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Purification and Analysis of bioactive compounds from *Citrus aurantifiolia* Linn stem bark by Gas- Chromatography-Mass spectrometry

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Abstract The objectives of this research are to extract the air-dried stem bark (500g) of *citrus aurantifolia* with methanol using cold infusion (maceration) technique, partition the extract with solvents of graded polarities (*n-hexane*, ethyl acetate, n-butanol suspended in water) and phytochemically screened and fractionate and purify the n-butanol partitioned portion using a combination of column and thin layer chromatography and finally subject the possible pure fraction(s) to gas chromatography and mass spectrometry (GC-MS) analysis. The methanol crude extract yield 14.90% $^{w}/_{w}$ dark green in colour, gummy in texture. The *n-hexane* partitioned portion yield 0.44% $^{w}/_{w}$ light green in colour oily paste texture, ethylacetate partitioned portion yield 5.32% $^{w}/_{w}$ dark brown in colour, gummy in texture, while n-butanol yield 21.04%$^{w}/_{w}$, brown in colour, gummy in texture and finally aqueous partitioned portion yield 52.08% $^{w}/_{w}$ brown in colour power in texture respectively. The presence of metabolites such as carbohydrates, cardiac-glycosides, terpeniods, flavonoids, tannins and phlobatannins were recorded in the methanol crude extract while, anthraquinones, alkaloids and saponins were not detected in methanol crude stem bark extract. Whereas cardiac-glycosides, terpeniods and flavonoids were present in *n-hexane* portion and n-butanol portion but carbohydrates, anthraquinones, tannins, saponins, phlobatannins and alkaloids were not found in both of the portions. The purification of compounds was done by using a combination of column and thin layer chromatography techniques. The n-butanol partitioned portion was subjected column chromatography after, rerunning, recombination and pooling four compounds, coded C_{a1}, C_{a2}, C_{a3} and C_{a4} were obtained. The melting points were sharp and uncorrected. In gas chromatography and mass spectrometry (GC-MS) analysis of compound of sample C_{a1} fourteen compounds were identified by comparison with the library of NIST. Among the compounds, were found to be 3, 5, 9-Trioza-5-Phosphaheptacos-18-en-1-aminium, Pentacosanoic acid, Oleic acid, 7, 8-Epoxylanostan-11-ol. Analysis of Compound of sample C_{a2} shows that only one compound was identified by comparison with the library of NIST. The compound was found to be 3*H*-Cycloocta[c]pyran-3-one. Analysis of Compound of sample C_{a3} shows eight compounds were identified by comparison with the library of NIST. Among the compounds were found to be 1, 3-Dioxane, Pregn-5-en-20-one, 9-Octadecenoic acid, Heptadecanoic acid, Epoxylanostan-11-ol. Analysis of Compound of sample C_{a4} shows that eight compounds were identified by comparison with the library of NIST. Among the compounds were found to be Glycidol stearate, Andrast-4-ene-3-one, Octadecanoic acid, Dihydromorphine. The dihydromorphine which believed to be a reduced formed of morphine with a molecular formula of $C_{17}H_{21}NO_3$. It has been reported that the 7, 8-double bond of morphine also is

not required for analgesic activity as indicated by the relative analgesic potency of dihydromorphine. Also, oxidation of the 6-OH of dihydromorphine to yield hydromorphone further increases activity.

Keywords *Citrus aurantifolia*, purity, column chromatography, Mass spectrometry

Introduction

Natural substances of botanical origin have been used throughout the world for human and animal health care [1-2 especially in Africa. The lack of apparent resistance development by pathogens to the phytochemicals present in herbal preparations as well as their good absorbance and to sugar (glycon) moiety which is absorbed and distributed in the system without problem thus carrying the active phytochemicals (aglycone) to the infected distribution to the area of infection perhaps due to the fact that apart from alkaloids, they are mostly compounds associated areas, make these compounds even more attractive [3-4].Knowledge of the chemical constituent of plants is desirable because such information will be of value for the synthesis of complex chemical substances[5] . Medicinal plants contain physiologically active constituents, which over the years have been exploited in traditional medical practice for the treatment of various ailments [6]. Researchers are currently being conducted on medicinal plants/extracts to isolate and purify the active fractions for preparation of drugs from natural sources [7] due to their less toxic effects and affordability [8]. The active principles isolated from plants appeared to be one of the important alternatives, when compared to many sub-standard orthodox synthetic medicines, because of their less or no side effects and better bio-availability [9-10].

Citrus aurantifolia was used traditionally as laxative, appetizer, stomachic, digestive, anthelmintic, dyspepsia, flatulence and helmenthiasis [11]. *Citrus aurantifolia* was also used for cold fevers, sore throats, sinusitis and bronchitis, as well as helping asthma. Its oil is mainly used as antidepressant because it promoted refreshment to the tide mind. It can be helpful for rheumatism arthritis, obesity and has an astringent and toning action to clear oily skin and acne, in the treatment of herpes, cuts and insect bites [12-13]. The objectives of this research are to extract the air-dried stem bark (500g) of *Citrus aurantifolia* with methanol using cold infusion (maceration) technique, partition the extract with solvents of graded polarities (*n-hexane*, ethyl acetate, n-butanol suspended in water) and phytochemically screened and fractionate and purify the n-butanol partitioned portion using a combination of column and thin layer chromatography and finally subject the possible pure fraction(s) to gas chromatography and mass spectrometry (GC-MS) analysis.

Experimentation

Sample Collection and Identification

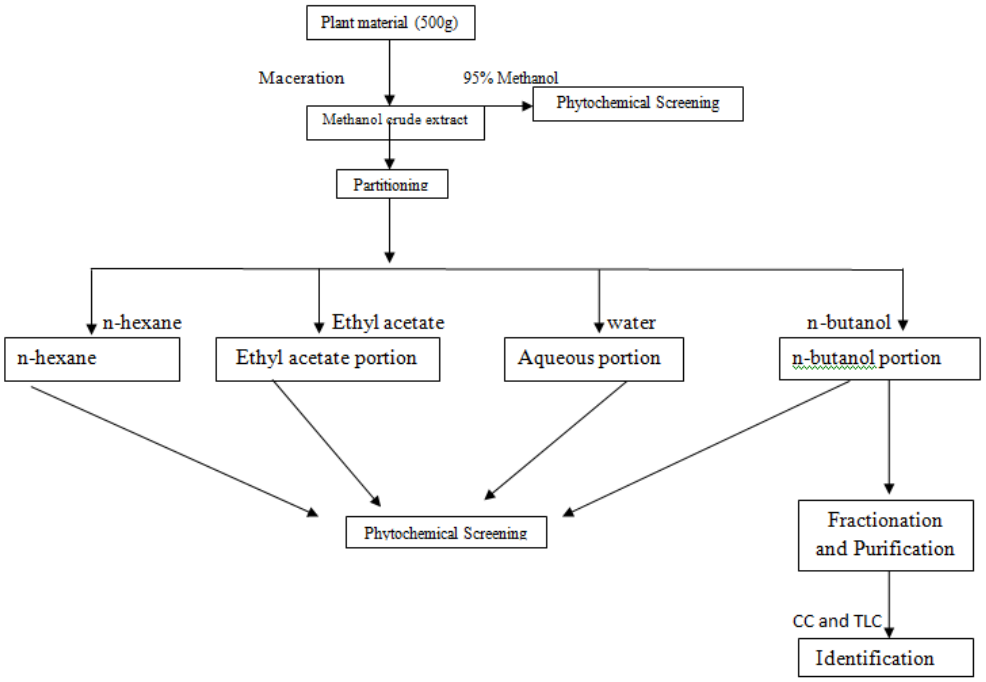
The stem bark of *Citrus aurantifolia* was collected from Damboa road near Mashidimami water ventures area at Maiduguri, Borno State, Nigeria and identified by a plant Taxonomist at the Department of Biological Sciences, University of Maiduguri. It was air-dried under laboratory condition and pulverized into fine powder with voucher number 323b and deposited in the research laboratory, Chemistry Department, University of Maiduguri.

Extraction and Preliminary Phytochemical Screening

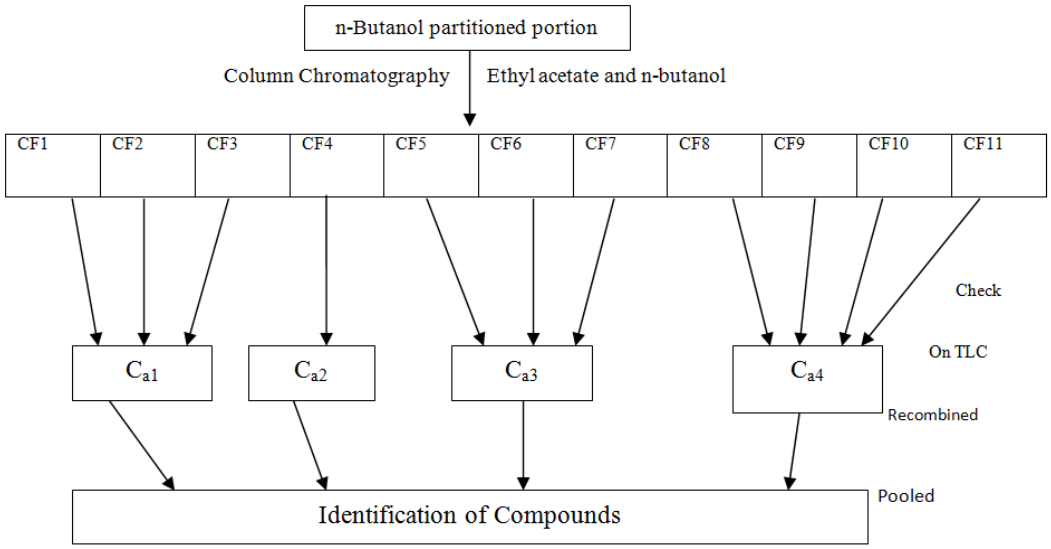
The powdered air dried material (500g) was extracted in methanol using cold infusion (maceration) technique; it was filtered and the filtrate was concentrated *in vacuo* using rotary evaporator at reduced pressure and the extract concentrate was estimated. The extract was subjected to Phytochemicals evaluation using standard procedures described by many authors [14-15].

Fractionation and Purification

Methanol extract of *Citrus aurantifolia* was partitioned using solvents of graded polarities. Dry partitioning was used, where the crude extract was partitioned sequentially with *n-hexane*, ethyl acetate and the residue later suspended in distilled water for further partitioning with n-butanol using separating funnel.



Scheme 1: Schematic Diagram (Summary) of Gradient Extraction of Stem bark of Citrus aurantifolia Maceration (cold infusion) techniques.



Scheme 2: Schematic Diagram (Summary) of Fractionation and Purification of Citrus aurantifolia

Structural identification using Gas Chromatography- Mass Spectrometry (GC-MS)

The gas chromatography system, fitted with a 30m × 250µm x 0.25µm Rtx-5MS capillary column, maximum temperature was 325^{o}C, coupled to Agilent 5977A MSD was used for futher purification and identification of compounds. The sample fractions were diluted with appropriate methanol (1/100, V/V) and filtered and 1µL were injected into injector. All data were obtained by collecting the full-scan mass spectra within the scan range. The percentage composition of the pure isolate constituents was expressed as a percentage by peak area. The identification and characterization of chemical compounds in the sample was based on GC retention time. The mass

spectra were computer matching with those of standards available in mass spectrum libraries that is National Institute of Standards and Technology.

Results and Discussion

Table 1: The weight, percentage yield, colour and texture of the methanol crude and partitioned portions of stem bark extract of *Citrus aurantifolia* Linn.

Parameters	**MCE**	**NHP**	**EAP**	**NBP**	**AQP**
Colour	Dark green	Light green	Dark brown	Brown	Brown
Texture	Gummy	Oily paste	Gummy	Gummy	powder
Weight(g)	74.50	0.11	1.33	5.26	13.02
Percentage yield(%)$^{w}/_{w}$	14.90	0.44	5.32	21.04	52.08

Key: MCE= Methanol crude extract, NHP= *n-hexane* extract, EAP= Ethyl acetate extract, NBP= n-butanol extract, AQP= Aqueous portion.

The table 1 showed the results of extraction of stem bark of *citrus aurantifolia*. The methanol crude extract yield 14.90% $^{w}/_{w}$ dark green in colour, gummy in texture. The *n-hexane* partitioned portion yield 0.44% $^{w}/_{w}$ light green in colour oily paste texture, ethylacetate partitioned portion yield 5.32% $^{w}/_{w}$ dark brown in colour, gummy in texture, while n-butanol yield 21.04%$^{w}/_{w}$, brown in colour, gummy in texture and finally aqueous partitioned portion yield 52.08% $^{w}/_{w}$ brown in colour power in texture respectively.

Table 2: Preliminary Phytochemical Screening of crude methanol and partitioned portions of stem bark extract of C*itrus aurantifolia* Linn.

S/No	**Test**	**MCE**	**NHP**	**EAP**	**NBP**	**AQP**
1	Test for Carbohydrates					
I	General test-molish test					
Ii	Test for monosaccharide-Barfoed test	+		-	-	+
Iii	Test for Free reducing sugars-Fhlings	+		-	-	+
Iv	Test for Combined reducing sugars	+	-	-	-	+
V	Test for Pentoses	+	-	-	-	-
Vi	Test for Ketoses	+	-	+	-	-
2	Test for soluble Starch	+	-	-	-	+
3i	Test for Anthraquinones	-	-	-	-	-
Ii	Test for Combined Anthraquinones	-	-	-	-	-
4	Test for Cardiac-glycosides					
I	Salkowski's Test	+	+	-	+	-
Ii	Liebermann-Burchadr's test	+	+	+	+	+
5	Test for Terpenoids	+	+	+	+	-
6	Test for Flavonoids					
I	Shinoda's test	+	+	+	+	-
ii.	Ferric Chloride test	+		+	+	+
iii.	Lead acetate test	-		-	-	-
iv.	Sodium hydroxide test	+		-	-	-
7	Test for Saponins					
i.	Fronthing test	-		-	-	-
8	Test for Phlobatannins	+		-	-	-
9	Test for tannins	-		-	-	-
i.	Ferric Chloride Test	+				
ii.	Lead acetate test	-		-	-	-

10	Test for Alkaloids					
I	Drangendroff's reagent	-	-	-	-	-
ii.	Mayer's reagent	-	-	-	-	-

Key: MCE = Methanol crude extract, NHP = *n-hexane* portion, EAP = Ethyl acetate portion, NBP = n-butanol portion, AQP = Aqueous portion, (+) = Present, (-) = Absent.

Table 2 showed results of preliminary phytochemical screening of the methanol crude stem bark extract together with its partition portions of *Citrus aurantifolia*. The presence of metabolites such as carbohydrates, cardiac-glycosides, terpeniods, flavonoids, tannins and phlobatannins were recorded in the methanol crude extract while, anthraquinones, alkaloids and saponins were not detected in methanol crude stem bark extract. Whereas cardiac-glycosides, terpeniods and flavonoids were present in *n-hexane* portion and n-butanol portion but carbohydrates, anthraquinones, tannins, saponins, phlobatannins and alkaloids were not found in both of the portions. The presence of carbohydrates, terpeniods, cardiac-glycosides and flavonoids were found in ethyl acetate portion however, anthraquinones, saponins, tannins, phlobatannins and alkaloids were not found. The aqueous portion revealed the presence of cardiac-glycosides and carbohydrates but flavonoids, anthraquinones, saponins, tannins, phlobatannins and alkaloids were absent.

Table 3: Determination of Melting point and Retention factor of compounds obtained in *Citrus aurantifolia*

S/No	Compounds	R_f Value	Melting Point (^oC)
1	C_{a1}	0.22	286.00-287.33
2	C_{a2}	0.67	290.00-291.00
3	C_{a3}	0.27	277.00-279.00
4	C_{a4}	0.25	262.00-264.00

Table 3 above showed the results of melting point and retention factor of compounds C_{a1}, C_{a2}, C_{a3} and C_{a4} obtained from stem bark extract of *Citrus aurantifolia*. Compound C_{a1} had melting point of (286.00-287.33 ^oC) with R_f value of (0.22). The melting point of compound C_{a2} was found to be (290.00-291.00 ^oC) with R_f value of (0.67). The melting point of compound C_{a3} was also found to be (277.00-279.00 ^oC) with R_f value of (0.27). The compound C_{a4} was found to had melting point of (262.00-264.00 ^oC) with value of R_f (0.25) respectively.

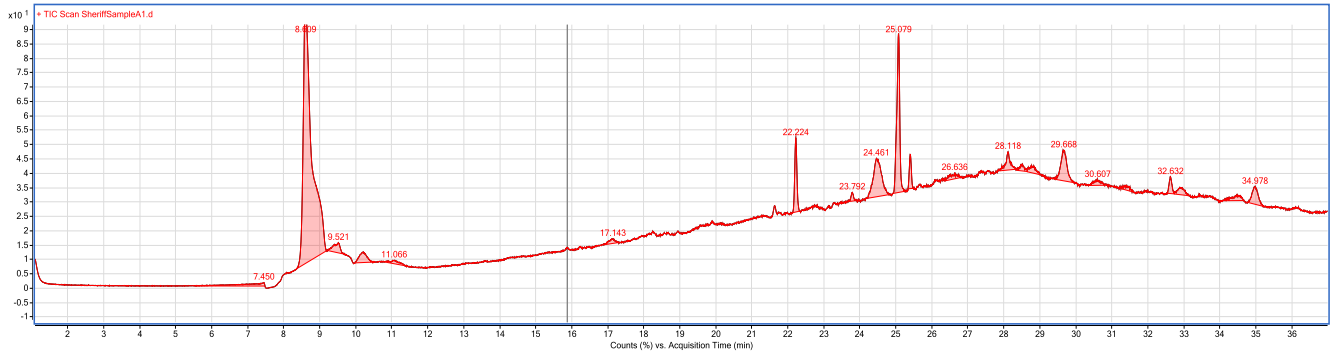


Figure 1: Chromatogram of Compound C_{a1}

Table 4: Gas chromatography and Mass spectrometry analysis of Compound C_{a1}

Peak no.	RT	Area	Height	Width	Name
1	7.45	2028596.68	50700.71	1.918	
2	8.609	61651725.23	3711485.52	0.446	
3	9.521	1831020.08	143966.32	0.446	
4	10.208	2202431.32	147431.25	0.479	
5	11.066	859725.32	48528.32	0.562	
6	17.143	805464.98	65260.29	0.396	9α-Floro-11β,17β-diol-17α-methyl-5α-

					androstan-3-one
7	22.224	4531454.89	1058072.72	0.19	Pentadecanoic acid
8	23.792	623651.83	125573.09	0.22	
9	24.461	8769302.49	548885.97	0.599	1,2,3-propanetryl ester
10	25.079	12974177.84	2268474.5	0.312	3,5,9-Trioza-5-phosphaheptacos-18-en-1-aminium,
11	25.4	1926283.96	489495.11	0.145	Pentacosanoic acid
12	26.636	12`18939.36	83858.42	0.452	
13	28.118	2332068.17	261295.48	0.446	3,19:14,15-diepoxypregnan-20-one
14	28.507	861278.79	96231.17	0.292	Dodecanoic acid
15	28.77	1256079.6	99415.8	0.355	7,8-Epoxylanostan-11-ol
16	29.668	5327476.59	437782.15	0.544	Oleic acid
17	30.607	1042524.58	77834.9	0.412	
18	31.402	740855.46	62331.82	0.309	1H-Cyclopropa[3,4]benz[1,2-e]azulene-4a,5,7b,9,9a(1aH)-pentol
19	32.632	1312368.65	236497.69	0.193	Preg-5-en-20-one
20	32.59	142196.51	104528.44	0.383	
21	34.486	1357943.29	80137.6	0.515	7,8-Epoxylanostan-11-ol
22	34.978	2960591.45	251046.88	0.416	5H-Cyclopropa(3,4)benz(1,2-e)azulen-5-one

The table 4 above showed the results gas chromatography mass spectrometry analysis of compound (C_{a1}). Fourteen compounds were identified by comparison with the library of NIST. Peak number five (5) had a retention time of 11.066 min. also peak number seven (7) had a retention time of 23.792 min. The remaining peaks had the following retention times respectively as shown in table 4. But other compounds could not be identified from the library.

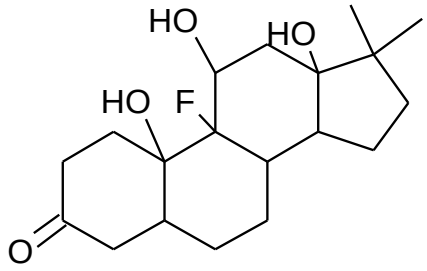


Figure 2: 9α-Flouro-11β-diol-17α-methyl-5α-andrastan-3-one

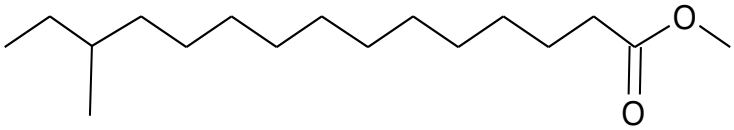


Figure 3: Pentadecanoic acid

Chromatogram of Compound C_{a2}

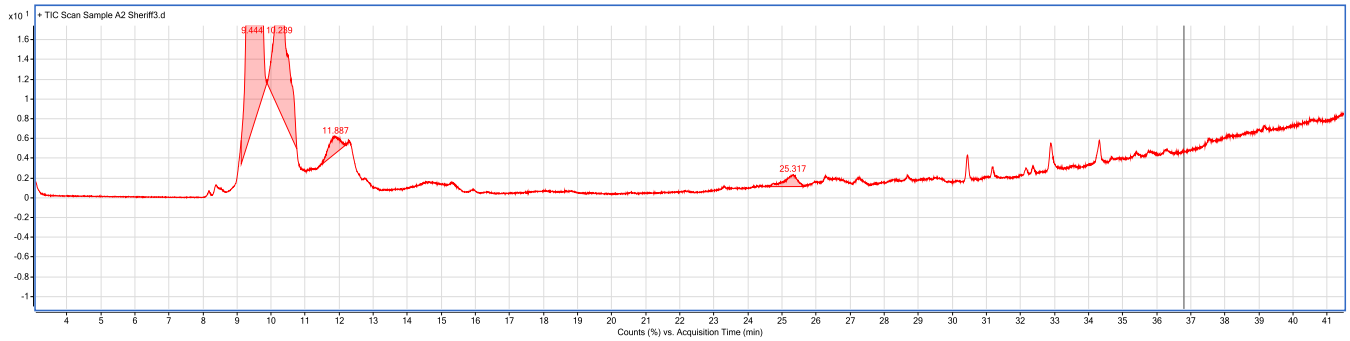


Figure 3: Chromatogram of Compound C_{a2}

Table 4: Gas chromatography and Mass spectrometry of Compound C_{a2}

Peak no.	RT	Area	Height	Width	Name
1	9.444	38317171.04	1803377.83	0.767	3H-
2	10.239	7924311.53	363764.02	0.868	Cycloocta[c]pyran-
3	11.887	789172.02	32922.65	0.687	3-one
4	25.317	619268.07	23135.7	0.973	

The above showed the results Compound C_{a2}. Only one compound with peak number (4) had a retention time of 25.317 min. It was identified by comparison with the library of National Institute of Standards and Technology (NIST). The remaining peaks had the following retention times respectively as shown in table 4. But other compounds could not be identified from the library.

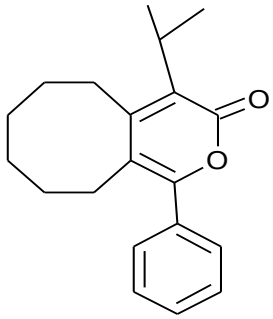


Figure 4: 3H-Cycloocta[c] Pyran-3-one

Chromatogram of Compound C_{a3}

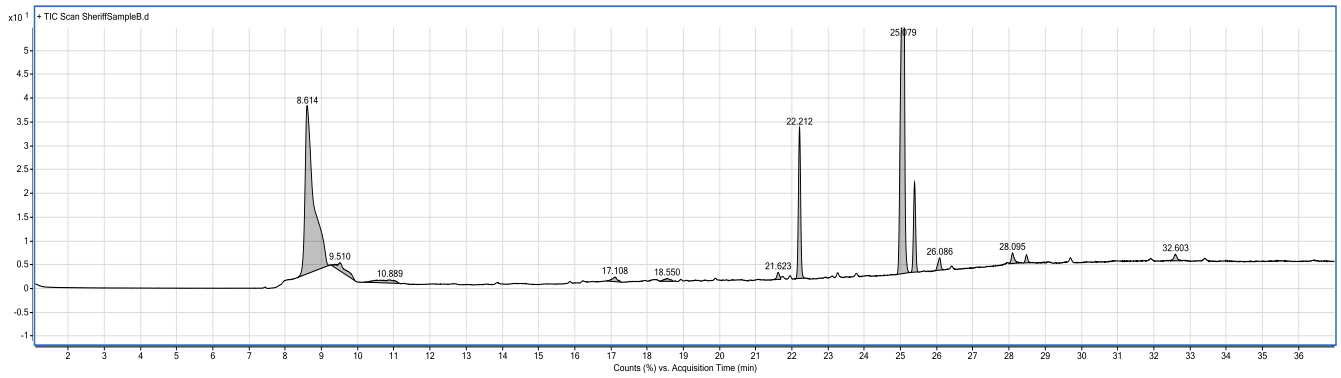


Figure 5: Chromatogram of Compound C_{a3}

Table 5: Gas chromatography and Mass spectrometry of Compound C_{a3}

Peak no.	RT	Area	Height	Width	Name
1	8.614	60641839.89	3601898.79	0.795	
2	9.51	3451029.82	1743.74.27	0.661	
3	10.889	2380074.82	68627.73	0.952	
4	17.108	1011121.64	97691.3	0.389	
5	18.55	74719.38	60689.24	0.389	1,3-Dioxane
6	81.683	788881.44	151796.9	0.189	Pregn-5-en-20-one
7	22.212	14013385.57	3249660.87	0.234	Hexadecanoic acid
8	25.079	59951252.6	9941428.8	0.365	9-Octadecenoic acid
9	25.388	7999572.23	1939082.76	0.2	Heptadecanoic acid
10	26.086	1482558.33	263582.69	0.224	7,8-Epoxylanostan-11-ol
11	28.094	1340421.12	226252.47	0.303	Docosanoic acid
12	28.484	740541.22	174734.2	0.165	Docosanoic acid
13	32.603	912328.48	140401.08	0.325	

The above showed the results Compound (C_{a3}). Eight compounds were identified by comparison with the library of National Institute of Standards and Technology (NIST). Peak number five (5) had a retention time of 13.824 min. also peak number seventeen (17) had a retention time of 27.139 min. The remaining peaks had the following retention times respectively as shown in table 4 but, other compounds could not be identified from the library.

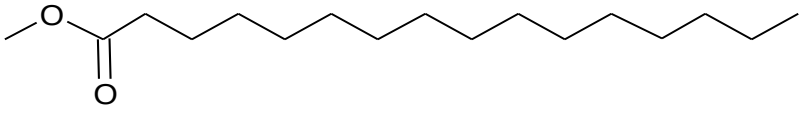


Figure 6: Hexadecanoic acid

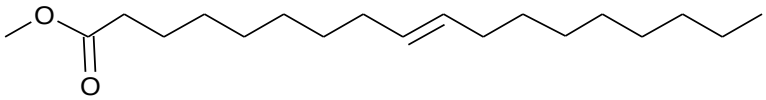


Figure 7: 9-Octadecenoic acid

Chromatogram of Compound C_{a4}

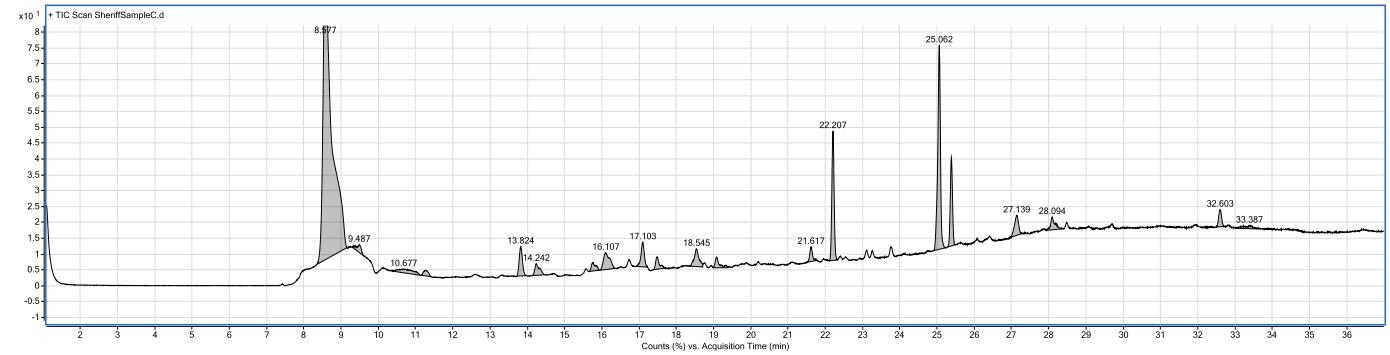


Figure 8: Chromatogram of Compound C_{a4}

Table 6: Gas chromatography and Mass spectrometry of Compound C_{a4}

Peak no.	RT	Area	Height	Width	Name
1	8.577	56878974.09	3456283.8	0.772	
2	9.487	832520.94	92937.58	0.309	
3	10.677	1380822.81	44585.36	0.75	
4	11.26	610675.28	65630.14	0.263	4H-cyclopropa[5',6']benz[1',2':7,8]azuleno [5,6-B]oxiren-4-one
5	13.824	2092952.91	350010	0.246	1-(p-methoxyphenyl)-3-phenyl-3-(2-oxocyclohexyl)-1-propanone
6	14.242	1227627.87	138423.73	0.346	Glycidol stearate
7	15.752	822539.41	101272.22	0.259	
8	16.107	2353589.79	199612.84	0.399	
9	17.103	1830642.51	292699.62	0.292	Androst-4-en-3-one
10	17.48	1032296.35	145430.43	0.303	1H2,8a-methanocyclopenta[a]cyclopropa[e]cyclodecane-11-1-one
11	18.544	1883667.35	210955.76	0.341	
12	19.077	995760.40	127479.33	0.395	
13	21.617	902040.09	173724.80	0.258	
14	22.207	6449043.45	1535593.58	0.210	Methyl-18-methylicosanoate
15	25.062	12132023.59	2422105.06	0.292	10-Octadecanoic acid
16	25.388	4348461.06	1050209.33	0.199	
17	27.139	1813519.54	237870.30	0.290	Dihydromorphine
18	28.094	1217287.93	152597.13	0.383	
19	32.603	1110441.91	203924.89	0.188	
20	33.387	683394.33	37546.01	0.578	

The above showed the results of compounds of Sample (C_{a4}) eight compounds were identified by comparison with the library of NIST. Peak number five (5) had a retention time of 13.824 min. also peak number seventeen (17) had a retention time of 27.139 min. The remaining peaks had the following retention times respectively as shown in table 6. But, other compounds could not be identified from the library. But, compounds could not be identified from the library of NIST.

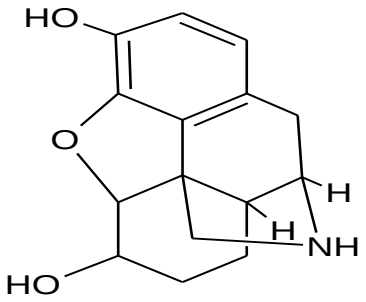


Figure 8: Dihydromorphine

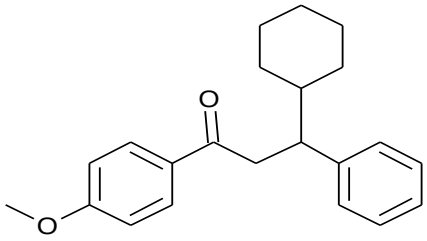


Figure 9: 1-(-P-methoxyphenyl)-3-phenyl-3-(2-oxocyclohexyl)-1-propanone

Plants are a valuable source of a wide range of secondary metabolites, which are used as pharmaceuticals, agrochemicals, flavours, aroma, colours, biopesticides and food additives. *Citrus* contained phytochemicals that were beneficial for healthIn extraction and partition of stem bark of *citrus aurantifolia*, methanol crude extract yield 14.90% $^{w}/_{w}$ dark green in colour, gummy in texture

The results of preliminary phytochemical screening of the methanol crude stem bark extract of *Citrus aurantifolia* together with its partitioned portions indicates that the plant contain many secondary metabolites. The presence of secondary metabolites such as carbohydrates, cardiac-glycosides, terpeniods, flavonoids, tannins and phlobatannins were observed in the extracts . These phytochemicals have been reported to influence physiological activities of the body . The absence of alkaloids and other constituents might be due to topographical variations. Phytochemicals found are implicated to have much medicinal importance [15].The phytochemical studies of the methanol crude stem bark extract of *Citrus aurantifolia* revealed presence of some useful chemical compounds such as flavonoids, cardiac-glycosides, tannins, saponins, and terpenoids. These compounds have been known to exert pharmacological and antagonistic effects and still some are capable of protecting the active ingredient in herbs from decomposing either chemically or physiologically [16]. Flavonoids exhibit several biological effects such as antihepatotoxic, anti-inflammatory and antiulcer activity[18-19]. Tannins are polyphenols that are obtained from various parts of different plants [20]. In addition to its use in leather processing industries, tannins have shown potential antiviral and antibacterial. [21-24]

The successful separation of biomolecules by the chromatographic technique depends upon suitable solvent system which needs an ideal range of partition coefficient (K) for each target compound . The purification of compounds was done by using a combination of column and thin layer chromatography techniques. The n-butanol partitioned portion was subjected column chromatography after, rerunning, recombination and pooling four compounds.

. In gas chromatography and mass spectrometry (GC-MS) analysis of compound of sample C_{a1} fourteen compounds were identified by comparison with the library of NIST. Among the compounds, were found to be 3, 5, 9-Trioza-5-Phosphaheptacos-18-en-1-aminium, Pentacosanoic acid, Oleic acid, 7, 8-Epoxylanostan-11-ol. Other compound could not be identified from the library. Analysis of Compound of sample C_{a2} shows that only one compound was identified by comparison with the library of NIST. Among the compound was found to be 3H-Cycloocta[c]pyran-3-one. Other compounds could not be identified from the library. Analysis of Compound of sample C_{a3} eight compounds were identified by comparison with the library of NIST. Among the compounds were found to be 1, 3-Dioxane, Pregn-5-en-20-one, 9-Octadecenoic acid, Heptadecanoic acid, Epoxylanostan-11-ol. Other compounds could not be identified from the library. Analysis of Compound of sample C_{a4} shows that eight compounds were identified by comparison with the library of NIST. Among the compounds were found to be Glycidol stearate, Andrast-4-ene-3-one, Octadecanoic acid, Dihydromorphine. Other compounds could not be identified from the library. The dihydromorphine which believed to be a reduced formed of morphine with a molecular formula of $C_{17}H_{21}NO_3$. The 7, 8-double bond of morphine also is not required for analgesic activity as indicated by the relative analgesic potency of dihydromorphine. Also, oxidation of the 6-OH of dihydromorphine to yield hydromorphone further increases activity.

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