EVALUATION OF PHYSICO-CHEMICAL AND ANTIMICROBIAL STUDIES OF *Delonix regia* AND *Piliostigma thonningii* SEED OILS

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Abstract

Delonix regia and *Piliostigma thonningii* seed oils were extracted with n-hexane using soxhlet extractor for six hours. The oils were concentrated over rotary evaporator to obtain golden yellow and greenish yellow coloured oils respectively. The oils were analysed for the following parameters: saponification value (142.08±1.00 and 129.45±0.47 mgKOH/g), iodine value (36.04±0.67 and 43.65±0.42 mg/iodine/100g), acid value (0.27±0.01 and 0.37±0.01 mg/KOH/g), specific gravity (0.79 and 0.81g/cm^3), peroxide value (14±1.58 and 12±1.00 mg/KOH/g), and free fatty acid value (53.3±1.00 and 72.9±0.45 mgKOH/g) respectively. Preliminary antimicrobial screening of the oils against three different bacterial strains: *Escherichia coli, Pseudomonas aeruginosa and Klebsiela oxytoca* revealed that PTO exhibited high antimicrobial activity against *E.Coli* while DRO showed no significant effects; DRO showed significantly high antimicrobial activities against *P.aeruginosa* than PTO and the antimicrobial activities of PTO against *K.oxytoca* is very high compared to DRO. The DPPH antioxidant assay of the oils revealed that DRO exhibited higher antioxidant (IC_{50} = 0.013 µg/mL) activity than PTO, (IC_{50} = 0.646 µg/mL), but the IC_{50} of DRO is lower than those observed for the positive control.

The result of GC-MS analysis showed the presence of 22 different compounds in DRO and 29 in PTO. The most abundant compound in DRO was 9,12-Octadecadienoic acid, methyl ester, (13.23 %). On the other hand, 9-octadecenoic acid (Oleic acid) was dominated in PTO by (15.4%). From this research finding, the seed oils of *D.regia and P.thonningii* may be of medicinally and industrially important and could also be used as a substitute for other oils or blended with other vegetable oils.

Keywords: *Seed oils*; *Delonix regia; Piliostigma thonningi; Antioxidant and Antimicrobial.*

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Introduction

Seed oils are good sources of oils of nutritional, industrial raw materials and nutraceuticals importance. Apart from being used as food, seed oils have also been used traditionally as medicine by several communities [1]. Thus, the utilisation of oil in various applications is largely determined by the yield, composition, physical and chemical properties of the oil [2]. A number of Plant seed oils have been characterized for the identification of several fatty acids of nutritional and nutraceutical importance but the vast majority have not been adequately evaluated.

Delonix regia or Poinaana regia (Boj. Ex. Hook) belongs to the family Fabaceae. It is a medium sized plant found in the tropical countries [3]. It is an ornamental tree and is widely planted in avenues, gardens, and along roadsides in residential and school compounds for shade and shelter [4]. Different parts of this plant are used in traditional medicine [5]. Its bark and flowers extracts have been reported to have broad spectrum antibacterial, antifungal and anti-inflammatory properties [6-8].

Phytochemicals such as anthocyanin, carotenoids, flavonol, and phenolic acids have been reported from the flower extracts of *D.regia* [9-10] and the presence of fatty acids such as maristic, palmitic, stearic, oleic and linoleic acids have been found in its seeds oil [11-12].

Piliostigma.thonningii is a leguminous plant belonging to the family *Caesalpiniacea*. It is commonly known as Camel's foot, Monkey bread, Rhodesian bauhinia and locally called "abefe"; "Kaloo" and "Okpoatu" in Yoruba, Hausa and Igbo respectively in Nigeria [13].

Various parts of *P.thoninngii* have been used traditionally for the treatment and management of various diseases in humans and animals [14]. The bark is used in the management of cough, stomach infections, malaria, leprosy, sore throat and various forms of inflammation. The roots and twigs are used in treating fever, dysentery, snake bites, hookworms and skin infections, while the leaves decoctions possess antibacterial, antimicrobial and antioxidant activities and used as laxatives for children and for dressing wounds[15].

Phytochemical screening of the genus *Piliostigma* revealed the presence of flavonoids [16], polyphenols [17] and essential oils [18-19].

The applications of seed oils are generally determined by their physicochemical properties and chemical compositions. Thus the uses of seed oils containing antimicrobial and antioxidants agents can increase the self-life of industrial foods products and fight against various microbial infections in addition to preventing oxidative stress related diseases.

Information on the physicochemicl properties including antioxidants, fatty acids profile and antimicrobial study of oils of *D. regia* and *P. thoninngii* is very scarce or not available from the literature. There is therefore a need to research into this in order to achieve the optimum utilization of these seed oils. In response to these needs, the

seed oils obtained from these plants were investigated for their physicochemical properties, antioxidant and antimicrobial activities.

Materials and Methods

Material and Chemicals

1,1-diphenyl-2-picrylhydraxyl (DPPH) and ascorbic acid (Vitamin C) were obtained from Sigma-Aldrich (Germany). Sodium hydroxide, n-hexane, ethyl acetate, hydrochloric acid, sulphuric acid, Wiji's solution, phenolphthalein, Potassium hydroxide, and ethanol, were obtained from the chemical store of the Department of Chemistry, Kwara State University, Malete, Nigeria. Solvents were redistilled before use while reagents were used without further purification. All other chemicals and reagent used were of analytical grade.

Microorganisms

Three gram negative bacteria namely; *Escherichia coli* (ATCC 25922)*, Klebsiella oxytoca* (ATCC 700324) and *Pseudomonas aeruginosa* (ATCC 27853) used in this study were collected from the Department of Microbiology, Kwara State University, Malete, Nigeria. Nutrient agar was used as the growth media for the bacteria.

Instrument: Gas chromatography–mass spectrometry (GC-MS).

GC-MS analysis of the oils was carried out in a Shimadzu GC-MS-QP-2010 plus chromatography with capillary column (methyl phenyl siloxane, 60 mm x 0.25 mm). The instrument operating conditions were: Carrier gas was helium with flow rate 1.6 mL/min. Column oven temperatures at 4 min and 8 min were 60 ^{0}C and 160-280 ^{0}C respectively. Injection temperature was 250 ^{0}C; volume was 8µL in split ratio1:0. The MS temperature source was 200 ^{0}C with interface temperature of 250 ^{0}C and solvent cut time of 2.5 min. The ionization mode was electron ionization and the mass range of m/z 40 to 400 while scan speed was 769 amu/s, start time and end time were 3.0 min and 27 min. respectively.

Identification of chemical constituents was based on the molecular formulae, molecular mass, retention index and percentage concentration (peak area). Interpretation of spectrum was conducted using the database of National Institute Standard and Technology (NIST 05). The name, molecular weight and structure of the components of the oils were ascertained. The spectrum of the unknown component was compared with the spectrum of the component stored in the NIST library.

Methods

Collection and identification of plant sample

The seeds of *D. regia* and *P. thonningii* were collected from Kwara State University, Malete environ. The plants were identified and authenticated at the Department of Plant and Environmental Biology, Kwara State University, Malete.

Preparation of extracts

The seeds of the samples were collected from the pod of the plants and sun dried for 3days. The seeds were pulverized using metallic mortar and pestle and sieved (1 mm and 125 µm mesh sizes) to afford a fine powder. The powdered samples were weighed and stored in a polyethylene bag until needed.

Extraction procedure

The pulverized samples of *D. regia,* (34.8 g) and *P. thonningii,* (21.02 g) were extracted respectively using n-hexane in a soxhlet extractor for six hours. The extracts were concentrated over rotary evaporator (IKA RV 10 digital) to obtain golden yellow and greenish yellow coloured oils which were coded DRO and PTO, respectively. The oils were weighed and kept in a desiccator until further analysis. The percentage yield and specific gravity were determined using the method of American Oil Chemist's Society (AOCS).[20]

Physicochemical analysis

Physico-chemical characteristics of DRO and PTO were determined using standard American Oil Chemist's Society (AOCS) method [20]. The parameter analysed were saponification value, iodine value (VI), free fatty acid value, acid value and peroxide value. The results obtained are shown in table 1.

Evaluation of antioxidant activities of DRO and PTO

DPPH Antioxidant Assay

The determination of the free radical scavenging activity of the two oils was carried using the DPPH (1, 1-diphenyl-2-picrylhydrazyl) assay as described by Cervato *et al.,* [21]. Briefly, appropriate dilution of the oil extracts (1 ml) was mixed with 3 ml of 60µM methanolic solution of DPPH radicals; the mixture was left in the dark for 30 min before the absorbance was measured at 517 nm. The decrease in absorbance of $DPPH^{\cdot}$ on addition of test samples relative to the control (ascorbic acid) was used to calculate the percentage inhibition (% Inhibition) according to the following equation:

$$\%\text{Inhibition} = [(A517_{control} - A517_{sample}) \div A517_{control}] \times 100.$$

The IC_{50}, which stands for the concentration of fraction required for 50% scavenging activity, was calculated from the dose-inhibition linear regression equation of each oil extract.

Evaluation of antimicrobial activities of DRO and PTO

Preparation of Mueller Hinto Agar (MHA)

MHA was prepared according to the manufacturer's instruction 38 g of MHA was dissolved in 1L of sterile distilled water. It was allowed to homogenize before sterilizing inside the autoclave at 121°C for 15 minutes. The sterilized MHA was ascetically poured into sterile disposable Petri dishes and allowed to set.

Preparation of Bacteria Innoculum

Innoculum of *P. aeruginosa*, *K. oxytoca* and *E. coli* was prepared according to Kirby- Bauer method. Little quantity of the bacteria culture was suspended in 9 ml sterile normal saline and serially diluted until the colour of the serially diluted bacteria and normal saline resembles the colour of 0.5 McFarland standards. The suspension was swabbed on the surface of the prepared MHA plates.

Antimicrobial Susceptibility Test

All the inoculated plates were bore at the center with 6 mm cork borer and each extract was introduced to the hole with the aid of capillary tubes. The plates were allowed to stand uprightly for about 20 minutes before they were transferred to the thermostatically stable incubator. All the plates were incubated at $35\pm2^{o}C$ (Normal body temperature).

Results and Discussion

Results of physicochemical parameters of DRO and PTO

D. regia, (DRO) and *P. thonningii,* (PTO) seed oils were characterized along with the physicochemical parameters listed in Table1 below.

Table 1: Results of the physicochemical analysis of oil extracts from *D. regia*, (DRO) and *P. thonningii,* (PTO).

Physicochemical parameters	(DRO) values	(PTO) values
Weight of extracts (g)	7.44	7.55
Percentage yield (%)	21.38	35.92
Specific gravity (g/cm^3)	0.79±0.01	0.81±0.02
Saponification (mgKOH/g)	142.08 ±1.00	129.4±0.42
Iodine value (mg/iodine/100g)	36.06 ±0.67	43.65 ±0.42
Peroxide value (mg/KOH/g)	14.0±1.58	12.0±1.00
Free fatty acid(mgKOH/g)	53.3 ±1.00	72.9±0.45
Acid value (mg/KOH/g)	0.27±0.01	0.37±0.01

Values are mean of three replicates. ±indicates the standard deviation from the mean

Antioxidant activities of DRO and PTO by DPPH assay

Table 2 below shows the results of DPPH antioxidant screening of DRO and PTO.

Table 2: Result of DPPH antioxidant screening of DRO and PTO.

Sample	IC_{50} (µg/mL)
DRO	0.255
PTO	0.646
Vitamin C	0.030

Result of antimicrobial activities of DRO and PTO

Table 3 below reveals the results of antimicrobial test of DRO and PTO against three different gram-negative bacterial strains.

Table 3: Results of antimicrobial test of DRO and PTO.

Extract	*E. coli*	*P. aeruginosa*	*K. oxytoca*
DRO	0.00 mm	13.0 mm	0.00 mm
PTO	9.0mm	0.00 mm	10.5 mm

Results of GC-MS Analysis of DRO and PTO

Result of GC-MS analysis of DRO

The result of GC-MS analysis of DRO as identified by GC-MS (figure 1a-b) revealed 22 different compounds. These compounds, with their molecular weights, molecular formulae, retention indices, and percentage concentrations as determined from their % peak areas are as shown in table 4 below. The most abundant compound detected was 9,12-Octadecadienoic acid, methyl ester (13.23 %).

Table 4: % Composition of the constituents of DRO determined by GC-MS.

S/N	Compounds	R.I	Molecular formula	Molecular weight	% Area	Mass peak
1	3-ethyl-2-methylhexane	778	C_9H_{20}	128	13.21	27,41,43,57,84
2	2-phenylpropane	928	C_9H_{12}	120	11.80	27,77,105,120
3	1,3,5-trimethylbenzene	1020	C_9H_{12}	120	3.38	27,77,91,105,120
4	1-ethyl-4-methylbenzene	1006	C_9H_{12}	120	6.79	27,77,91,105,120
5	bicyclo[2.2.1]hept-2-ene, 5-propyl	984	$C_{10}H_{16}$	136	4.90	27,39,66,77,91
6	Decane	1015	$C_{10}H_{22}$	142	6.14	27,41,43,57,71,85
7	2-ethyl-1,3-dimethylbenzene	1119	$C_{10}H_{14}$	134	3.31	91,119,134
8	2,4-dimethylstyrene	1110	$C_{10}H_{12}$	132	4.23	27,39,51,63,77,91 ,117,132
9	2-ethyl-*p*-xylene	1119	$C_{10}H_{14}$	134	7.63	27,91,105,119,134
10	Azulene	1069	$C_{10}H_8$	128	3.24	27,51,64,102,128
11	benzocycloheptatriene	1251	$C_{11}H_{10}$	142	1.67	27,63,89,115,141
12	2,4-decadienal	1220	$C_{10}H_{16}O$	152	0.63	27,41,55,67,81
13	bicyclo[4.4.1]undeca-1,3,5,7,9-pentaene	1189	$C_{11}H_{10}$	142	1.23	27,39,51,63,74,89 ,115,141
14	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester	1639	$C_{12}H_{14}O_4$	222	0.68	27,39,50,65,76,93, 105,149
15	1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester	1908	$C_{16}H_{22}O_4$	278	1.76	27,41,57,149
16	bonadecanoic acid	2266	$C_{19}H_{38}O_2$	298	3.35	27,41,43,57,73,85, 129
17	9,12-octadecadienoic acid, methyl ester	2183	$C_{18}H_{32}O_2$	280	13.23	27,39,41,55,67,81, 95,109
18	erucic acid	2572	$C_{22}H_{42}O_2$	338	5.26	27,41,55,69,83,97
19	9,12-octadecadien-1-ol	2069	$C_{18}H_{34}O$	266	1.82	27,41,55,67,81,95, 110,121
20	hexadecanoic acid	1968	$C_{16}H_{32}O_2$	256	3.82	27,41,43,60,73
21	1,E-11,Z-13-octadecatriene	1871	$C_{18}H_{32}$	248	1.11	27,29,41,55,67,81, 95,110
22	13-tetradece-11-yn-1-ol	1663	$C_{14}H_{24}O$	208	0.8	27,41,55,67,81,95, 107

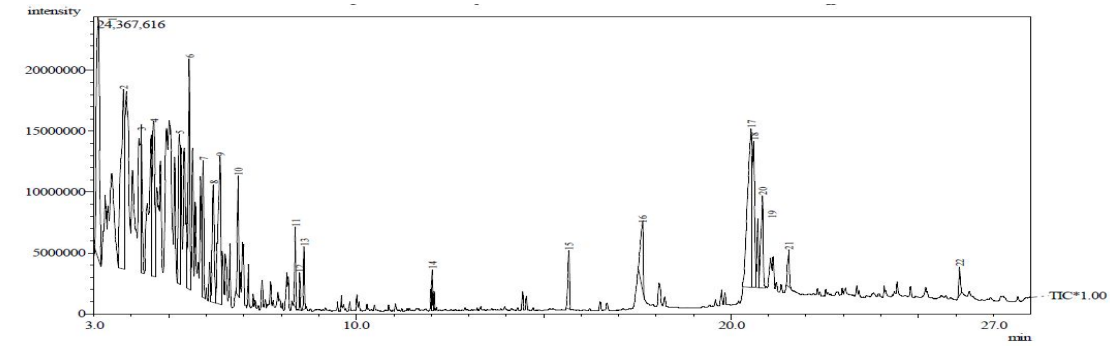


Figure 1a: GC-MS spectrum of DRO

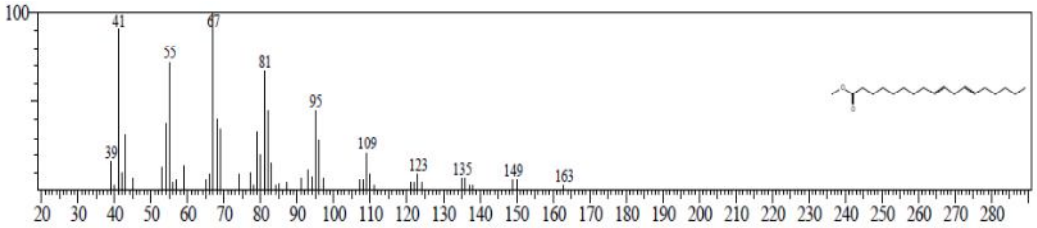


Figure 1b: GC-MS Spectrum of 9,12-Octadecadienoic acid, methyl ester

The result of GC-MS analysis of PTO

The GC-MS result of PTO revealed many compounds. These compounds, with their molecular weight, molecular formulae, retention index, and their % composition

determined from their peak areas are depicted in table 5. A total number of 29 compounds was identified including: oleic acid (15.40%); erucic acid (9.17 %); 4-oxatricyclo [4.3.1](3,8)undecan-5-one(6.86%); octadecanoic acid (6.84%); dodecane (4.46 %). The prevailing compound was oleic acid (15.60%). The GC-MS spectrum is shown in (figure. 2a-b).

Table 5: Result of GC-MS analysis of PTO.

S/N	Compound	Ret. Index	Molecular Formular	Molecular Weight	% Area	Mass Peak
1	Decane	1121	$C_{13}H_{28}$	184	3.92	41,47,57,71
2	bicyclo[3.1.1]heptan-3-one, 2,6,6-trimethyl (Isocamphopinone)	1109	$C_{10}H_{16}O$	152	3.15	41,55,69,83,95
3	4,7-methano-1H-inden -1-Ol	1069	$C_{10}H_{16}O$	152	3.14	41,45,66,79,91
4	4-oxatricyclo[4.3.1.1 (3,8)]undecan-5-one	1349	$C_{10}H_{14}O_2$	166	6.86	41,53,67,80,93,122
5	4-methylpropiophenone	1242	$C_{10}H_{12}O$	148	3.10	91,105,119,133,148
6	Dodecane	1214	$C_{12}H_{26}$	170	4.46	41,43,57,71,185
7	1,3-dimethyl -4-isopropylbenzene	1155	$C_{11}H_{16}$	148	3.68	27,39,51,65,77,91 ,105,117,133,148
8	1,3-dimethyl-(2,3-dihydroindene)	1169	$C_{11}H_{14}$	146	3.78	51,77,91,115,131, 146
9	1,1-dimethyl-(2,3-dihydroindene)	1181	$C_{11}H_{14}$	146	5.08	51,91,115,131,146
10	2-methoxy-4-methyl -4-phenyl-2-cyclohexen-1-one	1747	$C_{14}H_{16}O_2$	216	4.21	41,51,65,77,91,115, 129
11	1-methyl naphthalene	1345	$C_{11}H_{10}$	142	3.54	63,71,115,139,142
12	Tridecane	1313	$C_{13}H_{28}$	184	1.16	27,41,43,57,71,85
13	2,3-dimethyl naphthalene	1458	$C_{12}H_{12}$	156	1.08	115,128,141,156
14	1,8-dimethyl naphthalene	1458	$C_{12}H_{12}$	156	1.46	76,115,128,141,156
15	hexadecane	1612	$C_{16}H_{34}$	226	3.13	27,41,43,57,71,85
16	1-hexadecene	1602	$C_{16}H_{32}$	224	1.96	27,41,57,83,97,111
17	hexadecane	1612	$C_{16}H_{34}$	226	1.39	27,41,43,57,71,85
18	octadecanoic acid	2167	$C_{18}H_{36}O_2$	284	6.84	27,41,43,60,73,85, 129,284
19	1-pentadecene	1502	$C_{15}H_3O$	210	2.18	27,41,57,83,97,98,112
20	heptadecane	1711	$C_{17}H_{36}$	246	1.05	41,43,57,71,85,99
21	1-hexadecene	1602	$C_{16}H_{32}$	224	0.70	27,41,55,57,83,97,98, 125,151
22	oleic Acid	2175	$C_{18}H_{34}O_2$	282	15.40	27,41,55,57,69,83,97, 98,125
23	erucic acid	2572	$C_{22}H_{42}O_2$	338	9.17	27,41,55,69,83,97
24	heptadecanoic acid	2067	$C_{17}H_{34}O_2$	270	3.39	41,43,60,73,85,129
25	trifluoroacetic acid, n-octadecyl ester	2011	$C_{20}H_{37}F_3O_2$	366	1.89	39,41,43,57,83,97,111
26	nonadecane	1945	$C_{20}H_{42}$	282	0.95	27,41,43,57,71,85,99
27	9,12-octadecadien-1-ol	2069	$C_{18}H_{34}O$	266	1.13	41,55,67,81,95,110
28	1-hexacosanol	2848	$C_{26}H_{54}O$	382	0.92	18,41,43,57,83,97,111
29	1-eicosanol	2252	$C_{2O}H_{42}0$	298	1.26	27,41,43,57,83,97,111 , 125,

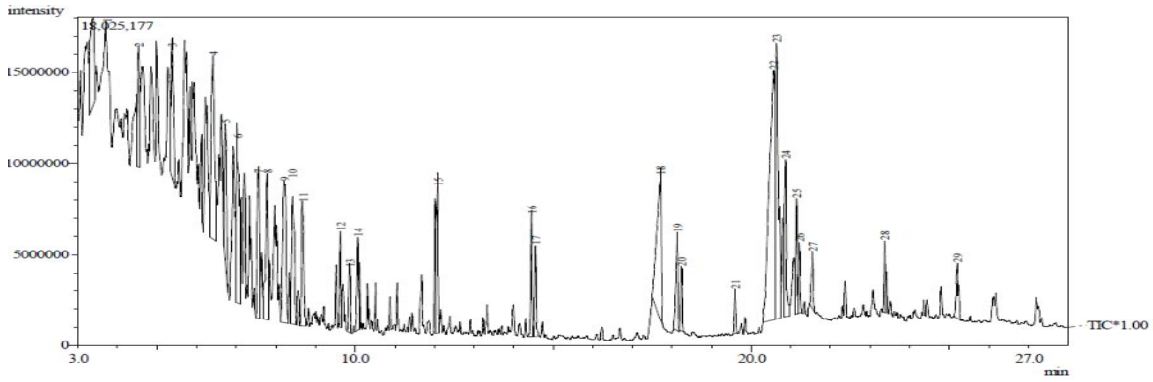


Figure. 2a: GC-MS spectrum of PTO

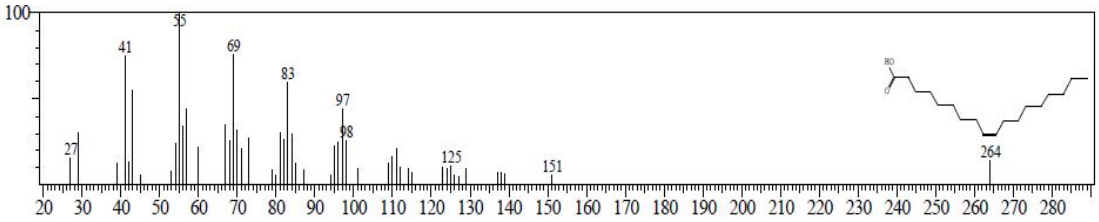


Figure.2b: GC-MS spectrum of 9-octadecenoic acid (oleic acid)

Discussion

Table 1 shows the results of the physicochemical properties of the oils extracted from *D. regia* and *P. thonningii* seeds (DRO and PTO), respectively. The specific gravity of DRO was found to be 0.79 g/cm^3 and quite lower than that of PTO which was 0.81 g/cm^3 indicating that the oils from both seeds are less dense than water and also, the values seem to indicate that no heavy element is present in both oils [22].

Peroxide values of 14±1.58 and 12±1.00 were obtained for DRO and PTO respectively in this study. Peroxide value is an indication of deterioration of oils. Oils with higher peroxide values are more unsaturated than those with lower peroxide values. More unsaturated oils are known to absorb more oxygen and develop higher peroxide values, and oils with higher peroxide values are prone to rancidity [22]. The WHO/FAO stipulated a permitted maximum peroxide level of oil not more than 10 M equivalent of peroxide oxygen/Kg of the oils [23].

Saponification values of the oils helps to determine the gravity of potassium hydroxide (in mg) needed to neutralize the acids and saponify the esters contained in 1 g of the lipid [24]. The saponification values obtained for DRO and PTO in this study were (142.08±1.00 mgKOH/g) and (129.45±0.42 mgKOH/g) respectively. It is therefore observed that the saponification value of DRO is higher than PTO. Although, the obtained values for DRO and PTO are lower than those of the common oils such as neem seed oil (213mgKOH/g) [25] and coconut oil (253mgKOH/g) [26]. However, the values obtained were higher than those obtained for pawpaw seed oil (24.13mgKOH/g), sweet orange seed oils (106.30mgKOH/g) [27] and beeswax (93 mgKOH/g), all of which are commonly used in soap making [28]. This indicates that

DRO and PTO could be also used in soap making since their saponification values fall within the range of these oils. The iodine values obtained for DRO and PTO were 36.04±0.67 and 43.65±0.42 mg/iodine/100g respectively. There is significant difference in their iodine values. The iodine value obtained for PTO is less than DRO, which shows that the oil could be classified as a non-drying oil. Non-drying oils have iodine values less than 100 and are useful in the production of soaps [23]. Acid values of 0.27±0.01 and 0.37±0.01 mg/KOH/g were obtained for DRO and PTO, respectively. There is no significant difference in the acid values obtained. The acid value obtained is lower compare to that of olive oil 17mgKOH/g [29] and that of shea oil 14.77± 0.065 reported by Wara *et al.* [30].

The free fatty acid values obtained for DRO and PTO are 53.3±1.00 and 72.9±0.45 mgKOH/g respectively. The free fatty acid concentrations of the oils were low which was consistent with the low acid value observed.

The result of the antioxidant analysis as shown in table 2, revealed that DRO exhibited high antioxidant (IC_{50} (µg/mL) = 0.255) activity than PTO, (IC_{50} (µg/mL) = 0.646) but lower compared to the reference standard ascorbic acid (IC_{50} (µg/mL) = 0.003).

The preliminary antimicrobial screening of DRO and PTO against three different gram-negative bacterial strains namely: *E. coli, P. aeruginosa and K. oxytoca* (Table 3), revealed that DRO showed significant activity against *P. aeruginosa* with no effects against *E. coli and K. oxytoca* while PTO exhibited significant antimicrobial activity against *E. coli and K. oxytoca* but zero activity against *P. aeruginosa.*

The result of GC-MS analysis of DRO exhibited 22 different compounds as (table 4). The most abundant compound was 9,12-octadecadienoic acid, methyl ester (13.23 %). The identified fatty acids include: nonadecanoic acid, (3.35%), erucic acid (5.26%) and hexadecanoic acid (3.82%) accounting in total for 12.43 % of the total oil content. Result of GC-MS analysis of PTO revealed 29 different compounds. The most abundant compound was found to be 9-octadecenoic acid (commonly known as oleic acid) which amounted to 15.40% of the total composition. This compound is an example of monounsaturated fatty acid. Compounds such as erucic acid (9.17%), heptadecanoic acid (3.39%) and octadecanoic acid (6.84%) were also present. These compounds accounted for 34.80% of the total composition. It is therefore, inferred that, PTO contained greater amounts of fatty acids as DTO (Tables 4 and 5).

Conclusion

In this study, oils from *D. regia* and *P. thonningii* seeds were extracted, and characterized using GC-MS. The physicochemical analysis of these oils (DRO and PTO), antimicrobial and antioxidant were also studied. The results obtained from physicochemical analysis presented saponification value, acid value, free fatty acid and Iodine values that fell within the range of those acceptable as having good potential for production of soap, paints, perfumes and varnishes. The results of antimicrobial and antioxidant indicated that the oil from *D. regia* and *P.thonningii* seeds can be used in food and pharmaceutical industries to inhibit the growth of certain bacterial and food deterioration. The results of GC-MS analyses revealed many bioactive compounds. The major compound in PTO was a monounsaturated fatty acid while that of DRO was ester. The fatty acids compositions of PTO is quite higher than that of DRO and this is directly coincide with the fatty acid values as evaluated in physicochemical analysis.

From this research finding, the seed oils of *D. regia and P. thonningii* may be of medicinally and industrially important. The oil could be used as a substitute for other oils or blended with other vegetable oils and hence the uses of these oils in industries should be encouraged.

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