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CHEMICAL COMPOSITION OF *IRVINGIA GABONENSIS* SEED OIL AND ITS NUTRITIONAL POTENTIAL ON STREPTOZOTOCIN-INDUCED ADULT WISTAR RATS.

By

[1]AGATHA ANAKE
[1]Department of Biochemistry, Faculty of Basic Medical Sciences, University of Calabar

ABSTRACT

The study investigated the chemical composition of *Irvingia gabonensis* seed oil and its nutritional potential on streptozotocin-induced adult Wistar rats. Thirty (30) rats of both sexes weighing between 100-150g were distributed into five groups of six rats; normal control (NC), diabetic control (DC) metformin, diabetic treated (DT) and normal treated (NT). The Results showed increase in body weight in all groups except DC which had a 20.72% decrease. The NC and NT body weights increased the most by 23.97% and 23.68%, respectively. The metformin group increased by 11.82% while DT increased by 3.37% indicating that the diabetic groups had body weights significantly lower (P<0.05) than NC groups. Blood sugar conc. in all diabetic groups increased above that of the normal (87.80±6.43mg/dL) at the beginning of the experiment with concentrations as high as (243.39±21.48mg/dL) for DC, (280.80±22.82mg/dL) for the metformin and (309.00±23.44mg/dL) for DT. NT had blood sugar levels significantly changed when compared to NC. On the 21st day, blood sugar conc. in the metformin treatment (136.00±11.36mg/dL) and the DT (186.67±1.86mg/dL) were significantly reduced (P<0.05) when compared to the FBG at the initiation of the experiment (2880.80±22.82mg/dL & 309.00±23.44mg/dL) respectively. TC conc. increased significantly (p<0.05) in DC (119.15±6.25mmol/L) compared to NC (91.88±6.60mmol/L). the metformin group's TC conc. (103±11.21mmol/L) decreased significantly (P<0.05) when compared to DC (119.15±6.25mmol/L). TC conc. In DT (117.11±13.17mmol/L) increased significantly (p<0.05) when compared to NC. NT had increased TC conc. TG conc. in the DC (115.46±16.41mmol/L) and DT (106.24±11.19mmol/L) were significantly increased (p<0.05) against NC (71.44±7.75mmol/L). TG conc in the metformin group (79.81±8.28mmol/L) and NT (91.16±19.85mmol/L) decreased significantly (P<0.05) when compared to DC (115.46±16.41mmol/L). TG conc in DT (106.24±11.19mmol/L) increased significantly (p<0.05) when compared to NC and the metformin treatment groups. HDL conc. were significantly (P<0.05) lower (10.09±1.39mmol/L, 15.97±3.60mmol/L, 13.93±2.67mmol/L) in all diabetic groups when compared to NC (24.11±1.75mmol/L); whereas DC and DT were significantly lower (P<0.05) when compared to NT (21.98±0.47mmol/L). LDL conc. increased significantly (P<0.05) in DC (82.97±8.47mmol/L) and DT (65.93±10.65mmol/L) when compared against NC (53.48±5.44mmol/L). The metformin treatment (61.85±1.71mmol/L) and NT (58.61±6.80mmol/L) had conc. significantly lower (P<0.05) than DC.

Keywords: Chemical Composition, *Irvingia Gabonensis*, Seed Oil, Nutritional Potential, Streptozotocin-Induced Adult Wistar rats

INTRODUCTION

In developing countries, many wild edible plants are exploited as food sources; hence they provide a sufficient level of nutrition to the inhabitants. Several plant seed oils are used as sources of fat and oil to augment supplies from the inadequate animal sources. One of these lesser known seed oil is *Irvingia gabonensis* seed oil. *Irvingia gabonensis* was mainly grown for mitigating deforestation and environmental degradation due to the size and height of its tree in the sub-Sahara African region from where it originates (Leakey, Greenwell, Hall, Atangana, Usoro, Anegbeh, Fondoun, & Tchoundjeu 2005).

Irvingia gabonensis is known for its numerous food and medicinal uses in Africa. This plant produces some seed rich in fat that is traditionally used to thicken soup. *Irvingia gabonensis* fruit is a broadly ellipsoid drupe; it is yellow and has a very juicy fibrous pulp when ripe. Its stony nut encases an oil-rich dicotyledonous kernel wrapped inside a brown seed-coat (Ogunsina, 2008a, b). In Nigeria, Ghana and Gabon, the powdered full fat kernels of *Irvinga gabonensis* is cooked with leafy vegetables and other additives into a thick, gelatinized, slimy soup called *ogbono* (Eka, 1980, Ekpe, 2007).The defatted flour of *irvinga gabonensis* is potentially useful as raw material in food products development (Ainge and Brown 2001). Based on its nutritional properties, the *Irvinga gabonensis* oil (Kuwing oil) has been reported as potential base material for confectioneries, edible fats, soaps and cosmetics (Agbor, 1994, Joseph, 1995 &Ayuk, Duguna, Kengue, Mollet, Tiki-Manga & Zenkeng, P.1999).

The chemical properties of the *Irvinga gabonensis* kernels have been the subject of earlier studies, but the majority of studies are based on the ethno-botanic character of *Irvingia gabonensis* tree. The seeds contain protein and fatty acids (Silou Biyoko, Heron, Tchapla & Maloumbi 2014). These various fatty acids in the diet exert different effects on serum lipid and lipoprotein concentrations. Results from previous studies suggests that some dietary fats and vegetable oils possess blood glucose lowering potential and have been found to be useful in the management of diabetes (Evert, Boucher, Cypress, Dunbar, Franz, Mayer-Davis & Yancy 2014). These oils contain various fractions of fat and other components such as phytosterols, leukotrienes and benzopyranols (Gupta and Nigam, 2015) that produce potent anti-hyperglycemic, antioxidant and hypolipidemic activities. These effects are achieved either by an increased insulin production from pancreatic beta-cells, inhibition of glucose absorption in the gut, stimulation of glycogenesis in liver or an overall increase in glucose utilization by the body (Verma, Singh, Amresh & Sahub 2010).

Lipids are considered one of the most elemental nutrients for humans. Lipid metabolism generates many bioactive lipid molecules, which are fundamental mediators of multiple signalling pathways and they are also indispensable compounds of cell membranes (Huang and Freter 2005). Any kind of changes in lipid metabolism can result in modification of membrane composition and subsequently in changes in its permeability. It may also lead to disruption of signalling networks and could be associated with some pathological states, such as cancer, cardiovascular, neurodegenerative, and metabolic diseases, and similarly with inflammatory complications (Brenna, 2002, Burdge and Calder, 2005). Lipids consist of fatty acids classified according to the presence or absence of double bonds as saturated fatty acids (without double bonds), monounsaturated fatty acids (with one double bond) and polyunsaturated fatty acids (with two or up to six double bonds); Furthermore, they are classified as cis or trans, based on the configuration of the double bonds and as n-3 or n-6 polyunsaturated fatty acids depending on the position of the first double bond from the fatty acid methyl-end. The human body cannot synthesize polyunsaturated fatty acids with the first double bond on C3 and C6 from the methyl-end because of the absence of appropriate enzymes. Thus, these fatty acids are essential fatty acids and they have to be obtained from a diet, particularly by the consumption of fish and fish oils (Brudge and Wootton 2002, Proust, Lucas, Deawailly 2014). Unsaturated fatty acids can exist in a cis- or trans-configuration. The cis configuration is found in most naturally occurring unsaturated fatty acids sources while the transconfiguration is the result of technology processing, such as hydrogenation. Cis-unsaturated fatty acids are potent inducers of adiposomes known as lipid droplets, which have important roles in cell signalling, regulation of lipid metabolism and control of the synthesis and secretion of inflammatory mediators (Bozza and Viola, 2014).

Recently, essential fatty acids have been considered as functional food and nutraceuticals. A lot of research studies have documented their significant roles in many biochemical pathways resulting in cardio protective effects because of their considerable antiatherogenic, antithrombotic, anti-inflammatory, antiarrhytmic, hypolipidemic effect, because of the potential of reducing the risk of serious diseases, especially cardiovascular diseases, cancer, osteoporosis, diabetes and other health promotion activities following from their complex influence on concentrations of lipoproteins, fluidity of biological membranes, function of membrane enzymes and receptors, modulation of eicosanoids production, blood pressure regulation, and finally, on the metabolism of minerals (Flachs, Horakova, Brauner, Rossmeisl, Pecina, Franssen-van Hal, Ruzickova, Sponarova, Drahota & Vlcek, 2005; Mobraten, Haug, Kleiveland & Lea 2005 ; Tvrzická, Staňková, Vecka, & Žák, 2009).Thus, dietary modulation with emphasis on the composition of dietary lipids could be a therapeutic option in the prevention of thrombosis and coronary infarctions and in the treatment of various diseases including heart diseases to improve the quality of arterial walls and vascular patency. The important role of dietary pattern and lifestyle on human health has been often documented. However, distribution and content of fatty acids differ in dependence on various plant sources of oils and technology process used for their production.

Diabetes mellitus is a progressive metabolic disease that has affected a considerable percentage of the global population. The most common form of diabetes is Diabetes mellitus, a metabolic disorder in which there is an inability to metabolize carbohydrates due to disturbances in insulin function. Diabetes mellitus is characterized by elevated glucose in the plasma and episodic ketoacidosis. Additional symptoms of diabetes include excessive thirst, frequent urination, hunger, fatigue & blurred vision. If left untreated the disease can lead to fatal ketoacidosis. Epidemiologic data indicated that 2.8% of the world’s population was diabetic in the year 2000 and it may progress to 4.4% of the world’s population by 2030. It affects all age groups of people and ethnic groups (Xing, Weinzimer, & Tansey 2009).

Hyperlipidemia is a metabolic complication of both clinical and experimental diabetes (Gandhi, 2001). Low density lipoprotein in diabetic patients lead to abnormal metabolism and is associated with increase in very low density lipoprotein (VLDL) secretion and VLDL catabolism. Ultimately this leads to atherosclerotic plaques (Howard, 1987). A number of known factors for coronary artery disease such as hypertension, obesity and dyslipidemia are more common in diabetics than in the general population.

Presently, diabetes is managed or controlled using pharmacologic agents and non-pharmacologic methods, such as diet and exercise. However, all the pharmacologic agents are not devoid of adverse effects and have not adequately proven to be effective in curbing the complications associated with Diabetes mellitus (Palumbo 2001) therefore triggering the scientific community to search for new drugs from all possible sources, including herbal medicines which might be less toxic when compared to the available drug therapy (Palsamy, Subramanian, &Resveratrol 2008). Several phyto consistuents possessing antidiabetic activity have been isolated and studied from many medicinal plants, but still scientists continue their research on medicinal plants to bring good antidiabetic drugs to the healthcare community. A vast array of plants utilized for the prevention and management of diabetes have been reported in several other studies. Their bioactive constituents including phytochemicals, fatty acids, vitamins and minerals are known to exert an influence on various metabolic cascades, which directly or indirectly affect blood glucose levels (Onoagbe, Negbenebor, Ogbeide, Dawha, Attah, Lau, Omonkhua 2010). These compounds have produced potent anti-hyperglycemic, antioxidant and hypolipidemic activities. These effects are achieved by either an increased insulin production from pancreatic beta-cells, inhibition of glucose absorption in the gut, stimulation of glycogenesis in liver or an overall increase in glucose utilization by the body (Verma *et al*., 2010). Results from previous studies suggested that some dietary fats and vegetable oils possess blood glucose lowering potential and have been found to be useful in the management of diabetes (Evert *et al*., 2014). These oils contain various fractions of fat and other component such as phytosterols, tocopherol, oryzanol, leukotrienes and benzopyranols which have been known to affect insulin resistance and metabolic controls (Gupta and Nigam 2015). **Statement of the problem**

a) Many seed oils are widely used for food preparation all over the world, but due to public perception that intake of these edible oils contributes to elevated blood glucose levels, dyslipidemia and increased cardiovascular risk has reduced their consumption
b) *Irvingia gabonensis* is a poorly studied plant that is widely consumed in our locality and is believed to have an effect on the lipid profile of a diabetic patient. It has also been shown that the seed oil has hypoglycaemic effect and has been used for the treatment of diabetes despite its high content of saturated fat (Ngala, Ampong, Sakyi & Anto 2016)

Aim of the study

The study is aimed at investigating the nutritional potential and chemical constituents of *Irvingia gabonensis* seed in health with focus on its seed oil.
Specifically, the study sought to:

a) To extract Kuwing oil from *Irvingia gabonensis* seed using the continuous Soxhlet extraction technique.
b) To determine the fatty acid composition of the extracted oil using gas chromatography.

LITERATURE REVIEW

Irvingia gabonensis

Irvingia gabonensis is a species of large evergreen trees in the genus *Irvingia* and family *Irvingiaceae* (Lamorde, 2010), it is commonly found in West and Central Africa and is known by the common names wild mango, African mango, bush mango,

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dika or *ogbono*. The geographical distribution of the species extends from the Casamance region (Senegal) to Angola and it is found in moist semi-deciduous forests. It is a wild forest tree growing up to the heights of 15-40m with a bole slightly buttressed, possessing dark green foliage and yellow flowers (Harris 1996)

Irvingia gabonensis fruit is a broadly ellipsoid drupe; yellowish and having very juicy fibrous pulp when ripe. Its stony nut encases an oil rich dicotyledonous kernel wrapped inside a brown seed-coat (Ogunsina 2008a, b). The average length, width and thickness of the nut are 43.3, 30.62 and 22.11 mm respectively (Ogunsina 2008a). In Nigeria, Ghana and Gabon, the powdered full fat kernels of *Irvingia gabonensis* are cooked with leafy vegetables (Eka, 1980; Ekpe 2007), chili powder, smoked fish, crayfish, meat, spices and other additives into a thick, gelatinized, slimy and assorted draw soup called *ogbono* soup which is usually eaten as a delicacy with solid foods such as *eba* or *fufu* or in the South western part of Nigeria. The defatted flour is used as raw material in food production. Based on its nutritional properties, the kernel oil and meal have been reported as potential base materials for confectioneries, edible fats, soaps and cosmetics (Agbor, 1994; Joseph, 1995 and Ayuk, 1999).

The fruits are sometimes referred to as 'Mangoes' (the synonym of African Bush Mango). They are unrelated, because the true Mango fruits are borne from the plant *Mangifera indica* of the plant family *Anacardiacea* (Akubor 1996). The differentiation between these two plants becomes important. *Irvingia gabonensis* is a plant, and the fruits it bears are sometimes referred to as the 'Mangoes' or 'African Bush Mangoes' despite being unrelated to the true Mango fruit (Sun and Chen, 2012). *Irvingia gabonensis* plays an important role in the rural nutrition, income and traditional medicine branches of western to south western tropical Africa i.e. from Nigeria to Angola (Lowe, Gillies, Wilson, & Dawson 2000). See the plate below.

Medicinal uses of *Irvingiagabonensis*

Medicinal treatments utilize the bark, kernels, leaves and roots of the fruit for a variety of ailments.

a. Diarrhea

The bark is mixed with palm oil for treating diarrhea. It was also reported that the shavings of the stem bark are eaten to stop diarrhea or dysentery in French Equitorial Africa (George and Zhao 2007).

b. Infections

The antibiotic property of the bark helps in healing scabby skin. The leaves and root extracts have documented inhibitory activity against several bacteria and fungi types (Fadare 2008)

c. Pain

The extract from the bark is ingested to produce analgesic effect. The boiled bark relieves tooth pain. The Mende tribe in Sierra Leone grind the bark into a paste with water and apply the product to the skin for pain relief. (George and Zhao, 2007).See Figure 1.

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Plate 1(a): Diagram of *irvingia gabonensis* fruits

Figure 1: Diagram showing seeds of *irvingia gabonensis*

d. Diabetes

Irvingia gabonensis seed is capable of reducing fasting blood glucose levels in obese beings (Ngondi, Djiotsa, Fossouo & Oben, J.2006).

e. Obesity

Irvingia gabonensis fruit suppresses hunger and as such very essential for people that want to minimize their food intake. Reduction of food and caloric intake help to maintain a healthy weight (Ngondi *et al*.,2006) evaluated the efficacy of *Irvingia gabonensis* seeds in obesity management.

Nutritional composition of *Irvingiagabonensis*

Table 1 are the edible seeds provide 697 calories in a 100gram portion and the following nutrients (*Tchoundjeu* and Atangana, 2007*):*

Fat	67 g
Carbohydrate	15 g
Protein	8.5 g
water	4 g
Calcium	120 mg
Iron	2.4 mg

Ogbono fruit is a rich source of potassium, iron, water, energy, protein, carbohydrate, ascorbic acid, sodium, amino acids, dietary fibre, calcium, magnesium and phosphorus. Besides the mentioned components, kernels of African mango contain traces of thiamine (vitamin B1), riboflavin (vitamin B2) and niacin (vitamin B3) (Zoue, 2013).

The seeds are rich in protein and fats. Fat is the most abundant component of kernels (70%) particularly two saturated fatty acids: 51.87% of myristic acid (C14:0) and 38.44% of lauric acid (C12:0) (Womeni, Ndjouenkeu, Kapseu, Tchouanguep, Parmentier & Fanni, 2006). The role of dietary saturated fatty acids on the plasma level and low-density lipoprotein (LDL) metabolism has been investigated mainly in animals and humans (Lagrost, Mensink, Guyard-Dangremon, Temme, Desrumaux, Athias, Hornstra & Gambert 1999, Nicolosi 1997). Saturated fatty acids, like myristic acid are generally considered to induce the increase in plasma cholesterol, especially in the LDL-cholesterol concentration (Woolett, Spady & Dietschy 1992). The approximate fatty acid composition is myristic acid 33–70%, lauric acid 20–59%, oleic acid 1–11%, palmitic acid 2% and stearic acid 1% (Ogunsina, Bhatnager, Indira & Radha 2012).

MATERIALS AND METHODS

Materials

Chemicals, reagents, glasswares and equipment

a. Ethanol (Gunsgdong Guandgua Chemical Factory Co. Ltd.,China).
b. Kits for lipid profile assays (purchased from Agape Diagnostics, Switzerland Gmbh, knonauerstrasse 54 – 6330 Cham – Switzerland).
c. GC-MS -QP2010 Plus (SHIMADZU-JAPAN), comprising of AOC-20i auto sampler and gas chromatograph interfaced with a mass spectrometer.
d. Rotary evaporator (200C, Ankita technologies, Indias).
e. Soxhlet extractor (AS Sigma-Aldrich Corp, USA).
f. Oven (UNE 700 Memmert, Germany).
g. A manual blender (BL770 Shark Ninja).
h. Buschnner funnel (Mvtex Science Industries, Karda Nagar Ambala).
i. Electronic weighing balance (ATX-224 Shimaz-Japn).
j. Whatman No 2 filter paper
k. On call plus one touch glucometer (ACON Laboratories Inc, 10125 Mesa Rim Road, San Diego. CA92121, USA)
l. Glucose strips
m. Lancet
n. Dissecting set
o. 5ml syringes and needles
p. Centrifuge (Model 80 SM -2-Surgefield medical England)
q. Streptozotocin (Glentham life sciences).

Purchase of plant materials and animal feed

Seeds of *Irvingia gabonensis* were purchased from Marian market in Calabar Municipal L.G.A in Cross River State. The specimen was identified and authenticated at the herbarium of the Department of Botany, University of Calabar and a voucher specimen number, Bot/Herb/UCC/295 was given while the animal feed was purchased from Watt market in Calabar South L.G.A in Cross River State.

Methods

Extraction of oil

The seeds were screened to remove the bad ones and other impurities and then homogenized using a manual blender. Then nine hundred and sixty grams of the homogenized sample was introduced in into a Soxhlet extractor. After 4 hours of extraction with ethanol as solvent. The solvent was evaporated under reduced pressure in a rotary evaporator and traces of the residual solvent were eliminated by drying oil in an oven at 80°C for 4 hours.

Identification of oil composition using gas chromatography–mass spectrum (GC-MS)

Identification of the oil composition sample was carried out using GC-MS -QP2010 Plus. The assay conditions were as follows: fused silica capillary column (Rastek RT x 5Ms; 30m x 0.25mm ID x 0.25um film thickness) composing of 5% diphenyl 95% dimethylpolysiloxane; column oven temperature at 80^{o}C, injection temperature maintained at 250^{o}C; injection mode split; pressure of 108kpa; total flow of 6.2ml/min at 1ml/min; column flow of 1.58ml/min; split ratio of 1.0 and solvent cut time of 2.50 min. Mass spectra were taken at start time of 3.0min and end time of 27.0min; while the ACQ mode- Scan was carried out at event time (0.50sec), with scan speed 1250m/s.

Identification of Component

The confirmation and interpretation of the mass spectrum GC-MS was done using the database of National Institute of Science and Technology (NSIT) consisting of more than 62000 patterns. The spectrum of the unknown samples were compared with that of the known components that are stored in the library, and their molecular weights, names and the structural formula were then elucidated.

Experimental Animals

Thirty (30) adult Wistar rats of both sexes weighing between 100-150g were obtained from the Animal House of the Department of Pharmacology, University of Calabar; Calabar. The rats were allowed one-week acclimatization in the Animal House of the Department of Biochemistry. The animals were housed in well ventilated cages (wooden bottom and wire mesh top) and kept under normal environmental conditions of room temperature (18°C-25°C), relative humidity and proper sanitary conditions. The animals were divided into five (5) groups of six (6) animals each. The dose for administration was obtained from a preliminary LD_{50} studies. Ethical approval for the animal study was gotten from the departmental Ethics Committee.

Experimental protocol

The animals were divided into five groups (5) groups having six (6) animals each as shown in table 3 below. The oil extract and metformin (Glucophage) were administered via oral gastric intubation twice daily at a six-hour interval (10am and 4pm) for 21days. Throughout this period the animals were maintained on pelletized grower's feed and tap water. Both the feed and water were provided *ad libitum*.

RESULTS

Gas Chromatography-Mass Spectrometry (GC-MS) composition of *Irvingia gabonensis*seed oil

The GC-MS screening of the ethanolic oil extract as presented in the chromatograph below (figure 4) showed 18 distinct peaks indicative of the presence of 18 bioactive constituents. The 18 constituents were identified by the help of mass spectrometry and were essentially constituted of organic compounds containing carbon atoms of between 9-26 chain lengths. The table 4 below presents the names, percentage peak area (% composition), molecular weight, retention time, and molecular formula.

The names and percentage composition of these compounds were; 1,2,3-Trimethylbenzene (0.76%), Decane (1.91%), 2-Nanonone(0.78%), 4,7-dimethyl Undecane (0.67%), 2-Undecanone (0.75%), Decanoic acid (0.81%), Tetradecane (1.58%), Dodecanoic acid (27.93%), Octadecane (1.52%), Tetradecanoic acid

(16.02%), Hexadecanoic acid methyl ester (2.00%), Hexadecanoic acid (12.34%), 11-Octadecanoic acid, methyl ester (5.51%) Octadecanoic acid methyl ester (3.53%), 9-Octadecanoic acid (13.75%), Octadecanoic acid (7.60%) 1-ethylpropyl heneicosane (1.51%), Docosanoic acid (1.02%).

TABLE 2: Volatile oil constituents in the ethanol extract of *Irvingia Gabonensis analysed by* GC-MS technique

No	Name of the compounds	Retention Time (Min)	Molecular Formular	Molecular Weightg/mol	Percentage Composition(%)
1	1,2,3-Trimethylbenzene	3.848	C_9H_{12}	120.19	0.76
2	Decane	4.229	$CH_3(CH_2)_8CH_3$	142.286	1.91
3	2-Nanonone	5.41	$C_9H_{18}O$	142.242	0.78
4	4,7-dimethyl Undecane	8.045	$C_{13}H_{28}$	184.367	0.67
5	2-Undecanone	8.205	$C_{11}H_{22}O$	170.30	0.75
6	Decanoic acid	9.41	$C_{10}H_{20}O_2$	172.26	0.81
7	Tetradecane	10.88	$C_{14}H_{30}$	198.394	1.58
8	Dodecanoic acid	12.229	$C_{12}H_{24.}O_2$	200.3178	27.93
9	Octadecane	13.445	$C_{10}H_{20}O_2$	172.26	1.52
10	Tetradecanoic acid	14.865	$C_{14}H_{28}O_2$	229.368	16.02
11	Hexadecanoic acid methyl ester	16.902	$C_{17}H_{34}O_2$	270.457	2.00
12	Hexadecanoic acid	18.164	$C_{16}H_{32}O_2$	256.43	12.34
13	11-Octadecanoic acid, methyl ester	20.009	$C_{19}H_{36}O_2$	296.4879	5.51
140	Octadecanoic acid methyl ester	20.372	$C_{19}H_{38}O_2$	298.511	3.53
15	9-Octadecanoic acid	21.031	$C_{18}H_{34}O_2$	282.468	13.75
16	Octadecanoic acid	21.219	$CH_3(CH_2)_{16}COOH$	284.484	7.60
17	1-ethylpropyl heneicosane	23.052	$C_{26}H_{54}$	366.707	1.51
18	Docosanoic acid	23.298	$C_{21}H_{43}COOH$	340.592	1.02

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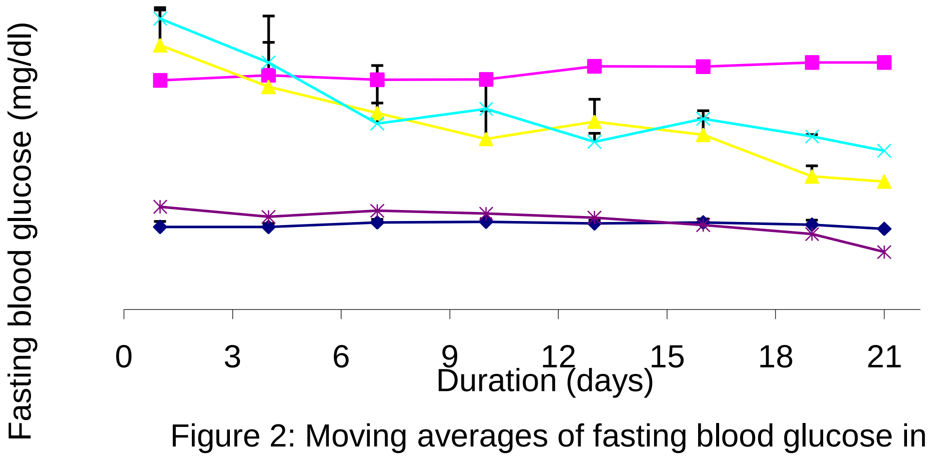

Figure 2: Moving averages of fasting blood glucose in different experimental groups.
Values are expressed as mean + SEM, n = 6.

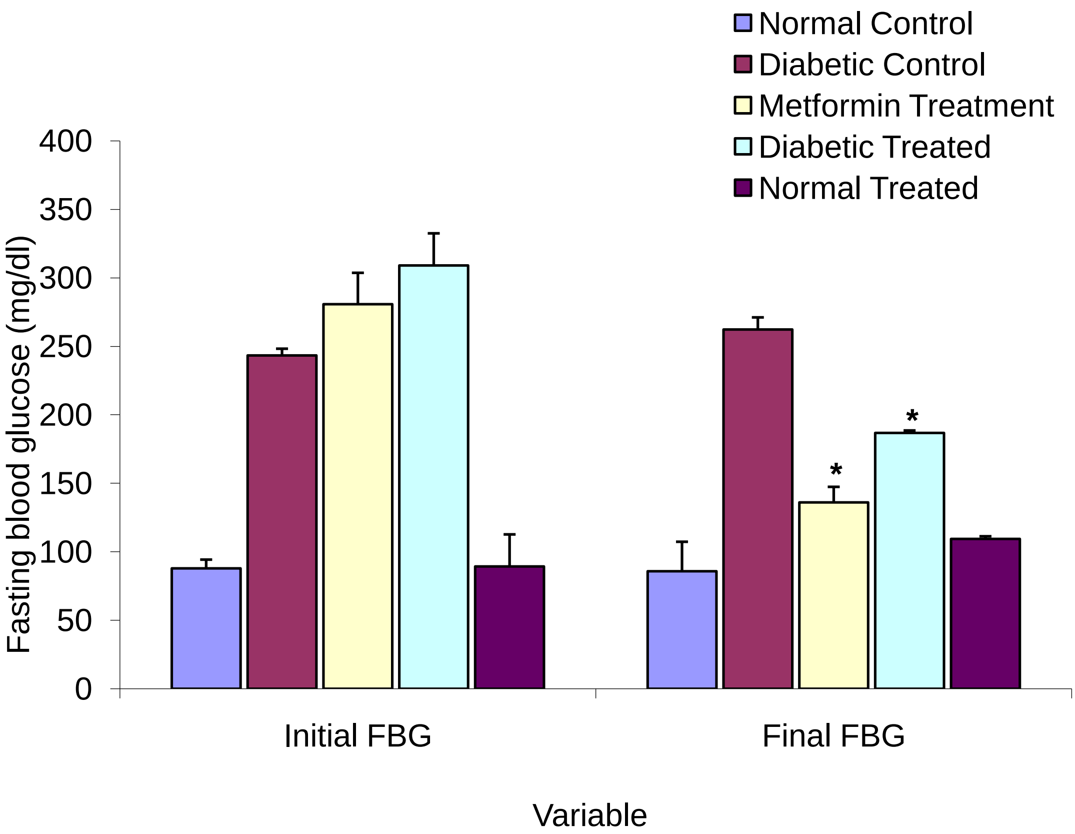

Figure 3: Comparison of initial and final fasting blood glucose concentrations in the different experimental groups.
Values are expressed as mean + SEM, n = 5.
*significantly different from it's Initial value at $p<0.05$.

Discussion

The GC-MS analysis shows the presence of eighteen compounds in the oil extract of *Irvingia gabonensis* seeds by comparing their retention times and their mass spectra interpretation. The peak value, retention indices, molecular formula, molecular weight and percentage composition of compounds identified are presented in Table 4. The structure of the various fatty acids and volatile phytochemicals (Fig 5-22) which contribute to the medicinal and biological activities of the seed oil extract of *Irvingia gabonensis* are listed in Table 4. *Irvingia gabonensis* seed oil comprised of fatty acids (79.46 %), esters (11.04 %), ketones (1.54 %), aromatic (0.75 %) and hydrocarbons (7.20 %).

The seed oil primarily consists of two saturated fatty acids: Dodecanoic acid (lauric acid) (27.93%) and Tetradecanoic acid (myristic acid) (16.02%). These two fatty acids, associated with 9-Octadecanoic acid (13.75%), Hexadecanoic acid (12.34%), Octadecanoic acid (7.60%); 11-Octadecanoic acid, Docosanoic acid (1.02%) and Decanoic acid (0.81) oleic acid (13.75%), palmitic (12.34%), stearic acid (7.60%), behenic acid (1.02%) and capric acid (0.81%) account for 79.47% fatty acids. 9-Octadecanoic acid (Oleic acid) was the only unsaturated fatty acid identified.

Conclusion

GC-MS analysis of *I. gabonensis* seed oil showed the presence of eighteen compounds comprising of fatty acids, esters, ketones, aromatic and hydrocarbons with fatty acids being the most abundant constituent and Lauric acid (dodecanoic acid) having the highest percentage composition.

This present study shows that *Irvingia gabonensis* oil had a beneficial effect on Diabetes mellitus associated dyslipidemia and glucose intolerance, thereby exhibiting a trend toward anti- atherosclerotic profile. This could be as a result of the chain lengths of the fatty acids present in the oil and how they were metabolized.

Irvingia gabonensis oil extract had favorable effects on lipoprotein levels in diabetic rats, by improving HDL-cholesterol levels with a resultant reduction in cholesterol and triglyceride levels via a reduced circulating very-low-density lipoprotein (VLDL).

The resultant effects of *Irvingia gabonensis* oil on the evaluated parameters in diabetic and non-diabetes indicated a reduction in total cholesterol, LDL and VLDL-cholesterol levels with a concurrent increase in HDL cholesterol and improved body weights. The oil extract also exhibited efficacious anti-hyperglycemic activity in diabetic rats.

On the basis of the current investigation it was noted that both metformin and *Irvingia gabonensis* possessed a blood glucose lowering activity and anti-hyperlipidemic effect suggested that these results provide nutraceutical evidence for its use in management of diabetes and dyslipidemia.

Recommendations

The following recommendations were drawn in line with the present study

1. Government and medical practitioners should encourage the extraction of Kuwing oil from *Irvingia gabonensis* seed using the continuous Soxhlet extraction technique.
2. Mores studies shoukd be carried to verify the potency of fatty acid composition of the extracted oil using gas chromatography.

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