



Full Length Research Article



Assay of Bioactive Compounds in Stored Kolanuts

Olahan, G.S.¹, Ajadi, I.¹ and Issa, B.T.¹

¹Department of Plant Biology, University of Ilorin, Nigeria.

*Corresponding Author's Email: olahan.gs@unilorin.edu.ng; +2348065919065)

Article History: Submitted, 14/11/2023, Accepted, 28/01/2023.

Abstract

Kolanuts are widely consumed by humans. The medicinal and therapeutic potentials of plants are credited to their bioactive compounds. This study was aimed at investigating the bioactive compounds in kolanuts from Ifelodun and Odo-Otin Local Government Areas of Osun State, popular kolanut producing LGAs in Nigeria. The bioactive compounds were identified using Gas Chromatography-Mass Spectrometry (GC-MS) to analyse crude extracts of the kolanuts using acetone:methanol (1:1 v/v) as the extractant. Twenty five (25) bioactive compounds were identified, with 9-Octadecenoic acid, methyl ester (32.91%) being the predominant compound. Six (6) of the bioactive compounds were common in all the kolanuts (caffeine, hexadecanoic acid, methyl ester, n-hexadecanoic acid, 9, 12-Octadecadienoic acid, methyl ester (z,z), methyl stearate, and phthalic acid, di(oct-3-yl) ester). Some of the bioactive compounds were identified only in the kolanuts from Ifelodun L.G.A. e.g. nonanoic acid, methyl-2-octylcyclopropene-1-heptanoate, 9octadecanoic acid (z), 9-octadecanoic acid. Also, 11-octadecanoic acid, methyl ester (z), 2chloroethyl linoleate, bicyclo (4.1.0) heptane, etc were present only in the kolanuts from Odo-Otin L.G.A. Out of the 25 bioactive compounds identified, only 12 have been reported to be present in kolanuts some of e.g. caffeine, n-Hexadecanoic acid, etc, while the remaining 13 have been reported in other plants other than kolanuts.

Keywords: (Kolanut, bioactive compounds, caffeine, dodecanoic acid, GC-MS)

Introduction

In the West African region, *Cola acuminata* and *C. nitida* produce seeds referred to as kolanuts, which have many applications in the areas of medicine, the economy, society, and other spheres. The three main dialects in

Nigeria have the names "Obi" by Yoruba, "Goro" by Hausa, and "Oji" by Igbo people for it. Many individuals eat a lot of these seeds, and a few of them are addicted. Kola nut extracts are also used for making a number of non-alcoholic beverages such as soft

drinks, wines, chocolate, as well as sweets (Asogwa *et al.*, 2006). In a bid to manufacture nanoparticles of silver with extremely strong antibacterial activities in an environmentally friendly manner, Lateef *et al.* (2016) utilized extracts from kolanut seed and its outer shell. The usage of kolanut seed aqueous extracts as a flavoring additive for carbonated drinks was additionally acknowledged by Adebayo and Oladele (2012).

Previous investigations have extracted a variety of secondary metabolites from kolanut seeds among which are theobromine, caffeine, theophylline, epicatechin, catechin, procyanidins, proanthocyanidins, kolatin, kolanin; quinic-, tetradecanoic-, tridecanoic-, dodecanoic-, nonanoic-, tannic- and chromogenic- acid as well as aliphatic and heterocyclic amines (Atawodi *et al.*, 1995; Odebode; 1996; Atawodi *et al.*, 2007; Mitani *et al.*, 2007; Niemenak *et al.*, 2008; Salahudeen *et al.*, 2015; Adesanwo *et al.*, 2017a; Julius *et al.*, 2017). Most, if not all the aforementioned secondary metabolites have significant therapeutic value and can treat various human diseases (Jaksa *et al.*, 2013; Buraimoh *et al.*, 2014). The aim of this work was to employ gas chromatography-mass spectrometry (GC-MS) to examine if kolanuts from two of Nigeria's largest kolanut producers, Ifelodun and Odo-Otin Local Government Areas of Osun State, contained any of the secondary metabolites mentioned above.

Materials And Methods Samples

Collection: Kolanut seeds were purchased from 2 locations (Ikirun I and Ikirun II) in Ifelodun local Government Area and 4 locations (Ekosin I, Ekosin II, Okuku I and Okuku II) in Odo-Otin Local Government Areas, all in Osun State, Nigeria. They were bulked on the basis of the Local Government Area from where they were purchased and properly labeled.

Preparation of the Samples for Extraction:

The kolanut seeds were dried out at 60°C for a period of 48 hours before being ground into 1 mm-sized particles in the plant biology department's laboratory at the University of Ilorin, Ilorin. Each ground sample was subsequently placed into an air-tight zip bag and issued a tag. Then, for extraction employing acetone and methanol in (1:1 v/v), the procedures of Khan *et al.* (2007) and Riazuddin *et al.* (2011) were adapted in the Chemical Engineering Laboratory, University of Ilorin, with just a few modifications namely; the use of mechanical shaker instead of glass-rod, and 150 mL of sodium sulphate instead of 200 mL .

Analytical-grade reagents were employed throughout. The extracts were then concentrated with a rotary evaporator at 37°C for 30 minutes to yield about 2 mL.

Phytochemical Screening of the Dried

Extracts: It was carried out on a Gas Chromatography Mass Spectrophotometer (GC-MS) Agilent Technologies 8890 Series GC System equipped with an Agilent 5977B Mass Selective detector Electron Impact Ionization (GC-MS). The HP-5 capillary column had a length of 30 m, an internal diameter of 0.32 mm, a film thickness of 0.25 µm, and was filled with 5% phenyl methyl siloxane. Under the following conditions: injection port 250°C (split-less, pressure 8.35 psi, purge flow 30 ml/min; purge time 1.0 min; total flow 35.35 ml/min); the GC-MS was operated in the chosen ion-monitoring mode. Column oven: initial 90°C kept for 3 minutes; 15 minutes of programming at 30°C/minute (between 90 to 200°C). (200 to 265°C) for 5 minutes, followed by 15 minutes at a rate of 3°C/min (265 to 276°C). The separated components flowed out of the column and into the Mass Spectrometer (MS), where analysis was completed. By comparing the retention indices and mass spectra of the bioactive compounds with the ones in the National Institute of Standards and

Technology (NIST) Library, the compounds were identified.

Results

Table 1 contains the Retention Times (R.T.s), Molecular Formulae, Molecular Weights, Compound Nature, Peak Area, Biological Activity and Names of the 14 bioactive compounds identified in the kolanut sample from Ifelodun local government area of Osun State, while Table 2 contains the same parameters for the 11 bioactive compounds identified in the kolanut sample from OdoOtin Local Government Area of Osun State in this study. Out of the total of 25 bioactive compounds, 6 were common in the kolanut samples from the two different Local government Areas, namely: caffeine, hexadecanoic acid, methyl ester, nhexadecanoic acid, 9, 12-Octadecadienoic acid, methyl ester (z,z), methyl stearate, and phthalic acid, di(oct-3-yl) ester (**Tables 1 and 2**). The following bioactive compounds were identified only in the kolanut sample from Ifelodun L.G.A., i.e. nonanoic acid, methyl-2-

octylcyclopropene-1-heptanoate, 9octadecanoic acid (z), 9-octadecanoic acid, methyl ester, methyl 2-octylcycloprone-1octanoate, 9,12-octadecadienoic acid, cisvaccenic acid and tetradecanoic acid (**Table 1 and Fig. 1**). Also, 11-octadecanoic acid, methyl ester (z), 2-chloroethyl linoleate, bicyclo (4.1.0)heptane, 3-methyl, cyclopropaneoctanoic acid, 2-octyl-, methyl ester, and cis-, tridecanoic were present only in the kolant sample from Odo-Otin L.G.A. (**Table 2 and Fig. 2**). Out of the 25 bioactive compounds identified in this study, only 12 have been previously reported in kolanut samples, i.e. caffeine, n-Hexadecanoic acid (Palmitic acid), Hexadecanoic acid, methyl ester, Cis-vaccinic acid, Dodecanoic acid, Tridecanoic acid, Tetradecanoic acid, Methyl 2-Octylcyclopropene-1-octanoate, 9Octadecanoic acid and Octadecenoic acid, methyl esters of different stereoisomers which include 9- Octadecanoic acid, methyl ester; 9,12-Octadecadionic, methyl ester (E, E) and 9, 12-Octadecadionic, methyl ester (Z,Z) (**Tables 1 and 2**).

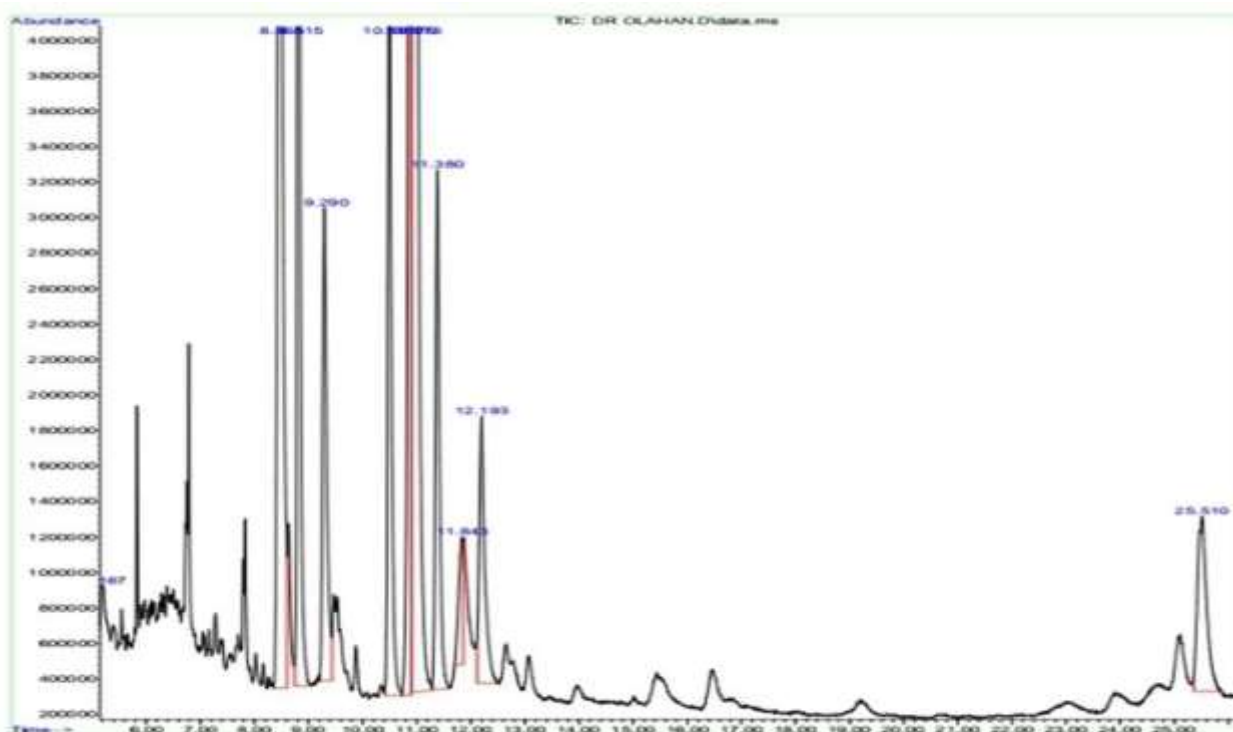


Fig. 1: GC-MS chromatogram of kolanut samples collected from Ifelodun Local Government Area

Table 1: Bioactive Compounds in Sample from Ifelodun Local Government Area of Osun State

S/N	Name	RT.	Peak Area	MF	Mw (g)	Compound Nature	Biological activity
1.	Nonanoic acid	5.187	1.02	C ₉ H ₁₈ O ₂	158.24	Saturated Fatty acid	Antimicrobial
2.	Caffeine	8.465	16.03	C ₈ H ₁₀ N ₄ O ₂	194.19	Methylxanthine Alkaloid	Anti-inflammatory and Bronchodilator
3.	Hexadecanoic acid, methyl ester	8.815	15.65	C ₁₇ H ₃₄ O ₂	270.50	Fatty acid methyl ester	Antioxidant, antiinflammatory and anti-microbial.
4.	n-Hexadecanoic acid	9.290	4.98	C ₁₆ H ₃₂ O ₂	256.43	Fatty acid	Antioxidant
5.	Methyl-2octylcyclopropene-1heptanoate	10.491	7.17	C ₁₉ H ₃₄ O ₂	294.5	Unsaturated Fatty acid	Antimicrobial
6	9,12-Octadecadienoic acid, methyl ester (Z,Z)-	10.879	8	C ₁₉ H ₃₄ O ₂	294.5	Poly Unsaturated Fatty acid	Antioxidant and anti-athritic
7.	9-Octadecenoic acid, methyl ester	10.973	32.91	C ₁₉ H ₃₆ O ₂	296.5	Fatty acid Methyl ester	Antioxidant, anticancer and antiinflammatory
8.	Methyl stearate	11.380	5.30	C ₁₉ H ₃₈ O ₂	298.5	Fatty acid Methyl ester	Antioxidant, antimicrobial and gastrin inhibitor
9.	Cis-Vaccenic acid	11.842	1.36	C ₁₈ H ₃₄ O ₂	282.5	Fatty acid	Antioxidant, anticancer and antiinflammatory
10	Methyl 2-Octylcyclopropene-1octanoate	12.193	3.61	C ₂₀ H ₃₆ O ₂	308.5	Unsaturated Fatty acid	Antioxidant
11	Phthalic acid, di(oct-3yl) ester	25.510	3.97	C ₂₄ H ₃₈ O ₄	390.6	Alkanoate	Antimicrobial
12	Tetradecanoic acid	9.290	4.98	C ₁₄ H ₂₈ O ₂	228.37	Saturated Fatty acid	Antioxidant, anticancer and antiinflammatory
13	9,12-Octadecadienoic acid, methyl ester (E,E)	10.879	8.00	C ₁₉ H ₃₄ O ₂	294.4	Fatty acid methyl ester	Antiperoxidation, antioxidant and antiarthritic
14	9-Octadecenoic acid (Z)-	11.842	1.36	C ₁₈ H ₃₄ O ₂	282.4	Fatty acid	Antioxidant and antimicrobial

Keys: SN= Serial Number; RT= Retention Time (Mins); MF =Molecular Formula; MW= Molecular Weight

Table 2: Bioactive Compounds in the Sample from Odo-Otin Local Government Area of Osun State

S/N	Names	RT	Peak Area	MF	Mw(g)	Compound Nature	Biological activity
1	Caffeine	8.465	12.59	C ₈ H ₁₀ N ₄ O ₂	194.19	Methylxanthine Alkaloid	Anti-inflammatory and Bronchodilator
2	Hexadecanoic acid, methyl ester	8.815	20.13	C ₁₇ H ₃₄ O ₂	270.50	Fatty acid Methyl ester	Antioxidant, antiinflammatory and anti-microbial
3	n-Hexadecanoic acid	9.309	2.69	C ₁₆ H ₃₂ O ₂	256.43	Fatty acid	Antioxidant
4	2-Chloroethyl Linoleate	10.491	7.62	C ₂₀ H ₃₅ ClO ₂	342.9	Fatty acid Methyl ester	Antiinflammatory
5	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	10.873		C ₁₉ H ₃₄ O ₂	294.5	Fatty acid Methyl ester	Antioxidant
			14.04				
6	11-Octadecenoic acid, methyl ester, (Z)-	10.979	26.71	C ₁₉ H ₃₆ O ₂	296.5	Fatty acid Methyl ester	Antimicrobial
7.	Methyl stearate	11.380	6.48	C ₁₉ H ₃₈ O ₂	298.5	Fatty acid Methyl ester	Antimicrobial and antioxidant
8.	Bicyclo[4.1.0]heptane, 3methyl-	12.193	3.64	C ₈ H ₁₄	110.2	Cycloalkane	Anti-obesity and food flavor
9.	Cyclopropaneoctanoic acid, 2-octyl-, methyl ester, cis-	13.075	0.92	C ₂₀ H ₃₈ O ₂	310.5	Cycloalkane Fatty acid Methyl ester	Antiinflammatory
10	Phthalic acid, di(oct-3-yl) ester	25.510	3.97	C ₂₄ H ₃₈ O ₄	390.6	Alkanoate	Antimicrobial
11	Tridecanoic	9.309	2.69	C ₁₃ H ₂₆ O ₂	256.43	Fatty acid	Antihelminthic

Keys: SN= Serial Number; RT= Retention Time; MF= Molecular formula; Mw=Molecular weight

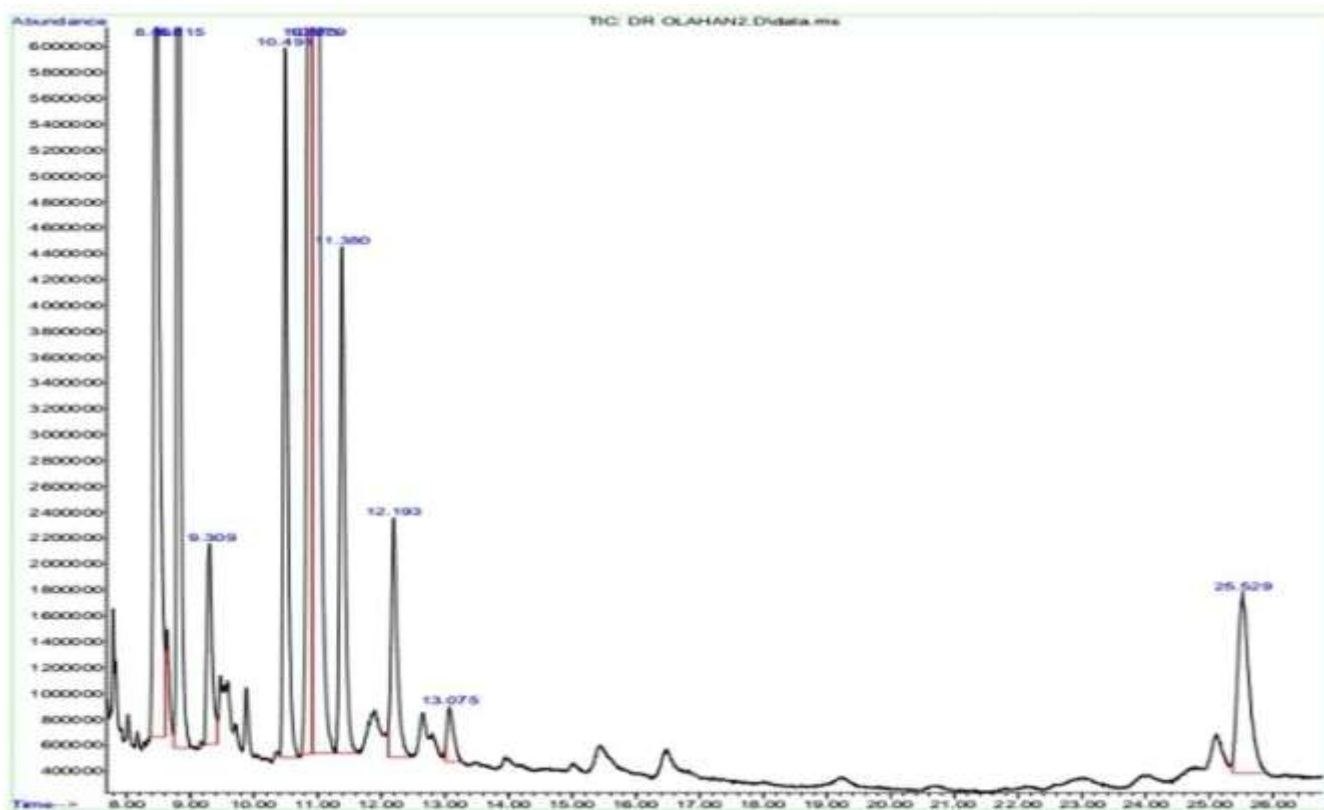


Fig. 2: GC-MS chromatogram of kolanut samples collected from Odo-Otin Local Government Area

some were found only in samples collected from Odo-Otin L.G.A.

Discussion

Gas Chromatography-Mass Spectrometry (GC-MS) analysis of crude extracts of kolanut seeds obtained using acetone:methanol (1:1 v/v) as extractants in this present investigation showed a total of 25 bioactive compounds, with 9-Octadecenoic acid, methyl ester (32.91%) being the most abundant compound depending on its RT and peak area percentage (Tables 1 and 2). Six (6) bioactive compounds were common to the kolanut samples from the two study areas (caffeine, hexadecanoic acid, methyl ester, n-hexadecanoic acid, 9, 12-Octadecadienoic acid, methyl ester (z,z), methyl stearate, and phthalic acid, di(oct-3yl) ester). Some bioactive compounds were identified only in the kolanuts from Ifelodun L.G.A., while

The difference in the bioactive compounds could be due to variations in the soil composition and cultivation methods of the two study areas (Abdoudramane et al., 2021). Twelve of the twenty five bioactive compounds have earlier been identified in kolanut seeds by Salahdeen et al. (2015), Adesanwo et al. (2017a) and Adesanwo et al. (2017b), respectively, namely: caffeine, nHexadecanoic acid, Hexadecanoic acid, methyl ester, Cis-vaccinic acid, Dodecanoic acid, Tridecanoic acid, Tetradecanoic acid, Methyl 2-Octylcyclopropene-1-octanoate, 9Octadecanoic acid and Octadecenoic acid, methyl esters of different stereoisomers which include 9- Octadecanoic acid, methyl ester; 9,12-Octadecadienoic, methyl ester (E, E) and 9, 12-Octadecadienoic, methyl ester

(Z,Z).

Various plants, other than kolanut seeds, have been found to contain the remaining compounds. Jayashree et al. (2018) confirmed the occurrence of 2-Chloroethyl Linoleate in *Cyprus Rotundus*; Ganesh and Mohankumar (2017) reported the discovery of nonanoic acid in *Sida cordata*; while Babaiwa et al. (2020) reported the finding of phthalic acid methyl ester. Toha et al. (2020) reported the existence of bicyclo (4.1.0) heptane, 3-methyl- in the leaf extract of *Clinacanthus nutans*; cyclopropaneoctanoic acid, 2-octyl-, methyl ester, cis has been reported from *Gracilaria* spp. (Tomaz et al., 2012); Methyl stearate was found in Australian lupin species, according to Mazumder et al. (2020), and 11octadecanoic acid, methyl ester was found in *Acacia nilotica* seeds, reported by Shoge and Amusan (2020).

Most of the discovered compounds have been found to exhibit intriguing biological properties. The antibacterial and antifungal properties of 9,12-octadecadienoic acid, methyl ester (E,E), Nonanoic acid, Tetradecanoic acid, Dodecanoic acid, Hexadecanoic acid, methyl ester, octadecanoic acid methyl ester have been reported (Sahin et al., 2006; Okada et al., 2011; Rahman, 2014; Adeniyi et al., 2017; Julius et al., 2017), while Tridecanoic acid, phthalic acid methyl ester, cis-vaccinic acid and methyl stearate only have an effect on species of bacteria (Seanego and Roland, 2012; Semwal et al., 2018; Babaiwa et al., 2020; Nakaziba et al., 2022). Caffeine, n-Hexadecanoic acid, Methyl-2octylcyclopropene-1-heptanoate, bicyclo (4.1.0) heptane, 3-methyl, cis-vaccinic acid and tetradecanoic acid have anti-oxidant property (Okada et al., 2011; Abubakar and

Majinda, 2016; Hussein and Hamad, 2020; Qadir et al., 2020; Toha et al., 2020).

11-octadecanoic acid, methyl ester and 9,12octadecadienoic acid, methyl ester (Z,Z) have antidiarrheal property (Hadi et al., 2016; Shoge and Amusan, 2020). 2-Chloroethyl Linoleate has anti-diabetic property (Jayashree et al., 2018). According to Salini et al. (2014), hexadecanoic acid methyl ester appears to possess a potential to lower blood cholesterol and selectively inhibits cyclooxygenase II enzymes, which results in a specific anti-inflammatory effect (Hema et al., 2011). Because fatty acids, fatty acid esters, and aliphatic chains (long chain alkanes and alkenes) typically accumulate within the lipid layer that covers the cell membrane as well as mitochondria, these chemical compounds possess antibacterial and cytotoxic properties. As a result, the cell structure is compromised and gets porous (Solorzano-Santo and MirandaNovales, 2012). According to Okwu and Morah (2006), fatty acids that are unsaturated are also known for lowering blood cholesterol levels.

Conclusion and Recommendation Twenty five (25) bioactive compounds were identified in the stored kolanut samples analysed in this study; out of which only 12 have been previously reported in stored kolanut seeds. All the bioactive compounds reported in this study are of great therapeutic values and can be used to treat a wide range of human diseases.

Author's Contributions: This manuscript is culled from an undergraduate project under the supervision of the Corresponding Author

References

Abdoudramane, W.D.B., Virginie, M.D., Aimée, G. and Edwige, B.O. (2021).

- Impact of organic or conventional cultivation and drying method on phenolic compounds, carotenoids and vitamin C contents in tomato. *World J. Adv. Res. Rev.*, 10: 360-372.
- Abubakar, M.N. and Majinda, R. (2016). GC-MS Analysis and Preliminary Antimicrobial Activity of *Albizia adianthifolia* (Schumach) and *Pterocarpus angolensis* (DC). *Medicines*, 3(3): 1 - 9.
- Adebayo, S.A. and Oladele, O.J. (2012). Medicinal values of kolanut in Nigeria: an implication for extension services delivery. *Life Sciences Journal*, 9(2): 887 - 891.
- Adeniyi, A., Ayodele, O.D. and Akinuoye, G.A. (2017). Comparative Study of the Proximate and Fatty Acid Profiles of *Cola Nitida*, *Cola acuminata* and *Garcinia kola*. *American Journal of Food Science and Nutrition*, 4(6): 80 - 84.
- Adesanwo, J.K., Ogundele, S.B., Akinpelu, D.A. and McDonald A.G. (2017a). Chemical analyses, antimicrobial and antioxidant activities of extracts from *Cola nitida* seeds. *Journal of Exploratory Research in Pharmacology*, 2: 67-77.
- Adesanwo, J. K., Seun, B. O., David, A. A. and Armando, G. M. (2017b). Chemical Analyses, Antimicrobial and Antioxidant Activities of Extracts from *Cola nitida* Seed. *Journal of Exploratory Research in Pharmacology*, 2(3): 67 - 77.
- Asogwa, E.U., Anikwe, J.C. and Mokuwunye, F.C. (2006). Kola production and utilization for economic development. *African Scientist*, 7(4): 217 - 222.
- Atawodi, S.E., Mende, P., Pfundstein, B., Preussmann, R. and Spiegelhalder, B. (1995). Nitrosatable amines and nitrosamide formation in natural stimulant: *C. acuminata*, *C. nitida* and *Garcinia kola*. *Food Chem. Toxicol.*, 33(8): 625-630.
- Atawodi, S.E., Pfundstein, B., Haubner, R., Spiegelhalder, B., Bartsch, H. and Owen, R.W. (2007). Content of Polyphenolic Compounds in the Nigerian Stimulants *Cola nitida* ssp. *alba*, *Cola nitida* ssp. *rubra*, and *Cola acuminata* (Schott & Endl) and Their Antioxidant Capacity. *J. Agric. Food Chem.*, 55(24): 9824–9828.
- Babaiwa, U.F., Eraga, S.O., Ojugo, E.O., Erharuyi, O. and Akerele, J.O. (2020). A preliminary study on the antimicrobial activities and gas chromatography-mass spectrometry (GC-MS) analysis of the ethyl acetate extract of *Dennettia tripetala* G. Baker seeds. *Bio-Research journal*, 18(1): 1094-1102.
- Buraimoh, A.A., Sumanu, A. and Ojo, S.A. (2014). Histological observations of the cerebellum of wistar rat following the administration of ethanolic extract of *Cola nitida*. *Annals of Experimental Biology*, 2(1): 58 - 62.
- Ganesh, M. and Mohankumar, M. (2017). Extraction and identification of bioactive components in *Sida cordata* (Burm.f.) using gas chromatography–

- mass spectrometry. *J. Food Sci. Technol.*, 54(10): 3082-3091.
- Hadi, M.Y., Mohammad, G.J. and Hameed, I. H. (2016). Analysis of bioactive chemical compounds of *Nigella sativa* using gas chromatography-mass spectrometry. *Journal of Pharmacognosy and Phytotherapy*, 8(2): 8 – 24.
- Hema R., Kumaravel, S. and Alagusundaram, K. (2011). GC/MS determination of bioactive components of *Murraya koenigii*. *Journal of American Science*, 7: 80-83.
- Jaksa, S., Endrini, S., Umeda, M., Izzah, W.N., Zen, W.M. and Othman, F. (2013). Effects of *Cola nitida* on tumour marker enzymes in rat liver during hepatocarcinogenesis. *J. Med. Plant Res.*, 7(18): 1222 - 1226.
- Jayashree, S., Vijayalakshmi, K. and Thomas, R.R. (2018). Identification of Bioactive compounds in *Cyperus rotundus* by GC-MS Analysis and their inhibitory effect on Diabetic complications through Molecular Docking. *Indo American Journal of Pharmaceutical Research*, 8(09): 1711 - 1719.
- Khan, I.A.T., Riazuddin, P. Z. and Ahmed, M. (2007). Multi-residue determination of synthetic pyrethroids and organophosphorus pesticides in whole wheat flour using gas chromatography. *Bull Environ. Contam. Toxicol.*, 79:454–458
- Lateef, A., Azeez, M.A., Asafa, T.B., Yekeen, T.A., Akinboro, A. and Oladipo, I.C. (2016). Biogenic synthesis of silver nanoparticles using a pod extract of *Cola nitida*: Antibacterial, antioxidant activities and application as a paint additive. *Journal of Taibah University for Science*, 10(4): 551 - 562.
- Mazumder, K. Nabila, L. Aktar, A. and Farahnaky, A. (2020). Bioactive Variability and In Vitro and In Vivo Antioxidant Activity of Unprocessed and Processed Flour of Nine Cultivars of Australian lupin Species: A Comprehensive Substantiation. *Antioxidants (Basel)*, 9(4): 282.
- Mitani, H., Ryu, A., Suzuki, T., Yamashita, M., Arakane, K. and Koide, C. (2007). Tropical application of plant extracts containing xanthine derivatives to prevent UV induced wrinkle formation in hairless mice. *Photodermatol. Photoimmunol. Photomed.*, 3(2): 86 - 94.
- Nakaziba, R., Amany, S.B., Sesaaazi, C.D., Byarugaba, F., Ogwal-Okeng, J. and Alele, P.E. (2022). Antimicrobial Bioactivity and GC-MS Analysis of Different Extracts of *Corchorus olitorius* L. Leaves. Available @ <https://doi.org/10.1155/2022/3382302>
- Niemenak, N., Onomo, P.E., Lieberei, R. and Ndoumou, D.O. (2008). Purine alkaloids and Phenolic compounds in three *Cola* spp and *Garcinia cola* grown in Cameroon. *S. Afr. J. Bot.*, 74(4): 629 - 638.

- Odebode, A.C. (1996). Phenolic compounds in Kolanut (*C. nitida* and *C. acuminata*) (Sterculiaceae). *Revista de Biologia Tropical*, 44(2): 513-515.
- Okada, Y., Motoya, T., Tanimoto, S., & Nomura, M. (2011). A study on fatty acids in seeds of *Euterpe oleracea* Mart seeds. *J. Oleo. Sci.*, 60(9): 463-467.
- Okwu D.E., & Morah F.N.I. (2006). The potentials of *Garcinia kola* seeds as source for nutraceuticals. *J. Med. Arom. Plant. Sci.*, 28: 605.
- Qadir, A., Aqil, M., Ali, A., Ahmad, F.J., Ahmad, S., Arif, M. and Khan, N. (2020). GC-MS analysis of the methanolic extracts of *Smilax china* and *Salix alba* and their antioxidant activity. *Turk. J. Chem.*, 44(2): 352 – 363.
- Riazuddin, K., Iqbal, M.F. and Abbas, M. (2011). Determination of multiresidue insecticides of organochlorine, organophosphorus and pyrethroids in wheat. *Bulletin of Environment Contamination and Toxicology*, 87 (3): 303 - 306.
- Salahdeen, H.M., Omoaghe, A.O., Ishehunwa, G.O., Murtala, B.A. and Alada, A.R.A. (2015). Gas chromatography mass spectrometry (GC-MS) analysis of ethanolic extract of kolanut (*Cola nitida*) (Vent) and its toxicity studies in rats. *Journal of medicinal plants Research*, 9(3): 56 - 70.
- Sahin, N., Kola, I. and Erdogan, Y. (2006). Investigation of antimicrobial activities of nonanoic acid derivatives. *Fresenius Environmental Bulletin*, 15(2): 141 – 143.
- Salini, T.S, Divakaran, D., Shabanamol, S., Sharrel, R., & Jisha, M.S. (2014). *World J. Pharm. Res.*, 3: 87.
- Seanogo, C.T. and Roland, N.N. (2012). Identification and Antibacterial Evaluation of Bioactive Compounds from *Garcinia kola* (Heckel) Seeds. *Molecules, Multidisciplinary Digital Publishing Institute*, 17(6): 6569-6584.
- Semwal, P., Painuli, S. and Badoni, H. (2018). Screening of phytoconstituents and antibacterial activity of leaves and bark of *Quercus leucotrichophora* A. Camus from Uttarakhand Himalaya. *Clin. Phytosci.*, 4: 30.
- Shoge, M. and Amusan, T. (2020). Phytochemical, Antidiarrhoeal activity, Isolation and Characterisation of 11-Octadecenoic Acid, Methyl ester Isolated from the seeds of *Acacia nilotica* Linn. *Journal of Biotechnology and Immunology*, 2(1): 1 – 12.
- Solorzano-Santos, F. and Miranda-Novales M.G. (2012). Essential oils from aromatic herbs as antimicrobial agents. *Curr. Opin. Biotechnol.*, 23: 136.
- Toha, Z., Haron, N.H., Kamal, N.N.S. and Arsad, H. (2020). Antioxidant, Antiproliferative Activities and Chemical Profile of *Clinacanthus nutans* Leaf Extracts Processed Using Two Different Pre-Extraction Drying Methods. *Med. Aromat.*

Plants (Los Angeles) 9: 361.

Tomaz, A.A, Cavalcanti, G.E., Vanderlei, M.F. and Leitão, E.V. (2012). Analysis and characterization of methyl esters of fatty acids of some Gracilaria species. Biochemical Systematics and Ecology, 44: 303 306