Antibacterial Efficacy, *In Vitro* Antioxidant and GC-MS Analyses of Cinnamon Bark

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Abstract

The antibacterial efficacy, in vitro antioxidant and bioactive compounds of cinnamon was investigated to ascertain its medicinal importance. From the experiment carried out it was observed that saponin, tannins, steroids, cardiac glycosides, alkaloids, flavonoids and anthraquinones were present in both the powder and the extract of ethylacetate, ethanol and water except antraquinones which was absent in ethanol extract. The extracts were tested on *Staphylococcus aureus, Salmonella gallinarum, Pseudomonas aeroginesa* and *Escherichia coli* at concentration of 200, 400 and 800 mg/ml. The zone of inhibition ranges from 8 to 20 mm. Significant difference was observed between the activities of the extracts on the tested organism at p-value ≤ 0.05. The three extracts showed antioxidant activities at concentration of 200,150, 100 and 50 µg/l and the same applied to the standard ascorbic acid. It was observed that all the extracts have high antioxidant activity at volume of 200 µl but decreases as the volume decreases. Several compounds were identified from the GC-MS analysis. A total of 17, 54 and 28 compounds were identified in aqueous, ethylacetate and ethanol extract respectively. Among the compounds identified are coumarin, trans-cinnamic acid and methoxycinnamaldehyde which have been reported to have antibacterial, wound healing and antioxidant activity.

Key words

Medicinal plant, Antibacterial, antioxidant and Bioactive compounds

1.0 Introduction

The use of plants for medicinal purposes is an age old tradition in Africa, Asia and Latin America[1,2]. About 80% of plants selected for analysis on the basis of ethnomedicinal information have demonstrated significant pharmacological activity[3].Over the last two decades increasing evidence have shown that plants are rich source of different classes of antibacterial substances that can defend the biological system against stress which is the major causes of diseases [4].

The desire to have cheap source of treatment of ailments and long term harmful effects of synthetic drugs during chemotherapeutic control of diseases have resulted in the search for alternatives especially in the developing countries.

The genus cinnamon belongs to the family of lauraceae which has over 300 evergreen aromatic trees and shrubs of which four species have great economic importance for their multiple culinary uses. The term cinnamon commonly referred to the dried bark of cinnamon zeylanicum and cinnamon aromaticum[5]. It has been reported that the lauraceae family possess significance biological activities including antimicrobial antifungal, antiviral, anti-alergic, antitumor, anti-diabetic, antipyretic, anti-ulcerogenic, anti-hypertensive gastro-protective, anti-lipemic, immunomodulatory and anaesthetic[6].

Traditionally, cinnamon is an attractive spice [7]. As a result of its refreshing effects that developed in the mouth it is used as a flavour in sweet and chewing gum, to remove bad odour from the mouth and also used in tooth paste [4]. Cinnamon bark has been used to make tea as well as herbal remedy for the treatment of common colds, cardiovascular disease, chronic gastrointestinal and gynaecological disorders in in oriental medicine. It was also used for the treatment of sore throats, cough, indigestion, abdominal cramps, intestinal spasms, nausea, and diarrhoea[8]. anti-mutagenic [9].The efficacy of plants as alternative to synthetic drugs is as a result of the presence of several bioactive compounds like as tannins, alkaloids flavonoid, phenols.

The aim of this study is to examine the phytochemicals, antibacterial activity, antioxidant property and bioactive compounds present in the crude extracts of cinnamon bark in some selected solvents using GC-MS.

2.0 Materials and methods

2.1 Sample collection

The Cinnamon bark was bought from a local market in Jos, pulverised and stored in nylon bags for further use.

2.2 Sample extraction

Maceration method was used for the successive extraction. 100 g of the powdered cinnamon was weighed into a flask containing 150 ml of 100% ethylacetate this was allowed to stand for 48 hours and was filtered. The residue(marc) was then dried in the oven. The residue was re-extracted with ethanol. The same procedure was repeated for water. The filtrates from the extractions were dried and stored in sample bottles for further use. Part of the extract was used for phytochemical screening, antioxidant, antibacterial and a GC-MS. Analysis

2.3 Preparation of the cinnamon powder for phytochemicals screening

This was done according to the method[10]

2.3. 1 Acidic extract preparation

Exactly 30 ml of 2 M HCl was added to 5 g of the powder in a beaker, covered and allowed to stand for 20 minutes. Filtration was done and the filtrate was set aside for analysis.

2.3.2 Alcohol extract preparation

About 5 g of cinnamon powder was weighed into a conical flask containing 30 ml of methanol, covered and left for 30 minutes and then filtered.

2.4 Phytochemical screening

The phytochemical screening was done according to the method Usman [11] and Osuagwu and Eme [10] as follows: The phytochemical screening was done using both the dried extract and the filtrate from alcohol and acid extract filtrates

Saponins

About 1 ml of the filtrate and 0.5 g of the extract were shaken with water in different test tubes. A layer of foam indicated the presence of saponins.

Tannins

To a 1 ml of aqueous and 0.5 g of the dried extract was added 3 drops of 5% ferric chloride in different test tubes. A blue colour was an indication that tannins was present.

Alkaloid

About 1 ml of acid extract filtrate and 0.5 g of dried extract was measured into a test tube followed by the addition of few drops of picric acid. The appearance of precipitate indicated the presence of alkaloids.

Steroids

About 2 ml of the methanol extract filtrate and 0.5 g extract was measured into different test tubes followed by the addition of 2 drops of H_2SO_4 on the wall of the test tube (to prevent boiling of the acid). A reddish brown ring indicated the presence of steroids.

Cardiac glycosides

About 3 drops of ferric chloride was added to 1 ml of the acid extract filtrate and 0.5 g of dried extract in different test tubes. The formation of a brown ring indicated the presence of cardiac glycosides.

Flavonoids

To 1 ml of the acid extract filtrate and 0.5 g of dried extract in different test tube was added 3 drops of sodium hydroxide. A persistent yellow colour was an indication that flavonoids was present.

Anthraquinones

To 1 ml of the alcoholic extract filtrate and 0.5 g of dried extract in different test tube was added 5 drops of ammonia and shaken vigorously. A pink colour was an indication of the presence of anthraquinones

2.5 *In vitro* antioxidant study

Ethylacetate, ethanol and aqueous extracts of Cinnamon bark were tested to ascertain their free radical scavenging activity using 1,1-diphenyl-2-picrylhydrazyl(DPPH).

The free radical scavenging activity was done according to the method[12]. In brief, 0.04 g of ethylacetate and ethanol extract were weighed and dissolved in 2 ml of methanol this was repeated for aqueous extract but dissolved in distilled water. The working solution was prepared by measuring 200 µl from the stock and made up to 1000 µl with 800 µl of methanol. Series of concentrations 200, 150,100, 75, 50 µl were measured into different test tubes. This was followed by the addition of 1000 µl of DPPH and was homogenised with Stuart votex mixer at 1400 rpm for two minutes. This was incubated at room temperature for 30 minutes. The absorbance was taken at 517 nm using Jen way 6310 spectrophotometer.

The radical scavenging activity was calculated as follows:

$$\frac{\mathrm{Ao} - \mathrm{A1}}{Ao} * \frac{100}{1}$$

A_0 - Absorbance of control, A_1 – Absorbance of sample.

2.6 Determination of antimicrobial activity using agar well diffusion methods

2.6.1 Media preparation

Nutrient agar was prepared according to the manufacturer instruction and was sterilized at 121^{O}C for 15 minutes. This was allowed to cool to 40^{O}C before pouring into sterile petri dish and allowed to solidified. The sterility check of the media was conducted at 37^{O}C for 24 hours.

2.6.2 Standardization of the isolates

The bacterial isolates were standardized using neflometre to get 0.5 macfalant standard concentration in a sterile test tube.

2.6.3 Inoculation of the bacteria isolates and creation of well

The bacterial isolates were inoculated on the whole surface of nutrient agar and allowed to soak completely. Coke borer was used to create wells in the nutrient agar.

2.6.4 Introduction of extraction

The prepared extracts concentrate were used to fill the agar wells, alongside the positive control at the centre, and then incubated at 37^{O}C for 24hrs.

2.6.5 Zone of inhibition

The zones of inhibition by each concentration on the bacterial isolates were red and measured in millimetres along with the positive control.

2.6.6 Minimum Inhibitory Concentration (MIC)

The minimum concentration of the extract that showed activity was diluted in 10 test tubes(doubling dilution) and 0.1 ml of the bacterial isolates was added to all the tubes (except the negative control) and were incubated at 37^{o} C for 24hrs after which the MIC was red.

2.6.7 Minimum Bactericidal Concentration(MBC)

The dilutions from the MIC in the whole test tubes was inoculated on the nutrient agar and incubated. The minimum concentration that stops the growth of the bacterial isolate completely was taken as MBC.

2.7 Statistical analysis

The experimental results were expressed as means ± SD and mean of three measurements. The *p*-value was taken as $p \leq 0.05$.

3. Results and discussion

3.1 Results

Table 1: phytochemicals screening result.

Parameters	Aqueous extract	Ethanol extract	Ethylacetate extract	Raw powder
Tannins	+	+	+	+
Saponins	+	+	-	+
Steroids	+	+	+	+
Alkaloids	+	+	+	+
Flavonoids	+	+	-	+
Cardiac glycosides	+	+	+	+
Antraquinones	+	-	+	+

Table 2: GC-MS results of aqueous extract**.**

S/N	RT	Compounds	Area %
1	20.7029	n-Hexadecanoic acid	4.329
2	21.1304	Hexadecanoic acid, ethyl ester	3. 1296
3	22.6701	cis-Vaccenic acid	13.1376
4	22.7726	E-2-Octadecadecen-1-ol	1.6343
5	23.8644	cis-13-Octadecenoic acid	15.3696
6	24.0328	9,17-Octadecadienal, (Z)-	4.4913
7	24.2152	(E)-9-Octadecenoic acid ethyl ester	8.4256
8	24.8068	Octadecanoic acid, ethyl ester	1.84
9	30.0977	Bis(2-ethylhexyl) phthalate	35.3439

10	32.0045	Oleic Acid	0.4687
11	32.1454	9-Octadecenal, (Z)-	0.3193
12	32.4906	9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	4.0204
13	32.526	9-Octadecenoic acid	0.9192
14	32.6091	13-Octadecenal, (Z)-	2.1508
15	32.8195	3-Eicosene, (E)-	0.441
16	32.931	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	0.7956
17	32.9645	9-Methyl-Z-10-tetradecen-1-ol acetate	0.1045

Table 3: GC-MS results of ethylacetate extract

S/N	Compounds	RT	Area pct
1	2-Dodecenal, (E)-	7.312	0.4443
2	Coumarin	8.1567	1.6081
3	Tetradecane	8.6587	0.615
4	Trans-Cinnamic acid	9.1228	2.101
5	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-	9.4857	0.382
6	(Z)-2-Methoxycinnamaldehyde	10.5034	9.5166
7	Ethyl 4-t-butylbenzoate	10.8784	0.1581
8	Nonadecane	10.9525	0.119
9	9-Octadecene, (E)-	12.9865	0.9023
10	Hexadecane	13.2252	0.6726
11	9-Eicosene, (E)-	17.3417	1.5525
12	Octadecane	17.5493	0.4692
13	Heptylcyclohexane	18.589	0.3557
14	9-Heptadecanone	18.6651	0.8902
15	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	18.8736	0.4121
16	Dibutyl phthalate	19.7924	1.2349

17	1-(9-anthracenyl)-Ethanone	20.4877	0.9045
18	n-Hexadecanoic acid	20.7763	9.1115
19	Eicosyl isobutyl ether	20.9562	0.7416
20	1-Octadecene	21.1415	0.632
21	Lauric acid, 2-methylbutyl ester	21.2139	0.7115
22 23	1-chloro-Heptacosane Propyl triacontyl ether	21.5185 22.9761 21.7179	4.6109 0.2254
24	Pentadecafluorooctanoic acid, octadecyl ester	21.7875	0.8351
25	tridecyl- Oxirane	21.8792	0.2625
26	1,1'-Bicyclohexyl, 4-methyl-4'-pentyl-	22.431	1.224
27	Cyclohexane, 1,1'-(1,3-propanediyl)bis-	22.6126	1.8181
28	11-Octadecenoic acid, methyl ester	22.9761	0.4004
29	9,12-Octadecadienoic acid (Z,Z)-	23.7318	0.8534
30	9-Octadecenoic acid	23.954	3.8434
31	Octadecanoic acid	24.4093	0.4787
32	Dichloroacetic acid, heptadecyl ester	25.0063	0.6616
33	Heptylcyclohexane	26.2953	0.3993

34	Cyclotetracosane	28.38	0.7434
35	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	29.3064	2.1035
36	3-Chloropropionic acid, heptadecyl ester	29.4551	0.3429
37	Cyclohexanemethanol	29.5475	1.9382
38	cis-Vaccenic acid	29.6837	2.8828
39	Oleic Acid	29.8474	0.7794
40	13-Octadecenal, (Z)-	29.9835	1.8611
41	Bis(2-ethylhexyl) phthalate	30.0992	3.383
42	tert-Hexadecanethiol	30.2485	2.9239
43	2-Piperidinone, N-[4-bromo-n-butyl]-	30.2891	2.4644
44	6-Bromohexanoic acid, pentadecyl ester	30.4115	2.2117
45	Aspidospermidin-17-ol, 1-acetyl-19,21-epoxy-15,16-dimethoxy-	30.5073	3.5463
46	2-Piperidinone, N-[4-bromo-n-butyl]-	30.6396	3.286
47	Aspidospermidin-17-ol, 1-acetyl-19,21-epoxy-15,16-dimethoxy-	30.7503	3.7336
48	tert-Hexadecanethiol	30.882	2.1832
49	1-Docosene	31.4984	0.7637

50	9-Octadecenoic acid (Z)-, 2-hydroxyethyl ester	32.2608	0.5324
51	6,11-Dimethyl-2,6,10-dodecatrien-1-ol	34.5447	0.272
52	Erucic acid	36.0796	0.2295
53	9-Octadecenoic acid	36.3498	0.6097
54	E-11-Hexadecenal	36.7043	1.2056

Table 4: GC-MS results of ethanol extract.

S/N	Compound	RT	Area pct
1	2,4-Di-tert-butylphenol	10.8968	0.1557
2	9-Octadecene, (E)-	12.9768	0.3995
3	1-Hexadecanol	17.3247	0.4428
4	1,2-Benzenedicarboxylic acid, butyl 2-ethylhexyl ester	19.7899	1.4837
5	n-Hexadecanoic acid	20.699	1.4228
6	Hexadecanoic acid, ethyl ester	21.1275	0.6445
7	Trichloroacetic acid, hexadecyl ester	21.3257	0.3487
8	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	22.7993	3.9622
9	Palmitic acid	22.9726	0.8011

10	9,12-Octadecadienoic acid (Z,Z)-	23.6983	0.4606
11	cis-Vaccenic acid	23.8662	5.2847
12	9,17-Octadecadienal, (Z)-	24.0229	1.531
13	9-Octadecenoic acid	24.2115	2.169
14	9-Eicosene, (E)-	24.3711	2.5235
15	Octadecanoic acid, ethyl ester	24.8061	0.7415
16	5-Eicosene, (E)-	24.9957	0.3627
17	Decyl oleate	26.8864	0.1341
18	Oleic Acid	27.0403	0.3177
19	Cyclopentadecanone, 2-hydroxy-	27.2422	0.47
20	12-Methyl-E,E-2,13-octadecadien-1-ol	28.0123	0.8661
21	9-Octadecenoic acid	28.3682	1.8647
22	Oxiraneundecanoic acid, 3-pentyl-, methyl ester, trans-	28.504	1.0845
23	7,11-Hexadecadienal	29.1543	1.4578
24	13-Octadecenal, (Z)-	29.7569	0.5992
25	Erucic acid	29.9418	0.616

26	Bis(2-ethylhexyl) phthalate	30.0943	23.1098
27	9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	35.2453	0.2875
28	Cycloeicosane	35.3628	0.0787

Table 5: Percentage inhibitory scavenging activity

Concentration(µg/l)	Ethylacetate(%)	Ethanol(%)	Water(%)	Ascorbic acid(%)
200	93.92	78.61	97.89	99.62
150	93.22	74.62	15.13	95.99
100	92.53	74.66	10.82	95.99
75	91.21	69.96	9.10	76.40
50	90.28	39.70	6.26	76.47

Table 6: Antibacterial activity of the extracts by Agar well diffusion method

Extracts	Isolate	Zone of inhibition (mm) at different concentration (mg/ml) of the extracts (Mean±SD)				
		200	400	800	Amoxicilin	*P-value*
Ethylacetate	Staphylococcus aureus	15.00±1.41^{c}	20.00±0.14^{b}	20.00±1.41^{b}	33±7.19^{a}	0.001***
	Pseudomonas aeroginesa	0.00±0.00^{c}	8.00±1.41^{b}	10.00±1.41^{b}	36.00±0.71^{a}	0.000***
	E. coli	0.00±0.00	0.00±0.00	0.00±0.00		-
	Salmonella gallinarus	17.00±1.41^{b}	18.00±0.57^{b}	20.00±0.42^{b}	37.00±1.41^{a}	0.000***
Aqueous						
	Staphylococcus aureus	0.00±0.00^{d}	15.00±1.41^{c}	19.00±0.14^{b}	32.00±1.41^{a}	0.000***
	Pseudomonas aeroginesa	0.00±0.00^{d}	16.00±1.41^{b}	18.00±1.41^{b}	30.00±1.41^{a}	0.000***
	E. coli	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	36.00±1.41^{a}	0.000***
	Salmonella gallinarus	0.00±0.00^{c}	0.00±0.00^{c}	20.01.41^{b}	35.00±2.83^{a}	0.000***
Ethanol						
	Staphylococcus aureus	0.00±0.00^{d}	15.00±1.41^{c}	19.00±0.14^{b}	32.00±1.41^{a}	0.000***
	Pseudomonas aeroginesa	0.00±0.00^{d}	9.00±1.41^{c}	17.00±1.41^{b}	31.00±1.41^{a}	0.000***
	E. coli	0.00±0.00^{b}	0.00±0.00^{b}	12.00±1.41^{a}	14.00±0.71^{a}	0.000***
	Salmonella gallinarus	0.00±0.00^{c}	0.00±0.00^{c}	14.00±1.41^{b}	39.00±1.41^{a}	0.000***

$^{a, b, c, d}$ Mean±SD with different superscripts; not significant on the same row differ significantly (P<0.05).

*** Significant at 1% , ** Significant at 5%, NS: Not significant.

Table 7: Minimum bacteria concentration

		MBC	Mg/ml	
		100	400	800
Extract	Bacteria			
Ethylacetae	Staphylococcus Aureus	+	+	+
	Salmonella gallinarum	+	+	+
	Pseudomonas aeroginesa	-	+	+
	Escherichia Coli	-	-	-
Aqueous	Staphylococcus Aureus	-	+	+
	Salmonella gallinarum	-	+	+
	Pseudomonas aeroginesa	-	+	+
	Escherichia Coli	-	-	-
Ethanol	Staphylococcus Aureus	-	+	+
	Salmonella gallinarum	-	+	+
	Pseudomonas aeroginesa	-	-	+
	Escherichia Coli	-	+	+

Key += shows inhibition

- Shows no inhibition

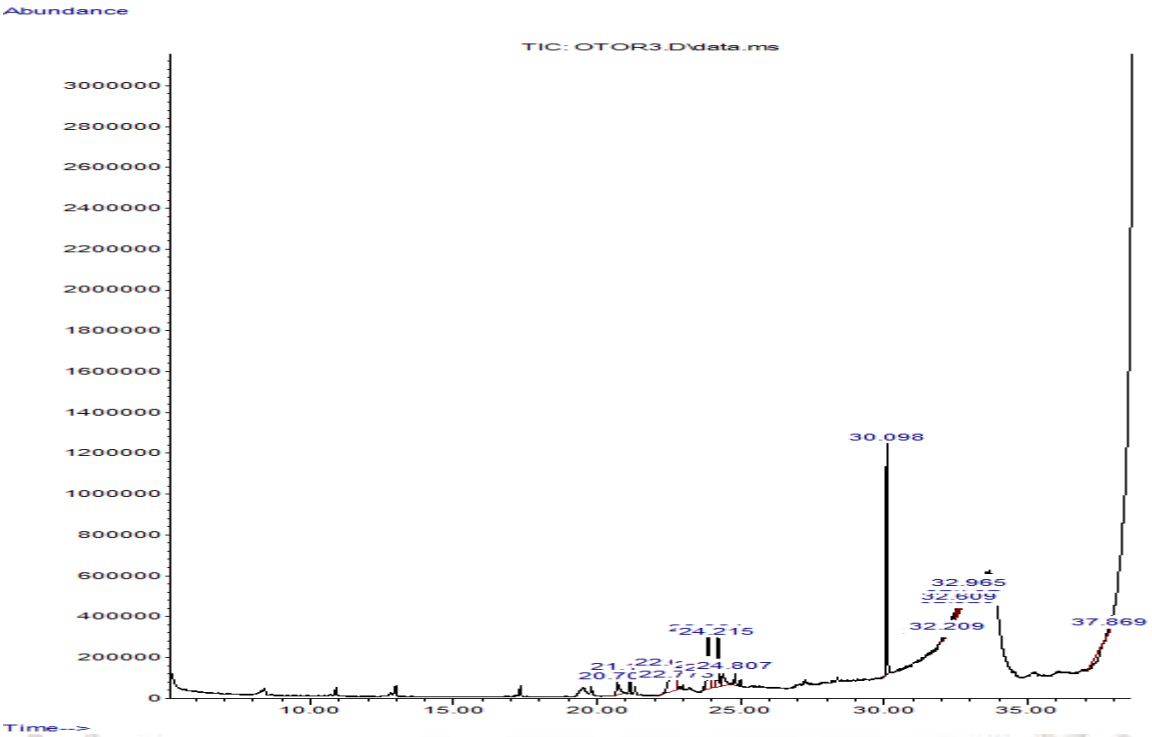

Figure 1: Chromatogram of the aqueous extract

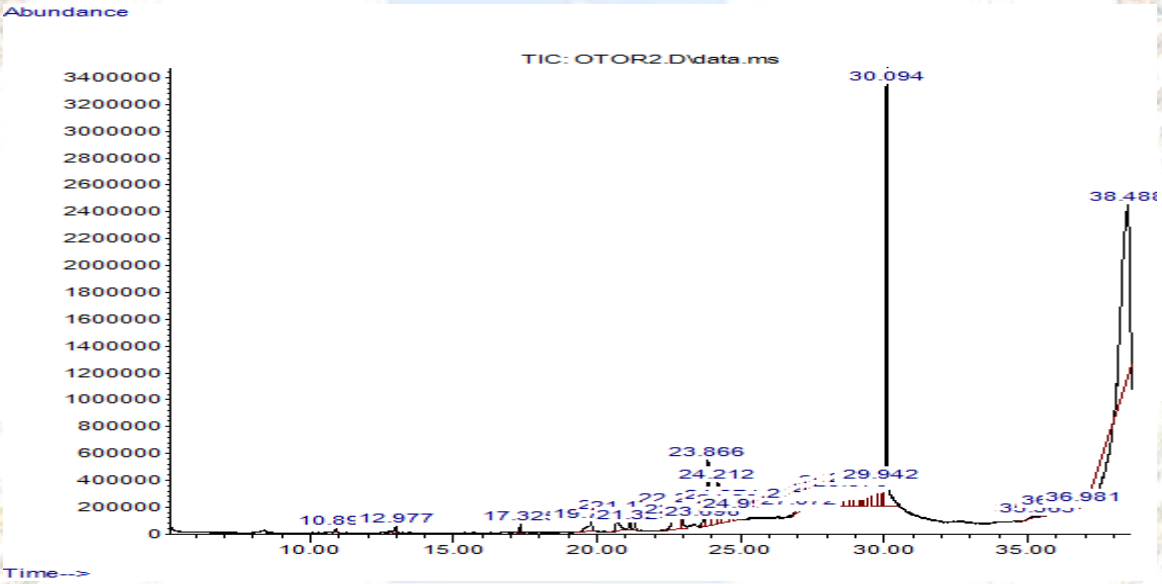

Figure 2: Chromatogram of ethylacetate extract

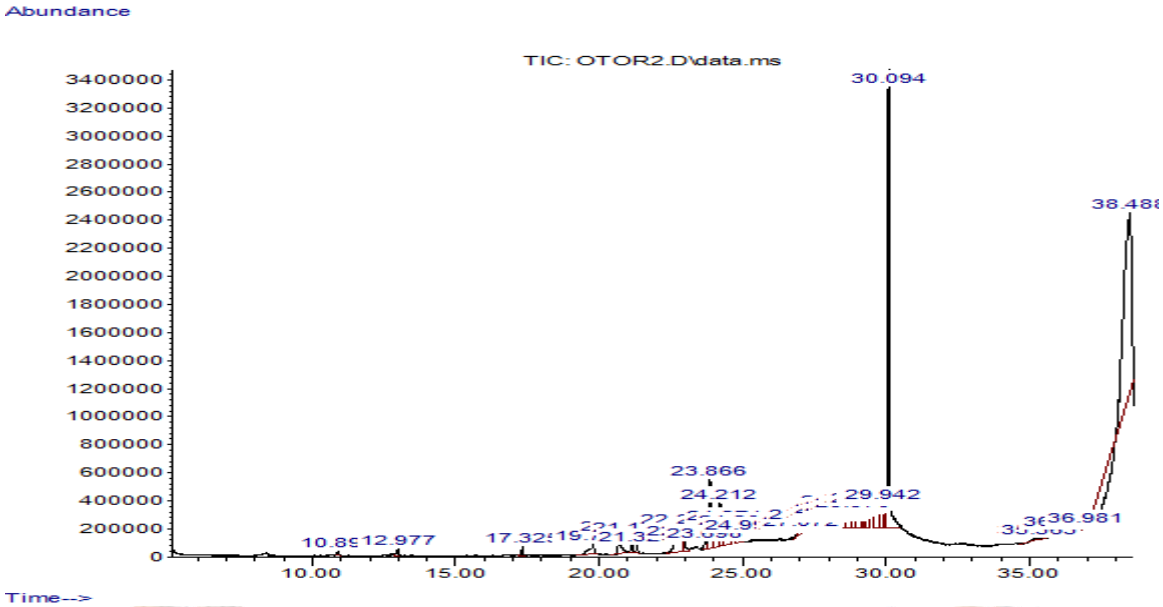

Figure 3: Chromatogram of ethanol extract

3.2.1 Discusion

The results of the phytochemical screening in Table 1 indicated the presences of saponin, tannins, steroids, cardiac glycosides, alkaloids, flavonoids and anthraquinones in the extracts and the powder with anthraquinones absent in ethanol extract. This result is similar to the study carried out [13] which reported the presence of these in the extract of acetone, methanol and water.

Table 2-4 showed the identified compounds by GC-MS . Table 2 is the result of the GC-MS analysis of aqueous extract with total of 17 compounds, Table 3 is the results of ethylacetate extract with a total of 54 compounds identified and Table 4 as that of ethanol extract with a total of 28 compounds. Some compounds identified in this study like hexadecanoic acid, oleic acid, octadecanoic acid, 9-octadecanoic acid, palmitic acid, cinnamaldehyde, are similar to the ones reported [14]. Methoxycinnamaldehyde, cinnamic acid and cinnamaldehyde were identified[15].

Among the medicinal compounds identified in this study are coumarin, transcinnamic acid and methoxycinnamaldehyde which have antioxidant and antibacterial activity.

Coumarin was reported to have shown a strong antioxidant activity compared to ascorbic acid and was suggested that the compound have great importance as therapeutic agent in preventing or slowing the progress of aging and age associated stress degenerated disease[16]. Strong antioxidant of coumarin was reported[17]. Coumarin derivatives were reported as good antioxidant with the antioxidant activity dependent on the position of the hydroxyl group. In which position 7 and 8 have the highest efficacy with efficacy decreasing with position[18].

Coumarins (aegelinol and agasyllin) isolated from the roots of ferulago campestris showed a significant antiibacteria effect at the concentration of 16 and 125 microg/l against *Staphylococcus aureus*, *Salmonella typhii*, *Enterobacter cloacae* and *Enterobacter aerogene*. Antibacteria activity was also observed against *Helicobacter pylori* at concentration 5-25 ug/l [19]

Forty-five(45) coumarins tested for antibacterial activity with concentrations between 62.5 to 2000 ug/l against 4 bacteria species *Escherichia coli, Pseudomonas aeruginosa, Baccilus cereus and Staphylococcus aureus*, showed that each compound have more or less pronounce antibacterial potencies on both gram positive and gram negative microorganism[20].

Cinnamic acid was used for the treatment of wound in rabbit and was seen to increase the rate of wound closure and hydroxyproline levels of tissue samples in the animals treated with cinnamic acid. The result was significantly higher than those of non-treated and vehicle- treated groups and histopathologically fibroblasts, hair follicles and reepithelialisation rate increased with enhanced neovascularization[21].

Both pure and nanoemusified trans-cinnamic acid have inhibitory activity on *S. aureus, S. typhimurium and P. aeruginosa* [22].

3.2.2 Antioxidant activity

Antioxidant activity of the three extract were tested using the DPPH radical scavenging method as indicated in Table 5. It was observed that all the three extracts exhibited good antioxidant activity at concentration of 200 µl when compared to ascorbic acid. This radical scavenging activity decreases with decreasing concentration which is an indication that the activity is concentration dependent. The results obtained in this study are similar to the results obtained by[23] who reported that the extract has strong antioxidant activity. Among the three extracts ethylacetate seems to have a high antioxidant.

3.2.3 Antibacterial activity.

The antibacterial activity of the three extracts are reported in the Table 6 and 7 with Table indicating the minimum inhibition capacity and Table 6 minimum bacterial concentration. The result in table 6 indicated that, the ethylacetate extract at a concentration of 200 mg/l was able to inhibit the growth of staphylococcus *aureus* and *Salmonella gallinarum* but could not inhibit the growth of *Pseudomonas aeroginesa* and *E. coli*. The activity of the ethylacetate increases with concentration and does not have activity on *E. coli* at all concentration. The same result was seen with aqueous extract in addition to no activity at 400 mg/l on Salmonella gallinarum. Though at 800 mg/l there was activity. Ethanolic extract has inhibitory activity on all bacterial including *E.coli* with the activity increasing with concentration. The results were observed to be on a good side base on the zone of inhibition of the extract to that of the standard drug. The results from this study is similar to the previous studies. Ethanol extract of cinnamon was reported to inhibit the growth of *staphylococcus aureus* and *E.coli* [24]. Ethanolic extract also inhibited the growth of *Pseudomonas spp* [21]. Methanolic extract of cinnamon has inhibitory activity on *P. aureginosa* and *E. coli* which is concentration dependent[14]. The ability of the extracts of cinnamon to inhibit the growth of theses bacterial can be attributed to the presence flavonoids, Alkaloids, quinones, steroids, saponins, and tannins [24]. This could also be due to the presence of cinnaldehyde [25] or the presence of coumarins.The MBC results in Table 7 showed that the mbc for ethylacete extract is at 100 mg/ml for *staphylococcus aureus* , 400 mg/ml for pseudomona aeroginosa and 100 mg/ml for *Salmonella gallinerum*. And for aqueous extract the mbc is at 400 mg/ml for all the bacteria except for E. coli. Ethanolic extract has 400 mg/ml for staphylococcus and *Salmonella gallinerum* and 800mg/ml for *E.coli* and *p. aeroginosa*.

Comparing the activities of these extract statistically , it was observed that there was significance diference between the concentration and betewwen the extract. Ethanol extract was observed to be more potent in its activity because it has activity on all the bacterial of interest.

3.3 **Conclusion**

From the analysis carried out the three extracts of cinnamon bark namely ethylacetate, ethanol and water showed good antioxidant and antibacterial activities. These activities could be as a results of the presence of tannins , saponinis, steriods, cardiac glycosides, flavonoids, alkaloids and anthraquinones. This can also be attributed to the presence of bioactive compounds detected by the GC-MS which included coumarin, transcinnamic acid and methoxycinnamaldehyde. These compounds have been reported in several journals for their antioxidant and antibacterial.

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