch solution was added and titrated with 0.025 N Na2S2O3 to a faint yellow colour. One millilitre (1 ml) of the starch indicator was added and the titration continued until the blue colour disappears.

Determine using AOAC [13] method.

$$P\ V = \frac{molar\ equivalent}{weight\ of\ oil\ sample} = \frac{SxNx100}{weight\ of\ oil\ sample}$$

Where; PV= Peroxide Value, S = Weight of $N_2S_2O_3$ used, N = Normality of $N_2S_2O_3$

2.8 Statistical Analysis

The data obtained were analysed statistically using the software package SPSS 15.0 (Statistical package for social science).

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Properties

The physiochemical properties of the different extraction methods (cold press and hexane solvents) were compared and the results are present on Table 1.

Acid value, free fatty acid, peroxide value, density, refractive index, viscosity and colour (L and b) values were higher in cold-press method compare with hexane solvent method (table 1). Higher amount of iodine value, saponification value, pH, colour (a) and percentage yield of oil was observed for oil extracted via hexane solvent (Table 1). The highest variance was seen for the oils in percentage yield (26.6) follow by the viscosity (24.30) (Table 1). The variance between acid value, free fatty acid, moisture content, specific gravity and the refractive index was not significant ($p<0.05$) (Table 1). There was a significant difference ($p<0.05$) between hexane solvent and cold-press methods in respect of

peroxide values, saponification values, pH, colour (L, a and b), percentage yield and iodine values.

3.1.1 Colour and odour

The oil extracted (cold press and hexane) from *M. oleifera* (*MO*) seed has an agreeable odour and the colour was light cream-yellow for traditional cold press oil and cream yellow for hexane solvent oil extracted. The cold press seed oil was transparent, clear, considerably brighter (higher L* value of 24.37) and much more yellowish in colour (higher b* value of 45.99) compared to the hexane solvent extracted oil having L value of 20.26 and b value of 41.78 respectively. The yellow colour of *MO* seed oil according to Anwar and Rashid [16], is attributed mainly to the natural pigments remaining in the oil during extraction. The cold press seed oil has a bland odour and natural taste. The taste was not affected by oxidation. It was pure with no additives. The hexane solvent extracted oil also has an agreeable odour and taste.

3.1.2 Percentage (%) oil yield

The percentage oil yield for traditional cold press and hexane-extracted oil was 12.26% and 38.92% respectively. The oil extraction with hexane solvent had the highest yield, according to Lumley and Colwell, [17], due to the ability of the polar solvent to overcome forces that bind lipids within the sample matrix). Oil extracted by traditional cold press method showed the lowest yield due to losses during the separation of the oil from the water. This result is in conformity with the result got from the work of Lalas and Tsaknis, [18]. This percentage yield of 38.92% for hexane solvent *M. oleifera* oil extraction was higher than that reported by AOCS, [12], 34.50%. The 38.92% yield of *M. oleifera* was consistent with the value reported by Lalas and Tsaksin [18] and fall within the range accepted by FAO/WHO [19] as reported by Adegbe et al., [2]. However, the oil yield was lower by 1.47 and 2.66% as compared with those of *M. oleifera* seeds reported from Sindh Pakistan (40.39%) by Anwar & Bhanger [20], and Nigeria (41.58%) by Anhwange et al. [21]. Also, the oil content (38.92%) in the present analysis of *M. oleifera* seeds extracted by hexane solvent method was found to be quite higher as reported by Pritchard [22], than some commonly grown oil seed crops such as cotton (15.0-24.0%) and soybean (17.0-21.0%) and somewhat comparable with those of safflower (25.0-40.0%) and mustard (24.0-40.0%).

3.1.3 Specific gravity

The specific gravity of *M. Oleifera* seed oil from cold press and hexane solvent extraction method was 0.896 and 0.887 g/ml respectively. The specific gravity of cold press *M. oleifera* seed oil (0.896 g/ml) was slightly higher than that of hexane solvent extracted *M. oleifera* seed oil (0.887 g/ml) oil. This is in contrast to Lalas and Tsaksi [18] work where the specific gravity (0.909) of hexane solvent extracted *M. oleifera* seed oil was slightly higher than that of cold press *M. oleifera* seed oil (0.899). This value is in agreement with the [19] international standard for edible oil.

3.1.4 Refractive index

The refractive index 1.467 and 1.457 for the cold press and hexane solvent extracted was in agreement with [19] (1.4677-1.4705) international standard for edible oil. However, the values of the refractive index (cold press and hexane solvent extracted method) in this study were slightly higher than the values reported by Tsaksin et al. [23] and Lalas and Tsaksin [18] respectively.

3.1.5 pH

The pH values of the cold press and hexane solvent extracted oils were 4.58 and 5.27 respectively with a variance of 0.69. The pH of the cold press sesame seed oil (4.58) was significantly lower ($p<0.05$) than that of the hexane solvent extracted sesame seed oil (5.27).

3.1.6 Viscosity

The viscosity of the cold press oil (81.50 mpas) was significantly ($p<0.05$) higher than that of the hexane solvent extracted oil (57.20 mpas). The values for the cold pres oil was lower than the value reported (103 mpa.s) by Tsaksin et al. [23] and slightly higher than that reported (80 mpa.s) by Lalas and Tsaksin [18] While, for the hexane solvent extracted the value (57.2 mpa.s) was slightly higher than the value reported (57 mpa.s) by Tsaksin et al. [23] and (47.00mpa.s) reported by Lalas and Tsaksin [18]. According to Tsaksin et al. [23], the viscosity of the oil produced with cold press method was the highest, possibly because of the water that was bound to the oil during extraction.

The physical properties of the oil extracted from *M. oleifera* seed were found to be in conformity with [19] standard. On the other hand, the

chemical properties of the oil are shown also in Table 1.

3.1.7 Acid value

An acid value of 6.49 mg/ KOHg-1, and 6.35 mg/ KOHg-1 for cold press and hexane solvent extracted oils respectively shows values higher than the acid value (4.00 mg/$KOHg^{-1}$) specified for edible oil by FAO/WHO [19] and 6.00 mg/ $KOHg^{-1}$ specify by codex [24] but this value was almost in agreement with Literature (5.0386 mg KOH/g) reported by [8]. The higher acidity of the cold press *M. oleifera* seed oil could be due to the higher content of polyunsaturated fatty acids, thereby resulting in the tendency of triglycerides to break down, which further increases the free fatty acid content [25]. This was corroborated by the value of the pH (4.58 and 5.27) for the cold press and hexane extracted oils respectively.

3.1.8 Iodine value

The iodine value of the oil of *M. oleifera* for the cold and hexane solvent extracted are 64.84 and 67.59 g I_2/100 g oil respectively. Iodine value is the measure of the degree of the unsaturation of the oil. Higher Iodine value indicates higher unsaturation of fats and oils. The values were a little less than [19] standard (80-106) and (104-120) for codex standard [26] for edible oil. The iodine value of cold press *M. oleifera* seed oil (64.84 g I_2/100 g oil) was significantly ($p<0.05$) lower than that of hexane solvent extracted *M. Oleifera* seed oil (67.59 g I_2/100 g oil) indicating a lower unsaturation of the oil for cold press *M. Oleifera* seed oil. The iodine values for the hexane solvent extracted oil were in range or conformity with the values reported in literatures (65.58 to 69.45 100/g) [20] and [2]. While that of cold press oil were slightly lower than 65.73 and 65.58 reported by Lalas and Tsaksin [18] and Tsaksin et al. [23] respectively. Both the cold press and hexane solvent extracted *M. oleifera* seed oil could be classified as non-drying oils according to Garba et al., [15], since their iodine values are lower than 100.

3.1.9 Peroxide value

Peroxide value was 5.42 and 5.00 meq O_2/kg oil for cold press and hexane solvent extracted respectively. They were significantly ($p<0.05$) different from each other. The values were by far lower than [19] standard of 10 (meq O_2/kg oil), but lower than the codex standard of 1.5-2.4 (meq O_2/kg) oil and lower than that reported by AOCS, [12]. The peroxide value (5.42 and 5.00 meq O_2/kg), according to McGinely, [26], was the measure of hydroperoxide products in the oils was significantly higher than those of *M. oleifera* oils from the Sindh province of Pakistan [20], and those of *M. oleifera* oils from India [18] and Kenya [23]. However, the peroxide value of moringa oil in this study was lower (9 meq O2/ kg of oil) to that reported by Salah [27]. A low peroxide value as seen in our study increases the suitability of the oil for a long storage due to low level of oxidative and lipolytic activities.

3.1.10 Saponification value

The Saponification value of the cold press and hexane solvent extracted oil were significantly different ($p<0.05$), 215.82 and 218 .21 mg KOH/g oil respectively, this values are far higher than [19] standard of 181.4±2.60 mg KOH/g oil, codex standard of 186–195 mg KOH/ g oil and all other values reported in the literature. The high saponification value suggests the use of the oils in production of liquid soap, shampoos and lather shaving creams [28].

3.1.11 Free fatty acid (FFA)

Also, the free fatty acid of *M. Oleifera* seed oil (cold press and hexane solvent extracted) were 3.24 and 3.16 mgKOHg-1 respectively and they are not significantly different ($p<0.05$) from each other. They are lower to 5.78-7.28 [19] standard. The free fatty acid and acid values of cold press *M. oleifera* seed oil (3.24% and 6.49 mg KOH/gr oil) were apparently higher than that of hexane solvent extracted *M. oleifera* oil (3.16% and 6.35 mg KOH/gr oil). This is due to the action of lipolytic enzyme which was enhanced by water contamination in oil during cold press extraction [18]. High free fatty acid cause soap formation during alcoholysis process from it's by-products.

3.2 Quantitative and Qualitative Characteristics

The chemical components of the *M. oleifera* seed oil were analyzed using multi-dimensional gas chromatography coupled with a gas-chromatography-mass spectrophotometer (GC-MS). Seven (7) components amounting to 100% were identified in the cold press M. oleifera seed oil, while three (3) components amounting to 100% were identified in the hexane solvent extracted M. oleifera seed oil. The identified components, their retention indexes, molecular formula (MF), molecular weight (MW), percentage composition and group/application of each component are given in Table 2.

The seven compounds from *M. oleifera L* cold press extracted and three compounds from *M. oleifera L* hexane solvent extracted were characterised in Table 2. Comparison of composition of oils from seeds revealed that the cold press *M. oleifera L* oil contains 12-Methyl-E,E-2,13-Octadecadien-1-ol (24.45%), 5,5-Dimethyl-1,3-dioxane-2-ethanol (58.91%), 9-Octadecanal (18:1) (oleic acid) (1.60%) 7,11-Hexadecadienal (5.62%), 2-Pentadecanol (3.08%), 2-Pentadecanol (2.41%) and Oxalic acid, cyclobutyl pentadecyl ester (3.93%). As against hexane solvent extracted *M. oleifera L* oil containing 7-hydroxyl-3-(1, 1-dimethylprop-2-enyl coumarin (0.14%) Dotriacontyl pentafluoropropionate (6.09) and 9, 12-octadecadienoic acid (Z,Z) (93.77%) The oil derived from the two methods of extraction does not contain any compound in common. While the two major compounds in cold press extracted oil was 5, 5-Dimethyl-1, 3-dioxane-2-ethanol (58.91%), and 12-Methyl-E, E-2, 13-Octadecadien-1-ol (24.45%), that of hexane solvent extracted was 9, 12-octadecadienoic acid (Z, Z) (93.77%). From the study, it is observed that the main compounds characterizing the oil of *M. oleifera* are qualitatively and quantitatively different.

M. Oleifera is rich in alcohol (58.91%) followed by phenols (24.45%), others are aldehyde (7.22%) alky alcohol (5.49%) and esters (3.93%). The phenol identified from the GC-MS analysis is 12-Methyl-E, E-2,13-Octadecadien-1-ol (24.45%). Phenolic compound according to Wojdyło, Teleszko, & Oszmia_nski, [29] has become increasingly popular for they are not only potent antimicrobials but they also have a different bioactive effect on human which include antioxidant, anticancerogenic, antidiabetic, antihypertensive, lipid profile, degeneration of vessels and an impact in reducing chronic diseases. Alcohols are components of household cleaning products. Alcohol in various forms is used within medicine as an antiseptic, disinfectant and antidote [30]. Aldehydes are derivatives of alcohol. They are formed by the removal of hydrogen by dehydrogenation. According to McDonnell and Russell [31] aldehyde for example formaldehyde is used in tanning, preservation, embalming, germicide, fungicide and insecticide for plants. Jerry and William reported that they are used industrially as solvent, perfumes and flavouring agents or intermediates in the manufacture of plastics, dyes and pharmaceuticals. Esters according to Ponnuswami, [32] are used in food and drug preservatives to resist the growth of microorganisms like moulds and yeast.

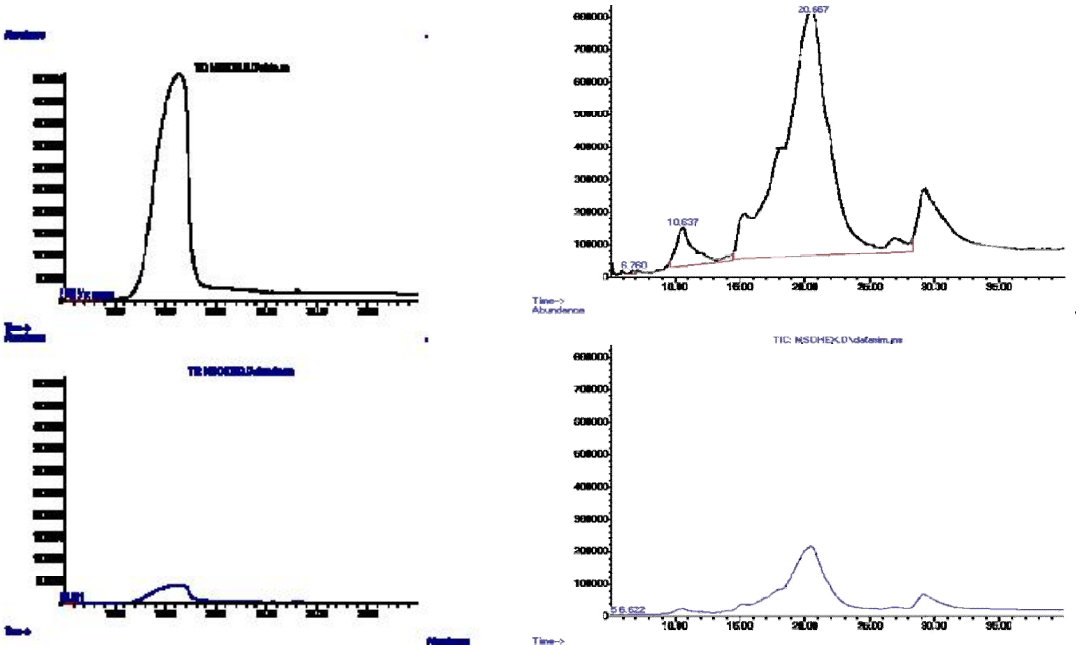

Fig. 1. GC-MS Chromatogram of the cold press and hexane solvent extracted Moringa seed oil

Table 2. GCMS Chemical Constituents of *M. oleifera* seed oil

Peak	Retention time	Area (%)	Molecular weight (g/mol)	Molecular formular	Molecule (compound)	Application
Cold press extracted *M. Oleifera* seed oil (MSO)						
1	5.408	24.45	280.496	$C_{19}H_{36}O$	12-Methyl-E,E-2,13-Octadecadien-1-ol	Phenol
2	5.941	58.91	160.213	$C_8H_{16}O_3$	5,5-Dimethyl-1,3-dioxane-2-ethanol	(Alcohol)
3	6.439	1.60	282.468	$C_{18}H_{34}O_2$	9-Octadecanal (18:1) oleic acid	Therapeutic uses (aldehyde)
4	6.795	5.62	236.399	$C_{16}H_{28}O$	7,11-Hexadecadienal	(Aldehyde)
5	7.186	3.08	228.42	$C_{15}H_{32}O$	2-Pentadecanol	Alkyl alcohol, flavouring agent and lower plasma cholesterol. Laundry products.
6	7.791	2.41	228.42	$C_{15}H_{32}O$	2-Pentadecanol	Same as above
7	8.680	3.93	354.531	$C_{21}H_{38}O4$	Oxalic acid, cyclobutyl pentadecyl ester	Petroleum jelly and antibacterial (ester)
Hexane solvent extracted *M. oleifera* seed oil MSO						
1	6.760	0.14	230.259	$C_{14}H_{14}O_3$	7-Hydroxyl-3-(1,1-dimethylprop-2-enyl) coumarin	Antifungal, anticoagulant and antimicrobial (ester)
2	10.637	6.09	612.895	$C_{35}H_{65}F_5O_2$	Dotriacontyl Pentafluoropropionate	Antimicrobial (ester)
3	20.667	93.77	280.446	$C_{18}H_{32}O_2$	9,12-Octadecadienoic acid (Z,Z), Linoleic acid	Fatty acid ester. Anti-Inflammatory, Antibacterial, Antiarthritic, Hepatoprotective, Anti-histaminic, Anticoronary

They have good odours hence, used in perfumes, food flavourings to spice up the flavour and smell of processed foods; in essential oils, cosmetics etc. Also, the present fat and oils are carboxylic acid esters of glycerine. Esters are used to make surfactants e.g. soap and detergents [32].

4. CONCLUSION

The oil extracted from Moringa seeds by the two extracting methods (cold press and hexane solvent) has good physicochemical properties in such a way that no additional processing operations methods will be needed for the oil. *Moringa oleifera* oil is edible and has the prospect of becoming a new source of oil. It contains high unsaturated to saturated fatty acids ratio as a result of its high iodine and saponification values and might be a suitable alternative for highly saturated oil such as olive oil in diets. The study revealed that the oils could be a potential source of useful drugs like insecticide, antimicrobial, antifungal, antioxidant, antiflammatory, hypocholesterolemic, antiarthritic, anticoronary and antiandrogenic activities. The production of useful oil from the *Moringa oleifera* seeds could be of economic importance of benefit to the areas where the tree is cultivated its full potential should be exploited.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jed W, Fahey SD. *Moringa Oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties; Part 1. Trees for Life Journal. Retrieved; 2008.
2. Adegbe AA, Larayetan RA, Omojuwa TJ. Proximate analysis, physicochemical properties and chemical constituents characterization of *Moringa oleifera* (Moringaceae) seed oil using GC-MS analysis. American Journal of Chemistry. 2016;6(2):23-28
3. Abdulkarim S, Long K, Lai O, Muhammad S, Ghazali H. Some physical-chemical properties of *Moringa oleifera* seed oil extracted using solvent and aqueous enzymatic methods. Food Chemistry. 2005;93(2):253-263.
4. Banerji R, Bajpai A, Verma SC. Oil and fatty acid diversity on genetically variable clones of *Moringa oleifera* from India. Journal of Oleo Science. 2009;58(1):9-16.
5. Dietz M, Metzler R, Zarate C. Food security in the village: The case of oilseed processing. Appropriate Technology. 1994; 20:9-11.
6. Anwar F, Latif S, Ashraf M, Gilani AH. *Moringa oleifera*: A plant with multiple medicinal uses. Phytotheraphy Research. 2007;21(1):17-25.
7. Anwar F, Ashraf M, Bhanger M. Interprovenance variation in the composition of *Moringa oleifera* from Pakistan. Journal of the American Oil Chemical Society. 2005;82(1):45-51.
8. Anwar F, Zafar S, Rashid U. Characterization of *Moringa oleifera* seed oil from drought and irrigated regions of Punjab, Pakistan. Grasas Aceities. 2006; 57(2):160-168.
9. Silva F, Matos J. Sobre disperses de *Moringa oleifera* paratratmento de ague. Technology Fortaleza. 2008;29:157-163.
10. Sengupta A, Gupta MP. Studies on the seed fat composition of *Moringaceae* family; 1997. Available:http://www.Tfljournal.Org/Article.Php/200512011249315866
11. Fahey J. *Moringa oleifera:* A review of the medical evidence for its nutritional, therapeutic, and prophylactic. 2005; Part 1. Trees.
12. American Oil Chemist's Society (AOCS). Official and Recommended Practices of the American Oil Chemists Society. 2001; 5th ed., AOCS Press, Champaign.
13. AOAC. Official methods of analysis (16th Ed.). 2005; Washington, DC: Association of Official Analytical Chemists.
14. Kate AE, Lohani UC, Pandey JP, Shahi NC, Sharkar A. Traditional and mechanical method of the oil extraction from wild apricot kernel: A comparative study. Research Journal of chemistry and environmental Science. 2014;2(2):54-60.
15. Garba AA, Medugu DW, Gwaski PA, Amusat RO. Extraction and characterization of *Moringa oleifera* seed oil. Applied Research Journal. 2015; 1(9):473-477,
16. Anwar F, Rashid U. Physicochemical characteristics of *Moringa oleifera* seeds and seed oil from a wild provenance of Pakistan. Pakistan Journal of Botany. 2007;39(5):1443-1453.

17. Lumley ID, Colw ell RK. Fats from fatty foods and determination of fat content. In: Analysis of fats and fatty foods. Rossell, J.B. and J.L.R. Pritchard, (Eds.). 1991;238-247.
18. Lalas S, Tsaknis J. Characterization of *Moringa oleifera* seed oil variety Periyakulam-1. Journal of Food Composition and Analysis. 2002;15:65-77.
19. FAO/WHO. Report of the 21st session of the Codex Alimentarius Committee on fats and oils. Kola Kinabalu, Malaysia; 2009
20. Anwar F, Bhanger MI. Analytical characterization of *Moringa oleifera* seed oil grown in temperate regions of Pakistan. Journal of Agriculture and Food Chemistry. 2003;51:6558-6563.
21. Anhwange BA, Ajibola VO, Oniye SJ. Chemical studies of the seeds of *Moringa oleifera (Lam)* and *Detarium microcarpum (Guill and Sperr)*. Journal of Biological. Science. 2004;4:711-715.
22. Pritchard JLR. Analysis and properties of oilseeds. In: Analysis of oilseeds, fats and fatty foods (Ed.): J.B. Rossell and J.L.R. Pritchard. 1991;80-98,127. Elsevier Applied Sciences, London, New York.
23. Tsaknis J, Lalas S, Gergis V, Dourtoglou V, Spiliotis V. Characterization of *Moringa oleifera* variety Mbololo seed oil of Kenya. Journal of Agriculture and Food Chemistry. 1999;47:4495-4499.
24. Codex Alimentarius. Named vegetable oils 8, codex standard. 2001;210.
25. Ruttarattanamongkol K, Siebenhandl-Ehn S, Schreiner M., Petrash A. Pilot-scale supercritical carbon dioxide extraction, physico-chemical properties and profile characterization of *Moringa oleifera* seed oil in comparison with conventional extraction methods. Industrial Crops and Products. 2014;58:68-77.
26. McGinely L. Analysis and quality control for processing and processed fats. In: Analysis of oilseeds, fats and fatty foods; (Eds.) J.B. Rosell and J.L.R. Pritchard. 1991;460-470. Elsevier Applied Science, New York.
27. Salah RM. Physiochemical properties of oil extracted from *Moringa* (*Moringa oleifera*) seeds, M.Sc, Thesis; University of Khartoum, Sudan; 2006.
28. Tunde-Akintunde TY, Oke MO, Akintunde. Sesame seed, oilseeds, Dr. Uduak G. Akpan (Ed.); 2012. ISBN:978-953-51-0665-4, InTech, Available:http://www.intechopen.com/books/oilseeds/sesameseed
29. Wojdyło A, Teleszko M, Oszmia_nski J. Antioxidant property and storage stability of quince juice phenolic compounds. Food Chemistry. 2014;152,261-270.
30. British national formulary : BNF 69 (69 ed.). British Medical Association. 2015;42: 838.
31. McDonnell G, Russell AD. Antiseptics and disinfectants: Activity, action, and resistance. Clin. Microbiol. Rev. 1999;12: 147-179.
32. Ponnuswamy I, Madhavan S, Shabudeen S. Isolation and characterization of green microalgae for carbon sequestration, waste water treatment and bio-fuel production. International Journal of Biological-Science Biological-Technology. 2013;5:17-26.

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