AAS and GC-MS analysis of phytocomponents in the leaf, stem and root of *Azadirachta indica* ***A. Juss*** **(Dongoyaro)**

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ABSTRACT

Objective: To determine the mineral component using AAS and screen for the presence of bioactive phytoconstituents in hexane extract of *Azadirachta indica A. Juss* leaf, stem and root using the GC-MS technique.

Methods: Mineral analysis was carried out using AAS**.** The leaf, stem and root hexane extracts of *A. indica* were prepared by standard procedure and concentrated at 40ºC using hot air oven. The concentrated hexane extracts were subjected to phytochemical analysis using GC-MS.

Results: The result of mineral analysis shows that *Azadirachta indica A. Juss* leaf, stem and root contain potassium, iron, copper, calcium, magnesium and sodium. The GC-MS analysis of the neem leaf, stem and root extract revealed the existence of the GC-MS chromatogram of twenty three peaks present. Ten chemical constituents were identified in the leaf of *A. indica*, six were found in the stem while seven were identified in the root of the plant by Gas Chromatogram Mass spectrometry (GC-MS) analysis.

Conclusion: The result of the analysis showed that the plant contains important minerals and many pharmacologically important bioactive compounds. The presence of various bioactive compounds justifies the uses of Neem for various traditional medicines.

Key words: AAS, *Azadirachta indica A. Juss*, GC-MS analysis, biological activities.

1. INTRODUCTION

The medicinal value of plants lies in some chemical substances that produce a definite physiological action on the human body. The most important of these bioactive constituents of plants are alkaloids, tannins, flavonoids, and phenolic compounds [1].

Neem (family Meliaceae, genus *Azadirachta*) is an evergreen tree grown in Nigeria and other countries in Africa. In Nigeria, neem is locally called Dongoyaro and is used for the treatment of malaria. It is one of the most well known plants indigenous to India and is cultivated in tropical and subtropical regions worldwide [2, 3]. Every part of the tree has been used as traditional medicine for household remedy against various human ailments, from

antiquity [4-8]. Study has shown that the various chemical compounds, antioxidants, fatty acids, flavonoids, biological activities etc. in the various components of *Azadirachta indica* can be evaluated from the flower, leaves and barks [9]. Dholi *et al*., 2011 reported on the antidiabetic activity of the plant [10]. In addition, the aqueous extract of Neem leaves had shown a good therapeutic potential as anti- hyperglycemic agent [11]. Saseed *et al*. 2008 and El-Mahmood *et al*. 2010 supported the use of Neem seeds for treatment of infectious diseases especially those involving the eye and ear [12,13]. Antimicrobial activities of Neem against human pathogenic bacteria have been studied [14-15]. The aim of this study is to determine the mineral components of *Azadirachta indica* and to screen the hexane extract of the plant using GC-MS technique with the possibility of discovering compound(s) of therapeutic value.

2. MATERIALS AND METHODS

2.1 Collection and identification of Plant extract

The *Azadirachta indica* ***A. Juss*** plant was obtained from Ikorodu in Lagos State, Nigeria.

The plant was authenticated from the department of Botany, University of Lagos, Lagos-Nigeria. Authentication number for the *A. indica* was given (6967). The plant name corresponds to the official botanical plant name in "The Plant List" (www.theplantlist.org).

2.2 Mineral Analysis of *Azadirachta indica* *A. Juss*

The mineral composition of the plant was analyzed on aliquots of dry-ashing. 2g of the *A. indica* leaf, stem and root were separately weight into 250ml conical flasks, 10ml of aqua regia was added (HNO_3 and HCl in the ratio 1:3), the mixture was heated on porcelain crucible until the brown fumes disappeared leaving white fumes. It was later filtered with whatman filter paper into universal bottle; the mineral elements in the samples were determined by Atomic Absorption Spectrophotometer (Model PerkinElmer AAnalyst 400).

2.3 Preparation of leaf, stem and root extract of *Azadirachta indica* *A. Juss*

The leaf, stem and root of *A. indica* were washed separately, air dried under shade in the Biochemistry Laboratory, pulverised to coarse power using industrial blender.
2g each of the leaf, stem and root of the grounded *A. indica* plant material were placed in timble and later placed in a Soxhlet extractor with 30 mL hexane and heated using heating mantle at 100^{o}C for 3 hours. The extracts were poured into separate beakers and concentrated with ultra sonic bath at 60^{o}C for one hour. The remaining extract was treated with anhydrous sodium sulphate to absorb the water in the samples and later treated with silica gel which helps to remove impurities in the samples. The extract was later used for GC-MS analysis.

2.4 GC-MS analysis of the leaf, stem and root of *Azadirachta indica* *A. Juss*

GC-MS analysis of the plant was carried out on an Agilent technology 7890 GC system equipped with a mass spectrometric detector (MSD). Ms model is agilent technology 5975 ms, the column used is HP-5MS agilent technology, length of the column is 30 m, internal diameter 0.320 mm, thickness of 0.25 μm. Volume of sample injected is 1μL. Oven temperature program with initial temperature of 80^{o}C to hold for 2 minutes at 10^{o}C/min to final temperature of 240^{o}C to hold for 6 minutes with injector temperature of 250^{o}C. The mobile phase is helium gas while the stationary phase is column.

2.5 Detection of components

Analysis of mass spectrum GC-MS was conducted by the database of National Institute Standard and Technique (NIST) having more than 62,000 patterns. The spectrum of the unidentified component was compared with the spectrum of the identified components stored in the NIST library. The name, molecular weight, structure of the components in the test material was ascertained (16, 17, 18)

A quasi-linear equation proposed by van Den Dool and Kratz [35] for temperature programmed retention index was used to calculate I^T in the present work:

$$I^T = 100\left(\frac{t_x - t_n}{t_{n+1} - t_n} + n\right)$$

where I^T is the temperature-programmed retention index of the interesting compound; t_n, t_{n+1}, and t_x are the retention times (in minute) of the two standard *n*-alkanes containing *n* and *n + 1* carbons and the compound of interest, respectively.

3. RESULT

The macro and micro elements analysis of the leaf, stem and root of *Azadirachta indica* ***A. Juss*** shows that the leaf contains higher concentration of more of the minerals, followed by the root while the stem has the least (Table 1).

Table 1. Mineral constituents of fresh leaf, stem and root of *Azadirachta indica A. Juss*

Sample	Iron (mg/L)	Copper (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)
Leaf	**42.2198**	**0.2632**	**10.5667**	**8.1372**	**8.9112**	**8.6701**
Stem	**17.3061**	**0.0046**	**10.3578**	**8.1425**	**6.8883**	**5.8487**
Root	**35.8699**	**0.1616**	**10.3994**	**8.1292**	**7.9143**	**8.0981**

Twenty three compounds were identified in the *Azadirachta indica* plant by GC-MS analysis. The Peaks are indicating the presence of bio-active compounds. Ten, six and seven compounds were identified in the *A. indica* leaf, stem and root extract respectively by GC-MS analysis. The Peaks are indicating the presence of bio active compounds. The GC-MS chromatograms of the twenty three peaks of the bio compounds detected are shown in Figure 1, 2 and 3 respectively.

The bioactive components were identified and characterized and interpreted on mass spectrum GC–MS conducted using the database of National Institute Standard and Technology (NIST) which is having more than 62,000 patterns. The bioactive principles with their molecular formulae, molecular weight, Retention Time (RT), Peak area (%), are shown in Table 1, 2 and 3 respectively.

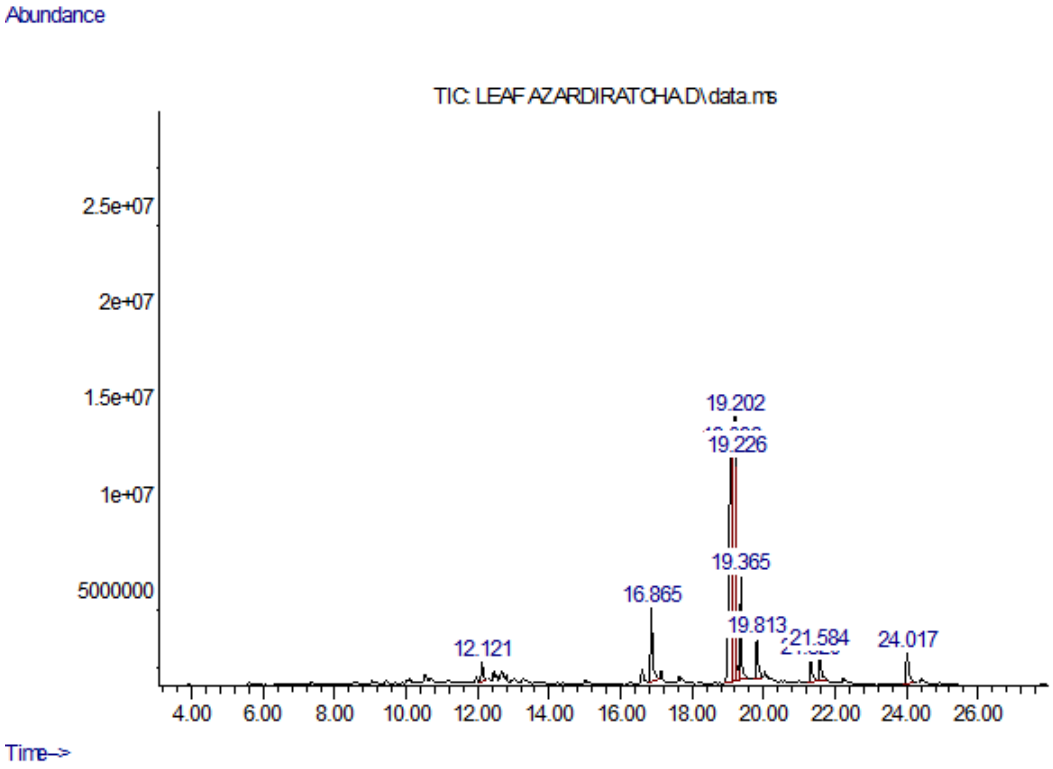

Figure 1. GC-MS Chromatogram of hexane leaf extract of *Azadirachta indica A. Juss*

Table. 2 Phytocomponents identified in the hexane leaf extract of *Azadirachta indica A. Juss* analysed by GC-MS.

SN	Retention Time	Retention index	Name of the compound	Molecular Formulae	Molecular Weight (g/mol)	Peak Area (%)	Activity
1	12.122	1781	Caryophyllene oxide	$C_{15}H_{24}O$	220.35046	1.62	Used as preservative in food, drugs an as antifungal agent against dermatophyt
2	16.865	2479	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270.4507	6.92	Anti-oxidant,antimicrobial, decr cholesterol, anti-inflammatory [19, 20].
3	19.097	2807	9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296.4879	25.49	Antioxidant, anti cancer [20, 21].
4	19.200	2822	13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.48794	40.52	[34]
5	19.229	2826	9-Octadecenoic acid, methyl ester (E)	$C_{19}H_{36}O_2$	296.48794	6.04	Antioxidant, anti cancer [20, 21].
6	19.366	2847	Methyl stearate	$C_{19}H_{38}O_2$	298.5038	6.99	They are used as solvents or cosolvents agricultural industry.
7	19.812	2912	(E)-9-Octadecenoic acid ethyl ester	$C_{20}H_{38}O_2$	310.5145	3.68	NF
8	21.317	3133	cis-11-Eicosenoic	$C_{21}H_{40}O_2$	324.5411	2.29	NF

			acid, methyl ester				
9	21.586	3173	Methyl 18-methylnonadecanoate	$C_{21}H_{42}O_2$	326.5570	2.65	NF
10	24.018	3531	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354.6101	3.79	NF

NF=Not found

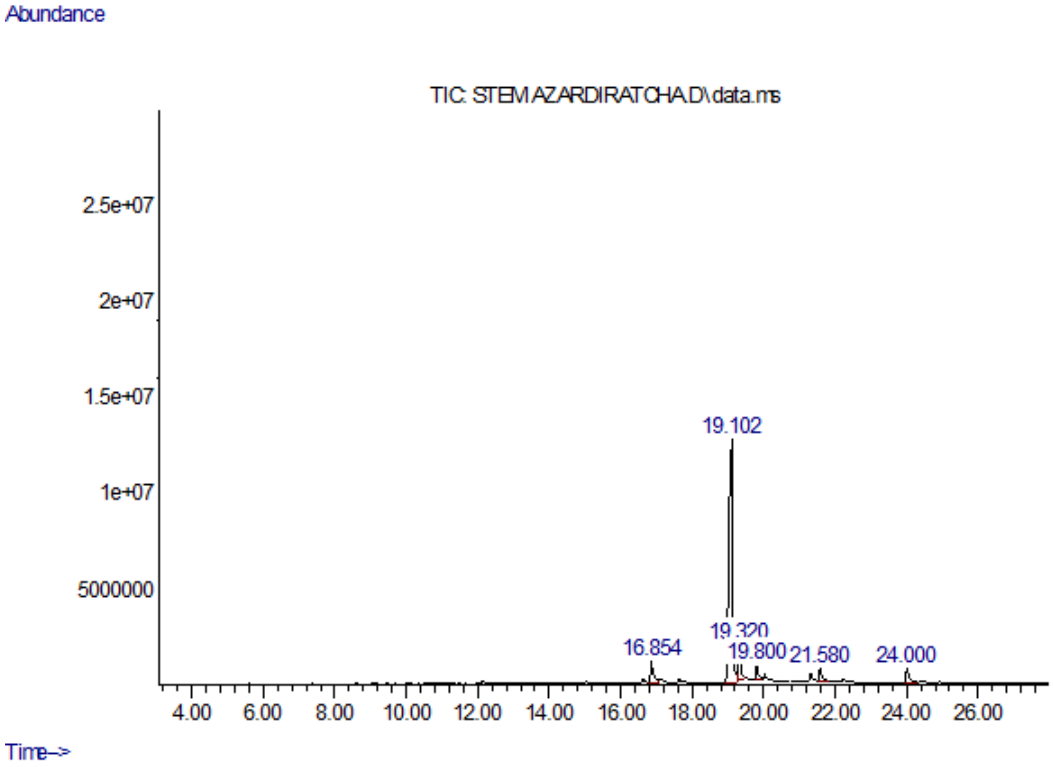

Figure 2. GC-MS Chromatogram of hexane stem extract of *Azadirachta indica A. Juss*

Table. 3 Phytocomponents identified in the hexane stem extract of *Azadirachta indica A. Juss* analysed by GC-MS.

SN	Retention Time	Retention index	Name of the compound	Molecular Formulae	Molecular Weight (g/mol)	Peak Area (%)	Activity
1	16.854	2477	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270.4507	5.64	Anti-oxidant, antimicrobial, d cholesterol, anti-inflammatory [19
2	19.102	2808	11-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.4879	78.39	NF

3	19.320	2840	Methyl stearate	$C_{19}H_{38}O_2$	298.5038 g/mol	6.29	
4	19.800	2910	(E)-9-Octadecenoic acid ethyl ester	$C_{20}H_{38}O_2$	310.5145 g/mol	2.81	NF
5	21.580	3172	Methyl 18-methylnonadecanoate	$C_{21}H_{42}O_2$	326.5570	2.62	NF
6	24.000	3528	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354.6101	4.24	NF

NF=Not found

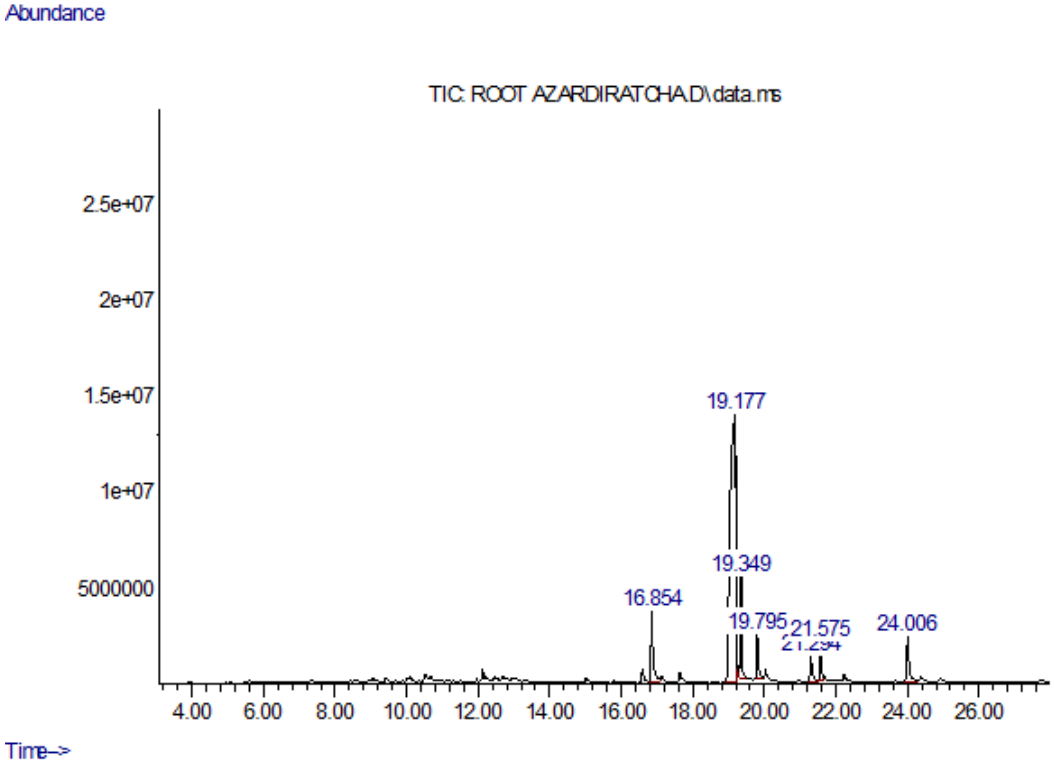

Table. 4 Phytocomponents identified in the hexane root extract of *Azadirachta indica A. Juss* analysed by GC-MS.

SN	Retention Time	Retention index	Name of the compound	Molecular Formulae	Molecular Weight (g/mol)	Peak Area (%)	Activity
1	16.854	2477	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270.4507	7.51	Anti-oxidant, antimicrobial, decrea anti-inflammatory [19, 20].
2	19.177	2819	9-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.4879	70.14	Antioxidant, anti cancer [20, 21].
3	19.349	2844	Methyl stearate	$C_{19}H_{38}O_2$	298.5038	6.78	They are used as solvents or cosolv agricultural industry.

4	19.795	2910	(E)-9-Octadecenoic acid ethyl ester	$C_{20}H_{38}O_2$	310.5145	4.03	NF
5	21.294	3130	cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324.5411 g/mol	2.79	NF
6	21.575	3171	Methyl 18-methylnonadecanoate	$C_{21}H_{42}O_2$	326.5570	3.04	NF
7	24.006	3529	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354.6101	5.72	NF

NF=Not found

Figure 4 -14 below show the mass spectrograms of chemical bioactive compounds for Docosanoic acid, methyl ester, Methyl 18-methylnonadecanoate, cis-11-Eicosenoic acid, methyl ester, (E)-9-Octadecenoic acid ethyl ester, Methyl stearate, 9-Octadecenoic acid, methyl ester (E), cis-13-Octadecenoic acid, methyl ester, 9-Octadecenoic acid (Z)-, methyl ester, Hexadecanoic acid, methyl ester, Caryophyllene oxide and 11-Octadecenoic acid, methyl ester respectively.

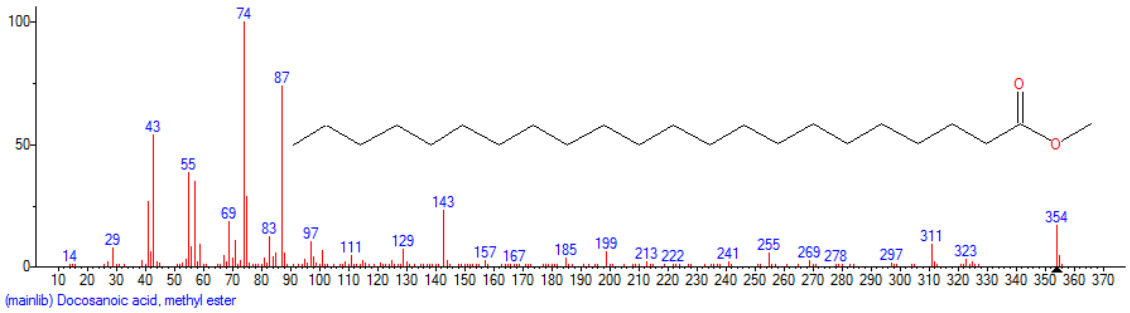

Figure 4. Mass spectrum of Docosanoic acid, methyl ester structure (3.79%, RT 24.018).

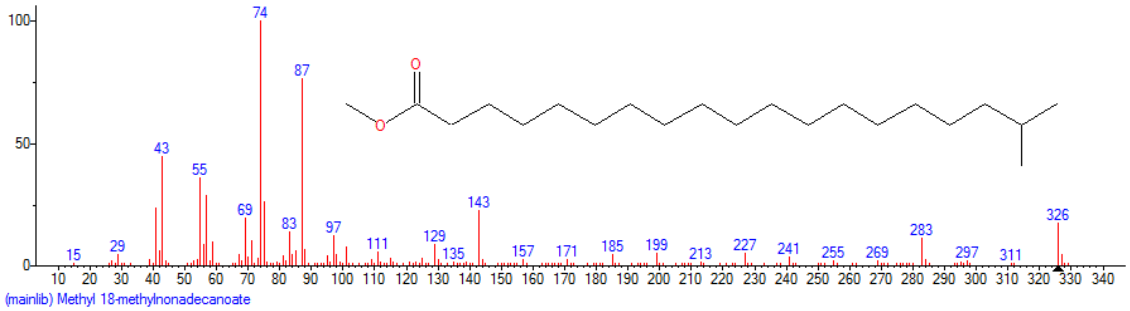

Figure 5. Mass spectrum of Methyl 18-methylnonadecanoate structure (2.65%, RT 21.586).

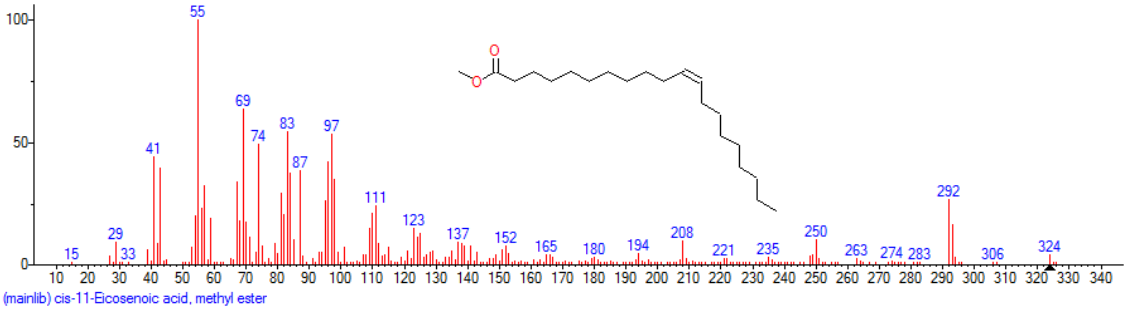

Figure 6. Mass spectrum of cis-11-Eicosenoic acid, methyl ester structure (2.29 %, RT 21.317).

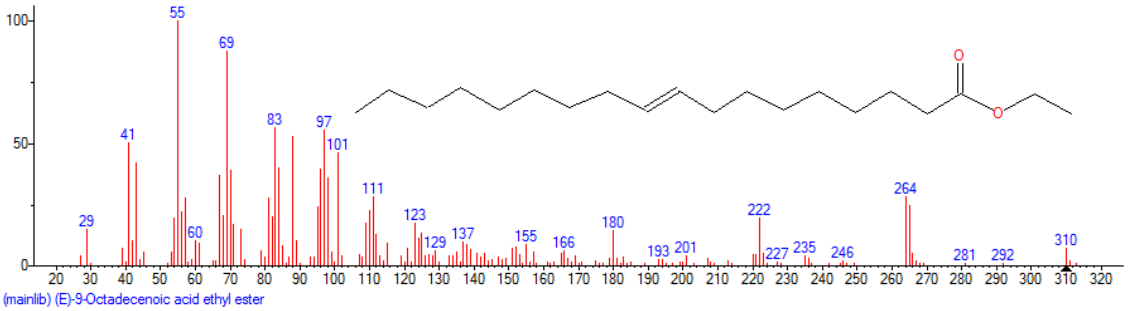

Figure 7. Mass spectrum of (E)-9-Octadecenoic acid ethyl ester structure (3.68 %, RT 19.812).

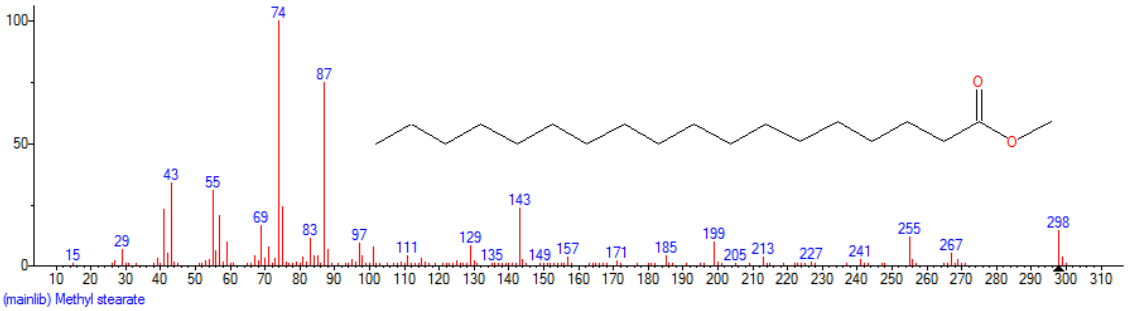

Figure 8. Mass spectrum of Methyl stearate structure (6.99%, RT 19.366).

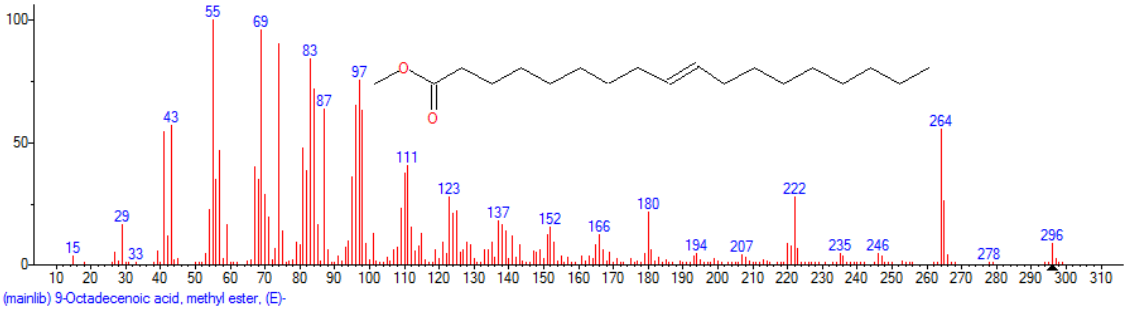

Figure 9. Mass spectrum of 9-Octadecenoic acid, methyl ester (E) structure (6.04 %, RT 19.229).

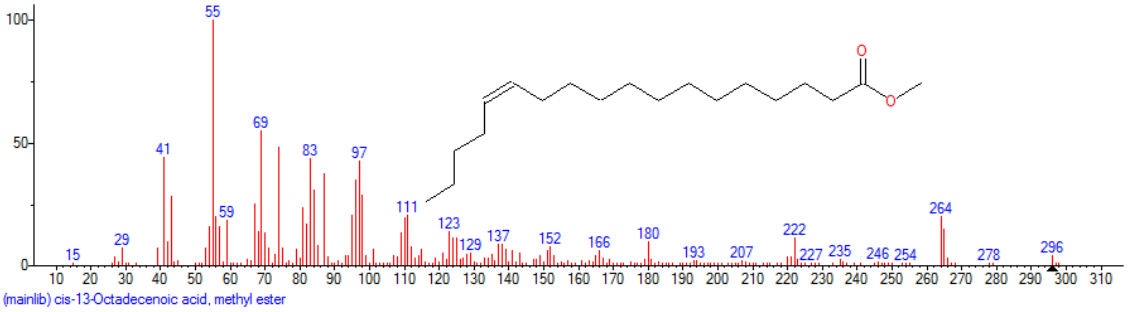

Figure 10. Mass spectrum of 13-Octadecenoic acid, methyl ester structure (40.52 %, RT 19.200).

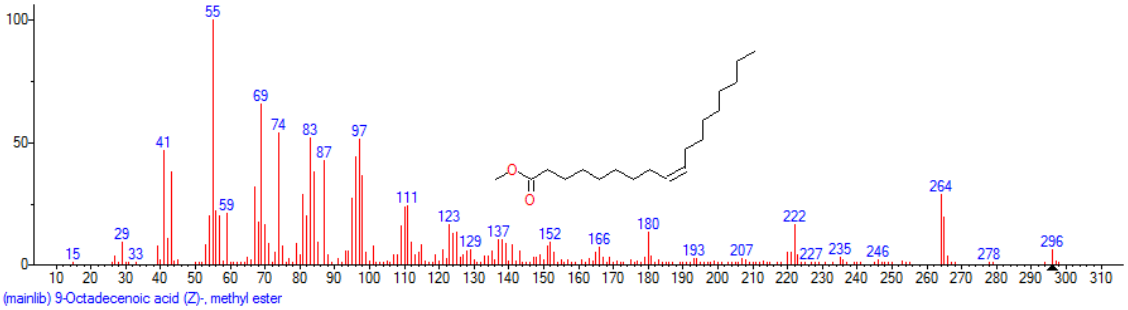

Figure 11. Mass spectrum of 9-Octadecenoic acid (Z)-, methyl ester structure (25.49 %, RT 19.097).

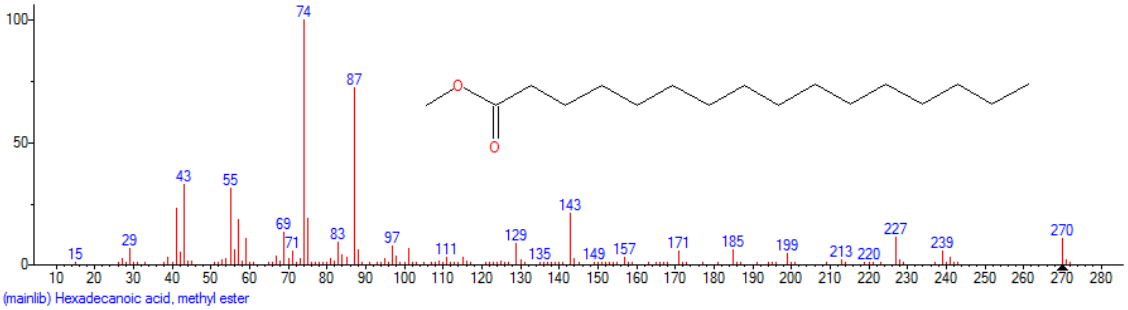

Figure 12. Mass spectrum of Hexadecanoic acid, methyl ester structure (6.92 %, RT 16.865).

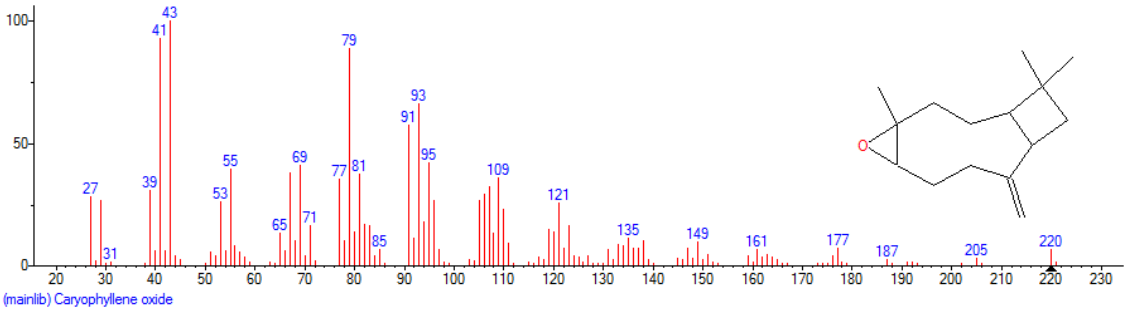

Figure 13. Mass spectrum of Caryophyllene oxide structure (1.62 %, RT 12.122).

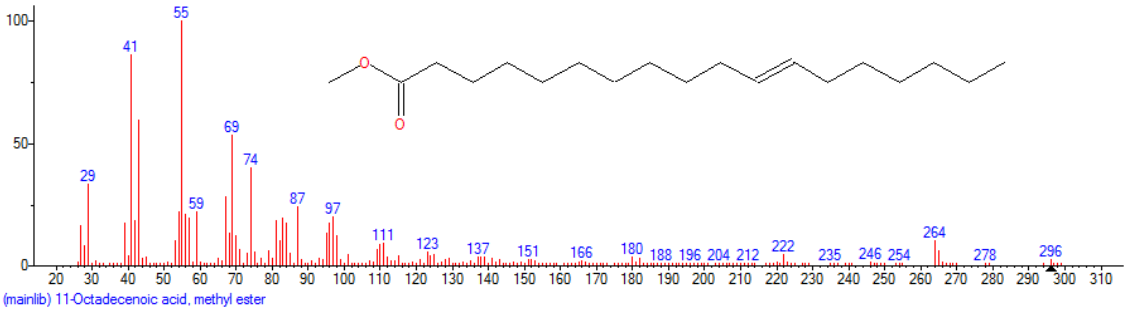

Figure 14. Mass spectrum of 11-Octadecenoic acid, methyl ester structure (78.39 %, RT 19.102).

4. DISCUSSION

Plants contain numerous phytochemical constituents, many of which are known to be biologically active compounds and can be used in the synthesis of drugs. The result for mineral analysis of fresh neem leaf, stem and root show the concentration of minerals such as Fe, Cu, Na, Mg, K, and Ca in the plants. Other research work also confirms the presence of vital minerals in *A.indica* plant [22]. The Na+/k+ ration of *A. indica* leaf, stem and root is

also less than one, based on daily recommendation which suggest that *A. indica* could be suitable for reducing high blood pressure. The mineral contents of *A. indica* in this study are lower than the percentage recommended by the Food and Agriculture Organization [23]. Sodium is 2400 mg, potassium (4700 mg) and calcium (1000 mg). This suggests the need to supplement a diet base on *A. indica* with complementary mineral elements to make it more nutritious.

Gas chromatography coupled with mass spectrometry (GC-MS) is an established technique for reliable identification of bioactive compounds existing in medicinal plants including volatile matter, long chain and branched chain hydrocarbons, alcohols, acids, esters [24-27] For quantitative determination, gas chromatography with flame ionization detector (GC-FID) and GC-MS are preferred [28,29]. The GC-MS analysis was based on the computer evaluation of mass spectra of samples through NIST by direct comparison of peaks and retention time with those for standard compounds, with eight peak index [30] and computer matching with the NIST. Besides that, the characteristic fragmentation patterns greatly helped in the identification of a particular class of compounds [30]. The identified compounds of the hexane extract of the leaf, root and stem of *Azadirachta indica* ***A. Juss,*** their retention time, peak area, molecular formulae, molecular weight, and their activities are given in the result. The GC-MS results showed the presence of twenty three compounds in the different parts of the plant. Out of which 10 compounds are found in the leaf: Caryophyllene oxide (1.62%), Hexadecanoic acid, methyl ester (6.92%), 9-Octadecenoic acid(Z)-, methyl ester (25.49%), cis-13-Octadecenoic acid, methyl ester (40.52%), 9-Octadecenoic acid, methyl ester (E) (6.04%), Methyl stearate (6.99%), (E)-9-Octadecenoic acid ethyl ester (3.68%), cis-11-Eicosenoic acid, methyl ester (2.29%), Methyl 18-methylnonadecanoate (2.65%) and Docosanoic acid, methyl ester (3.79%). The stem contain six compounds: Hexadecanoic acid, methyl ester (5.64%), 11-Octadecenoic acid, methyl ester (78.39%), (E)-9-Octadecenoic acid ethyl ester (2.81%), Methyl stearate (6.29%), Methyl 18-methylnonadecanoate (2.62%), Docosanoic acid, methyl ester (4.24%). Seven compounds were found in the root, they are: Hexadecanoic acid, methyl ester (7.51%), 9-Octadecenoic acid, methyl ester (70.14%), Methyl stearate (6.78%), (E)-9-Octadecenoic acid ethyl ester (4.03%), cis-11-Eicosenoic acid, methyl ester (2.79%), Methyl 18-methylnonadecanoate (3.04%) and Docosanoic acid, methyl ester (5.72%). The GC-MS of *A. indica* has also been reported by other research studies to contain bioactive compounds [31-32]. Chenganmal and Yamalai shows that neem flower extract revealed the existence of GC-MS chromatogram of thirty peaks present. Eight chemical components were identified by GC-MS analysis. The major constituents were Caryophyllene(4.29%), n-Hexadecanoic acid(27.41%), 9,12,15-Octadecatrienoic acid, (Z,Z,Z) (3.74%), 9,12-Octadecadienoic acid (Z,Z) (3.58%),which possess many biological activities [33]. Mohammad (2016) explains the medicinal important of *Azadirachta indica* (Neem) as follows: anti-Inflammatory, hepatoprotective effect, wound healing effect, antidiabetic activity, antinephrotoxicity effect, neuroprotective effects, antimicrobial effect, immunomodulatory and growth promoting effect and that *A. indica* mouth rinse is equally effective in reducing periodontal indices. In the compounds obtained, some components were biological active; of anti-inflammatory, antifungal, antioxidant and anticancer. All these compounds are important in the formulation of different medicines. Hexadecanoic acid, methyl ester is used as antioxidant, anti-inflammatory, possess hypolipidemic properties and is also used as an antimicrobial agent [19,20]. 9-Octadecenoic acid (Z)- methyl ester has antioxidant activity, is anticarcinogenic; used as dermatitigenic flavour and exists in human blood and urine where it serves as endogenous peroxisome proliferator-activated receptor ligand.[20,21]. 9-Octadecenoic acid, methyl ester (E) posses antioxidant properties and anti cancerous activities [20, 21]. Methyl stearate is used as solvents or cosolvents and oil carrier in agricultural industry. 13-Octadecenoic acid methyl ester is used as fatty acids, which

selectively inhibit eukaryotic DNA polymerase activities *in vitro* [34]. This study shows the formulae and structures of active compounds which may be used in the synthesis of drugs. This result also enhances the traditional usage of *A. indica* which possesses a number of bioactive compounds.

5. CONCLUSION

The result of the GC-MS analysis showed that the hexane extract of *Azadirachta indica A. Juss* contains many pharmacologically important biological bioactive compounds.

CONFLICT OF INTEREST STATEMENT

We declare that we have no conflict of interest.

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REFERENCES

1. Hill RA. Terpenoids. In Thomson RH, (ed). Chemistry of Natural Products, Blackie Academic and Professional. London. 1985; 106-134.

2. Bailey LH, 1953. The Standard Cyclopedia of Horticulture", The Macmillan Company, New York.

3. Engler A, Melchoir H and Werdmann E. Syllabus der Pflanzenfamilien. Gebruder Borntraeger, Berlin, Germany; 1964.

4. Chopra RN, Nayer SL and Chopra IC. Glossary of Indian Medicinal Plants, CSIR, New Delhi.1956.

5. Chopra RN, Chopra IC, Handa KL and Kapur LD, 1958. Indigenous Drugs of India, U.N. Dhur and Sons, Kolkata, 1958; pp. 51–595.

6. Kirtikar KR and Basu BD. Medicinal Plants (eds Blatter, E., Cains, J. F., Mhaskar, K. S.), Vivek Vihar, New Delhi, 1975; p. 536.

7. Koul O, Isman MB and Ketkar CM. Properties and uses of neem, *Azadirachta indica*. *Can. J. Bot.* 1990*;* 68, 1–11.

8. Chatterjee A and Pakrashi S. The Treatise on Indian Medicinal Plants,1994; 3, p. 76.

9. El-Hawary SS, El-Tantawy ME, Rabeh MA, Badr WK, *Intern Journ of Appl Res in Natural Products*, **2013**;6: 33.

10. Dholi SK, Ramakrishna R, Mankala SK and Nagappan K. *Invivo* Antidiabetic evaluation of Neem leaf extract in alloxan induced rats. *Journal of applied Pharmaceutical science*, 2011; 7, 100-105.
11. Sonia B and Srinivasan BP. Investigation into the Anti diabetic activity of *Azadirachta indica*. *Indian journal of pharmacology*, 1999; 31.138-141.
12. Saseed AK and Aslam J. Study on the effect of Neem (*Azadirachta indica*) leaves smoke in controlling airborne Bacteria in Residential premises. *Current research in Bacteriology*, 2008; 1 (2). 64-66.
13. EI- Mahmood AM, Ogbonna OB and Raji M.The antibacterial activity of *Azadirachta indica* (Neem) associated with eye and ear infections. *Journal of medicinal plant Research*, 2010; 4 (14).1414-142.
14. Maragathavalli S, Brindha S, Kaviyarasi NS, Annadurai B and Gangwar SK. Antimicrobial activity in leaf extract of neem (*Azadirachta indica* linn.) *I.j.s.n.,* 2012*;* vol. 3(1). 110-113.
15. Parmar Namitha, Rawat Mukesh, *Intern Res Journ of Pharma*, **2012**;3:31.
16. Principe P. Monetising the pharmacological benefits of plants. US Environmental protection Agency, Washington, D.C. 2005; pp. 1991.
17. Stenhagen E, Abrahamson S and McLafferty F. Registry of Spectral Data. J. Wiley and Sons, New York, NY, 1974.
18. Jennings W and Shibamoto T, Quality of Flavour and Fragrance Volatiles by Glass Capillary Gas Chromatography. Academic Press, New York, NY 1980.
19. Akpuaka A., Ekwenchi, MM, Dashak DA and Dildar A. Biological Activities of Characterized Isolates of n-Hexane Extract of *Azadirachta indica* A. Juss (Neem) Leaves. New York Sci. J, 2013; 6(6):119-124.
20. Hema R., Kumaravel S., Alagusundaram. GC/MS Determination of Bioactive components of *Murraya koenigii*. Journal of American Science. 2011;7(1):80-82.
21. Syeda FA, Habib-ur-Rahman AM, Khan, Choudahry M.I, Atta-Ur-Rahman. *Inter. J. Genetics Mol. Biol*. 3, 2011; 95.
22. Afolabi G, Oluwade A, Tunde O. Estimation of proximate and mineral composition of some tropical Crops. African Agricultural Journal. 1995; 21:103.
23. FAO. Law and sustainable development in Rio: Legal trends in agriculture and natural resource management. FAO Legislative Study. 2003;73.
24. Sermakkani M, Thangapandian V. GC-MS analysis of Cassia italic a leaf methanol extract. Asian Journal of Pharmaceutical and Clinical Research. 2012;5(2):90-94.

25. Kumar A, Kumari PS, Somasundaram T. Gas Chromatography-Mass Spectrum (GC-MS) analysis of bioactive components of the methanol extract of *Halophyte, Sesuvium portulacastrum L.* IJAPBC. 2014;3(3):766-772.

26. Cong Z, Meiling Q, Qinglong S, Shan Z, Ruonong F. J. Pharm. Biomed. Anal. 2007; 44:464.

27. Johnson M, Mariswamy Y, Gnaraj WF. Chromatographic finger print analysis of steroids in *Aerva lanasa* L. by HPTLC technique. Asian Pal. J. Trop. Biomedicine. 2011;1:428-433.

28. Haznagy-Radnal E, Czigle S, Mathe I. TLC and GC analysis of the essential oils of Stachys species. Journal of Planar Chromatography. 2007;20:189-196.

29. Lampronti I, Saab AM, Gambari R. Antiproliferative activity of essential oils derived from plants belonging to the Magnoliophyta division. Int. J. Oncol. 2006;29:989.

30. Mass Spectrometry Data Centre. Eight peak index of mass spectra: the eight most abundant ions in 31,101 mass spectra, indexed by molecular weight, elemental composition and most abundant ions (4 volume set). 2nd ed. Aldermaston: Mass Spectrometry Data Centre; 1974.

31. Akpuaka1 A, Ekwenchi1 MM, Dashak1 DA, Dildar A. Gas Chromatography-Mass Spectrometry (GC/MS) Analysis of Phthalate Isolates in n-Hexane Extract of *Azadirachta indica A. Juss* (Neem) Leaves. *J Am Sci* 2012;8(12):146-155.

32. Jessinta S, Nour AH, Tajuddin SN and Nour AH. Chemical Characterization and Biological Study of *Azadirachta* indica Extracts. European Journal of Academic Essays. 2014; 1(10): 9-16.

33. Chenganmal M and Yamalai M. Determination of bioactive components in *Azadirachta indica* flowers using GC-MS analysis. Asian Journal of Plant Science and Research, 2015, 5(8):61-65.

34. Yoshiyuki M, Nobukazu T, Hisaaki Y, Takayoshi K, Megumi O, Hirokazu S, Horie T, Norikazu A, Masakazu Y, Akio M, Shonen Y, Kengo S. Fatty acids selectively inhibit eukaryotic DNA polymerase activities *in vitro*: Biochimica et Biophysica Acta (BBA)-Gene Structure and expression, 1996, 1308(3): 256-262.

35. Mohammad A. Alzohairy. Therapeutics Role of *Azadirachta indica* (Neem) and Their Active Constituents in Diseases Prevention and Treatment Hindawi Publishing Corporation Evidence-Based Complementary and Alternative Medicine Volume 2016, Article ID 7382506, 11 pages http://dx.doi.org/10.1155/2016/7382506.

36 Van den Dool, H.; Kratz, P.D. A generalization of the retention index system including linear temperature programmed gas-liquid partition chromatography. *J. Chromatography A* **1963**, *11*, 463–471.