Nigerian Journal of Pharmaceutical and Biomedical Research
Vol. 8 Issue.1 April, 2024. p-ISSN: 2579-1419 e-ISSN: 2814-1423

Profiling of Semi-polar Secondary Metabolites from the Methanol Leaf of *Murraya paniculata* (L.) Jack by Chromatographic Technique

Emmanuel E. Odion[1*], Daniel A. Ambe[2], Mary Akhere[1], Eravweroso C. Odiete[3]

[1]Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Benin, Benin City, Edo State, Nigeria.
[2]Department of Pharmacognosy and Natural Medicine, Faculty of Pharmacy, University of Uyo, Akwa-Ibom State, Nigeria.
[3]Department of Pharmaceutical Microbiology, Faculty of Pharmacy, University of Benin, Benin City, Nigeria
Email: emmanuel.odion@uniben.edu, doi.org.10.55639/njpbr.1011.001

Abstract
Murraya paniculata of family Rutaceae is likewise noted as Jasmine orange and its leaves are used in the treatment of stomach arch, gastralgia and menstrual flow booster. These potentials can be linked to the phytochemicals in the leaf. This work aim at evaluating these phytoconstituents in the leaves of Murraya paniculata by using established methods and chromatographic methods. Secondary metabolites in the pulverized leaf was determined by the used of standard methods and the phytoconstituents in the methanol leaf extract was determined by Gas Chromatography-Mass Spectrometry (GC-MS) and High Pressure Liquid Chromatography (HPLC). Phytochemical screening revealed alkaloids, steroids, flavonoids and glycosides. GC-MS analysis showed sixteen compounds, with 7-methyl-1,2-dihydroquinoxalin-2-one with the highest percentage area. HPLC analysis further confirmed benzamide-alkaloid. These justify the presence of different secondary metabolites with varying pharmacological potentials.

Keywords: *Murraya paniculata*, GC-MS, RHPLC, Secondary metabolites

Introduction

Murraya paniculata (L.) Jack is an evergreen tropical shrub belonging to the Rutaceae family. It originate in Australia, naturalized in south and southeast Asia and largely cultivated in different parts of the world for its landscaping potentials (Seidemann, 2005). The plant was first given the name *Chalcas paniculata* by Linnaeus Carl in 1767, other names by which *Murraya paniculata* is known by include; Jasmine orange, mock orange and China box. Jasmine orange is used for cultivar of *Murraya paniculata* species found in hot and warm climate (Nguyen *et al*., 2019). The plant have been reported with an average height of about 10 ft and differentiated by its alternate, hairless and shiny leaves. Each leaf occurs as 3 to 7 oddly compound leaflet, that is oval to cunnate-obovate 2.0 to 9.0 cm in length and 1.9 to 6.0 cm broad (Dosoky *et al*., 2016). Related species of *Murraya paniculata* have been identified-*Murraya lucida, Murraya omphalocarpa, Murraya cyclopensis, Murraya elongata, Murraya exotica, Murraya alata* and *Murraya sumatrance* (Nguyen *et al*., 2019).

Traditional herbal medical practitioners use the plant in the treatment of bruises, gastralgia, headache, rheumatism, stomach ache, skin

irritation and swelling. Also, it has been used as menstrual flow booster and antidote in the treatment of snake poison (Joshi and Gohil, 2023). Pharmacologically, *Murraya paniculata* have shown Analgesic (Podder *et al.*, 2011), Antibacterial (Saqib *et al.*, 2015), Antidiarrheal (Gautam *et al*., 2012), Bronchodilator and vasodilator (Rahman *et al.*, 2010; Saqib *et al*., 2015), Anticancer (Baker *et al.*, 2017), Anti-inflammatory (Rahman *et al*., 2010), Antifungal (Punasiya *et al*., 2020), Antioxidant (Zhu *et al*., 2015), Antihelmintic (Boonkusol *et al*., 2017), Anti-anxiety and depressant (Sharman *et al*., 2017), Gastro-protective and Reno-protective potential (Lu *et al*., 2021), Anti-obesity (Iswantini *et al*., 2011) and Anti-hyperglycemic activity (Gautam *et al*., 2012).

These activities can be ascribed to the presence in the *Murraya paniculata* of secondary metabolites. These group of phytochemicals include alkaloids, flavonoids, glycosides, saponins, steroids, tannins and triterpenoids. Literature search revealed that the leaves of *Murraya paniculata* contain murrayanone; murraculatin; umhengerin; gardenin A, E, C; 5-O-desmeth-ylnobiletin; 5,3'-dihydroxy-6,7,4',5'-tetramethoxyflavone; 5,6,7,8,3',4',5'-heptamethoxyflavone; 3,5,7,8,3',4',5'-heptamethoxyflavone and 5,3',5'-trihydroxy-6,7,4'-trimethoxyflavone were identified in chloroform extracts of *Murraya paniculata* leaf. Also, in the leaf and shoot of *Murraya paniculata* extracts, it has been reported that methyl ethers (5,8,3'-trihydroxy-6,7,4'-trimethoxy flavone 8-O-beta glucopyranoside and 5,8-dihydoxy-6,7,3',4'-tetramethoxy flavone 8-O—beta-glucopyranoside were identified, these are examples of glycosides of flavone. Polymethoxylated flavonoids were also identified from the leaf extracts through the use of High Performance Liquid Chromatography hyphenated with Mass Spectrometry (HPLC-MS) analytical method (Joshi and Gohil, 2023).

Most of these compounds are polar in nature-flavone and glycosides with limited non-polar phytochemicals. Thus, paucity of secondary metabolites with non-polar or semi polar constituents lead to this study. This study aims at identifying non polar and semi-polar secondary metabolites in the leaves of *Murraya paniculata* using GC-MS and reversed HPLC analysis.

Materials and Methods

Collection and identification

Collection of *Murraya paniculata* was done in January at Ekosodin Community in Benin City. It was identified by Prof. H.A. Akinnibosun of the Department of Plant Biology and Biotechnology, University of Benin. The herbarium number UBH-M589 was issued and specimen sample was deposited in the herbarium.

Preparation, Extraction and Concentration

The leaves of *Murraya paniculata* were carefully plucked off the stem and air dried for 21 days under shade to prevent the decomposition of the photo-labeled compounds in the leaves. Thereafter the dried leaves were placed in an hot air oven for 4 hours before it was powdered using mechanical binder to fine powder.

Eighty gram (80 g) pulverized leaf of *Murraya paniculata* was macerated with 750 mL of methanol (99 %) for three days (3 days) in a maceration chamber. After which the solvent was decanted and passed through filter paper (size 1µm) and filtrate was collected in a container. Using a rotary evaporator at 60^{o}C, the filtrate was concentrated in-vacuum. The concentrate obtained, was maintained at a temperature of 4^{o}C in a refrigerator until used.

Phytochemical Screening

The secondary metabolites in the powdered leaves of *Murraya paniculata* was determined using methods described by Sofowora (1993) and Trease and Evans (1989). The phytochemicals evaluated are alkaloids, flavonoids, glycosides, saponins, steroids, tannins and triterpenoids.

Chromatographic Analysis

The chromatographic technique used in this study are GC-MS and HPLC analysis and have been previously described.

Briefly, Agilent 6890N Gas Chromatograph was used for molecular weight determination. The column length and internal diameter measures 30 m x 0.25 mm DB 5MS coated fused silica with a film thickness of 0.5 µm. Pressure head in the column was preserved at 20 psi to maintain a steady flow of Helium (carrier gas) at the rate of 1 ml/min. Other operating conditions were predetermined. Initial temperature of 55 ^{O}C was set for the column for 0.4 min, this was increased at a rate of 25 ^{o}C to 200 ^{o}C, further increase was done to 280 ^{o}C at 8 ^{o}C for 1 min. Finally, a rate increase of 25^{o}C for 1 min was done and the temperature of 300^{o}C was achieved and held for 2 mins. Data from the National Institute of Standard Technology version 23 were used to compare data obtained (Odion *et al*., 2013).

For the HPLC analysis, a 200 mg portion of the methanol leaf extract of *Murraya paniculata* was homogenized with hexane: dichloromethane solvents (ratio 1:1) and deionized water (200 mL). These were refluxed while continuously stirring for 1 hr before cooling to ambient temperature. The mixture was passed through Whatman filter paper (diameter 125 mm) before diluting with 2 % solution of ammonia to 1:3 (v/v). Hydrochloric acid (0.01 M) was used to adjust the pH to neutral (7) before analyzing in HPLC.

The product obtained was analyzed using a chromatographic system, consisting of autosampler (1100TC) with loop fixed (100 µL) and detector (UV-Visible). Analysis was done in Agilent Lichrospher 100-5RP8 (250 x 4.6 mm, 5 µm) column at 45±1^{o}C. Mobile phase is made up of methanol and phosporic acid (0.1 %) and separation was carried out by maintaining isocratic mode while eluting at 1 mL per min. flow rate with a total run time of 9 min. Data acquisition and integration were performed by the Analyst 1.5 software. (Odion *et al*. 2023)

Results

Alkaloids, flavonoids, glycosides, steroids, tannins and triterpenoids were indicated in the pulverized leaf of Murraya paniculata while saponins was absent (Table 1).

Table 1: Phytochemical screening of the pulverized leaf of *Murraya paniculata*

Phytochemical	Inferences
Alkaloids	+
Flavonoids	+
Saponins	-
Tannins	+
Glycosides	+
Triterpenoids	+
Steroids	+

+ = present - = absent

GC-MS analysis of the leaf crude extract of *Murraya paniculata* disclosed sixteen secondary metabolites (Table 2), these include 2-Methoxy-4-vinylphenol; Dimethyl 6-methoxyquinolinate; Estran-17-one, 3-hydroxy (3.alpha.,5.alpha.)-; 1-(3',5'-Dibromo-4'-hydroxyphenyl)-5,5-dibromo-2,4-dioxohexahydropyrimidine; Pyridazin-3(2H)-one, 5-chloro-2-(3-trifluoromethylphenyl)-4-methoxy-; Pyrano[2,3-b]indole, 2,3,4,4a,9,9a-hexahydro-4a-methyl-; Pyrazine, 2,5-dimethyl-3-(3-methyl-3-butenyl)-6-(3-methylbutyl)-; Isoquinoline, 6, 7, 8-trimethoxy-; Isoquinoline, 3, 4-dihydro-6,7-dimethoxy-1-methyl-7-Methyl-1,2-dihydroquinoxalin-2-one; 2-1-Phenyl ethylidene-hydrazono-3-methyl-2,3-dihydrobenzothiazole; 6-Methyl-triazolo(4,3-b)(1,2,4)-triazine; trans-2,3-Methylenedioxy-b-methyl-b-nitrostyrene; 2-Nitro-4-(trifluoromethyl)phenol; Ethanimidamide, 2-chloro-N2-(2-chlorobenzenesulfonyloxy)- and perhydro-htx-2-one, 2-depentyl-,acetate ester.

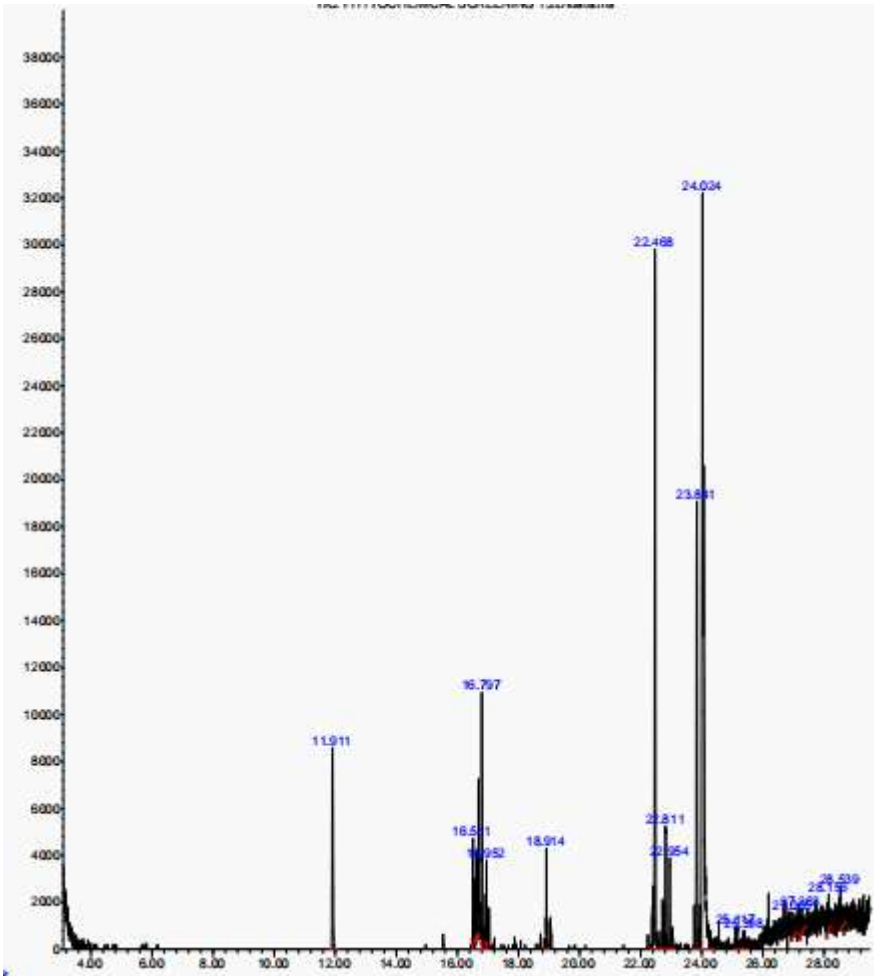


Figure 1 : GC-MS Chromatogram of the methanol leaf extract of *Murraya paniculata*

Table 2: GC-MS determination of the methanol extract of *Murraya paniculata* leaf

S/N	Retention Time (min)	Percentage Area	Molecular weight	Molecular formula	Compound
1	11.911	5.37	150.17	C9H10O2	2-Methoxy-4-vinylphenol
2	16.511	2.95	225.20	C10H11NO5	Dimethyl 6-methoxyquinolinate
3	16.797	6.61	276.42	C18C28O2	Estran-17-one, 3-hydroxy (3.alpha.,5.alpha.)-
4	16.952	1.41	341.18	C11H7NO3Br4	1-(3',5'-Dibromo-4'-hydroxyphenyl)-5,5-dibromo-2,4 dioxohexahydropyrimidine
5	18.914	1.48	269.19	C12H8N2O2F3	Pyridazin-3(2H)-one, 5-chloro-2-(3-trifluoromethylphenyl)-4-methoxy-
6	22.468	17.56	189.25	C12H15NO	Pyrano[2,3-b]indole, 2,3,4,4a,9,9a-hexahydro-4a-methyl-
7	22.811	4.86	245.41	C16H25N2	Pyrazine, 2,5-dimethyl-3-(3-methyl-3-butenyl)-6-(3-methylbutyl)-
8	22.954	1.93	219.24	C12H13NO3	Isoquinoline, 6,7,8-trimethoxy-
9	23.841	12.79	205.27	C12H15NO2	Isoquinoline, 3,4-dihydro-6,7-dimethoxy-1-methyl-
10	24.024	37.29	160.17	C9H8N2O	7-Methyl-1,2-dihydroquinoxalin-2-one
11	25.117	1.24	281.40	C16H15N3S	2-1-Phenyl ethylidene-hydrazono-3-methyl-2,3-dihydrobenzothiazole
12	25.398	1.15	123.09	C4H5N5	6-Methyl-triazolo(4,3-b)(1,2,4)-triazine
13	27.005	1.29	221.22	C11H11NO4	trans-2,3-Methylenedioxy-b-methyl-b-nitrostyrene
14	27.263	1.41	207.11	C7H4F3NO3	2-Nitro-4-(trifluoromethyl)phenol
15	28.156	1.50	283.13	C8H8Cl2N2O3S	Ethanimidamide, 2-chloro-N2-(2-chlorobenzenesulfonyloxy)-
16	28.539	1.17	281.39	C16H27NO3	Perhydro-htx-2-one, 2-depentyl-,acetate ester

The chromatogram of the HPLC analysis of the methanol leaf extract of *Murraya paniculata* is presented in figure 2. The red plot represent the standard alkaloidal reagents used for the analysis while the blue plot represent the methanol extract of *Murraya paniculata* leaf. Comparison of the plot revealed that the methanol leaf extract of *Murraya paniculata* contained benzamide

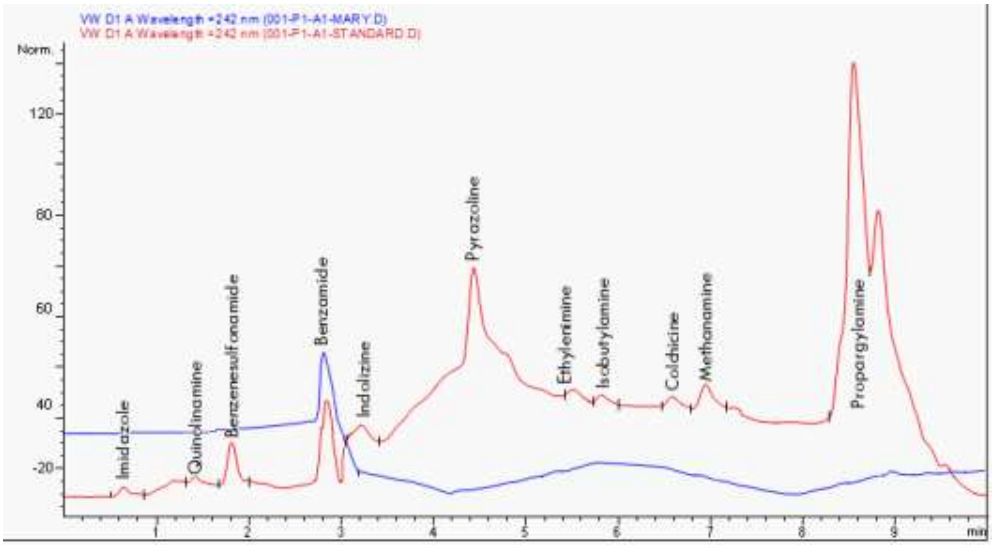


Figure 2: HPLC Chromatogram of the methanol leaf extract of *Murraya paniculata*

The concentration of the benzamide obtained was 29.53 ng/µL, from the 50 µg of the crude extract of *Murraya paniculata* utilized in the analysis. The retention time was recorded at 2.726 min, while the amount per area was obtained at 115.827 X 10^{-2} ng/µLm^2.

Table 2: HPLC analysis of the methanol leaf extract of *Murraya paniculata*

Retention Time [min]	Amount/Area	Amount [ng/ul]	Compound Name
2.726	115.827e-2	29.53	Benzamide

Discussion

Previous studies on the powdered leaves of *Murraya paniculata* agrees with this finding (Sonter *et al.*, 2021) while finding from Ramar and Jeyasankar (2016) reported absence of flavonoids, this difference may be due to geographical variation or difference in the time of collection of the plant, since seasonal and diurnal variation affect the sequestration of plant phytochemicals (Odion *et al.*, 2023).

Study by Shah and coworkers (2016) identified forty-eight (48) compounds from the hexane-ethylacetate soluble fraction of ethanol extract of the aerial part of *Murraya paniculata.* Three main compounds were reported: 6-amino-4-oxochromen-2-carboxylate, tetrahydrodehydrogeijerin and 7-methoxy-6(3-methyl-2-oxobutyl) 2H1-benzopyran-2-one. While alcohol, aldehyde, ketone, amino acids, and polycyclic compounds were reported in minor quantity. In this study, 7-methyl-1,2-dihydroquinoxalin-2-one (37.29 %), pyrano[2,3-b]indole,2,3,4,4a,9,9a-hexahydro-4a-methyl (17.5 %) and isoquinoline-3,4-dihydro-6,7-dimethoxy-1-methyl (12.79 %) were the major products. 2-methyl-4-vinylphenol have been reported in buckwheat as one of the natural flavouring agent (Janes *et al.*, 2008). Pamaquine a derivative of 6-methoxyquinoline was one of the earliest synthesized antimalarial medication used in the treatment resistance experienced to Plasmodium parasites during the second war

world (Caprio, 2008). 3-hydroxy Estrane-17-one is a steroid with derivatives that have proven antitumor potential by inhibiting 17β-HSDI (Jojart *et al*., 2017). Quinoxaline derivatives have been reported as non peptide antagonist of interleukin-8 molecule receptors which are involved in several inflammatory reactions and in cancer (Li *et al.*, 2013). Isoquinoline-3,4-dihdro-6,7-dimethoxy-1-methyl have been reported in the leaf of *Aristolochia elegans* (Wu *et al.*, 2000) and root of *Menispermum dauricum* (Zhang *et al*., 2004). Cactus of *Pachycereus weberi* and *Carnegiea gigantea* have also been reported to contain salsolidine derivative (Isoquinoline, 3,4-dihydro-6,7-dimethoxy-1-methyl) (Pummangura *et al*., 1982; Roush *et al*., 1985). The HPLC result disclosed benzamide moiety as the alkaloidal group in the leaf of *Murraya paniculata*, this further buttress the phytochemical screening result which have indicated the presence of alkaloids (Table 1). Though the GC-MS analysis have identified particular compounds with alkaloidal moiety in their molecule; 6,7,8-trimethoxyisoquinolin; 3,4-dihydro-6,7-dimethoxy-1-methylisoquinoline;7-methyl-1,2-dihydroquinolin-2-one and dimethyl, 6-methoxyquinolinate. Also included are: 6-methyl-triazolo (4,3-b)(1,2,4,)-triazine; 2-1-phenylethylidene-hydrozono-3-methyl-2,3-dihydrobenzothiazole; pyrazine, 2, 5-dimethyl-3-(3-methyl-3butenyl)-6-(3-methylbutyl); pyrano [2,3-b]indole, 2, 3, 4, 4a, 9, 9a-hexahydro-4a-methyl; pyridazin-3,3(2H)-one,5-chloro-2-(3-trifluoromethylphenyl)-4-methoxy; 1-(3',5'-dibromo-4'-hydroxyphenyl)-5, 5-dibromo-2,4-dioxohexahydropyrimidine; dimethyl 6-methoxyquinolinate. Some of these compounds were included as alkaloid due to the presence of nitrogen in the ring or cyclic structure. These indicate high content of alkaloids in the leaf of *Murraya paniculata* (eleven compounds identified of the total of sixteen compounds). The presence of 6-methyl-triazolo (4,3-b)(1,2,4)-triazine in the leaf justify its ethno-medicinal usage of the leaf for skin irritation or disease (antifungal agent).

Murraya paniculata is rich in phytochemical that could be responsible for the pharmacological potentials exhibited by the plant. The phytochemicals ranges from alkaloids, flavonoids, glycosides, steroids, tannins and triterpenoids. Some of the alkaloids identified are 7-methyl-1,2-dihydroquinoxalin-2-one; pyran[2,3-b]indole-2, 3, 4, 4a, 9, 9a-hexahydro-4a-methyl and isoquinoline-3,4-dihydro-6,7-dimethoxy-1-methyl. These compounds have been reported to possess activities which the plant have been ascribed to possess traditionally, thus validating their potential pharmacological activities.

Declaration of Conflict of Interest: None

Acknowledgement: The authors wish to thank Prof Joesph Ebigwei of Mifor Consult for running the GC-MS and HPLC analysis.

References

Baker, D.H.A., Ibrahim, E.A., Kandeil, A., and Baz, F.K.E. 2017. Sterols bioactivity of Ruta graveolens L. and *Murraya paniculata* L. International Journal of Pharmacy and Pharmaceutical Science. 9(2):103-8.

Boonkusol, D., Detraksa, J., Duangsrikaew, K., and Tongbai, W. 2019. In vivo efficacy of Murraya paniculata leaf in controlling natural hel-A Brief Review on *Murraya paniculata* (Orange

Jasmine) minthiasis in goat. American Journal of Animal Veterinary Science. 14(2):95-100.

Camara, M. B., Lima, A. S., Jumbo, L. O. V., Tavares, C. P., Mendonça, C. de J. S., Monteiro, O. S., Araújo, S. H. C., Oliveira, E. E. de, Lima Neto, J. S., and Maia, J. G. S. 2023. Seasonal and circadian evaluation of the Pectis brevipedunculata essential oil and Its acaricidal activity against Rhipicephalus microplus (Acari: Ixodidae). Journal of the Brazilian Chemical Society, 34, 1020–1029.

Caprio, V. (2008). Pyridines and their Benzo Derivatives: Reactivity of Substituents.Reference Module in Chemistry, Molecular Sciences and Chemical Engineering; Comprehensive. Heterocyclic Chemistry III. Volume 7, 2008, Pages 101-169

Dosoky, N.S., Satyal, P., Gautam, T.P., and Setzer, W.N. 2016. Composition and Biological Activities of *Murraya paniculata* (L.) Jack Essential Oil from Nepal. Medicines (Basel). 26;3(1):7. doi: 10.3390/medicines3010007.

Gautam, M.K., Gangwar, M., Nath, G,, Rao, C.V., and Goel, R.K. 2012. In-vitro antibacterial activity on human pathogens and total phenolic, flavonoid contents of *Murraya paniculata* Linn. leaves. Asian Pacific Journal of Tropical Biomedicine. 2(3 Suppl):S1660-3.

Gautam, M.K., Gupta, A., Vijaykumar, M., Rao, C.V,, and Goel, R.K. 2012. Studies on the hypoglycemic effects of *Murraya paniculata* Linn. extract on alloxan-induced oxidative stress in diabetic and non diabetic models. Asian Pacific Journal of Tropical Disease. Suppl 1:S186-91.

Iswantini, D., Silitonga, R.F., Martatilofa, E., and Darusman, L.K. 2011. Zingiber cassumunar, Guazuma ulmifolia, and *Murraya paniculata* extracts as antiobesity: in vitro inhibitory effect on pancreatic lipase activity. HAYATI Journal of Bioscience. 18(1):6-10.

Janes, D, Kantar, D, Kreft, S, and Prosen, H. 2008. Identification of buckwheat (*Fagopyrum esculentum Moen*ch) aroma compounds with GC-MS. Food Chemistry. 112: 120–124. doi:10.1016/j.foodchem.2008.05.048

Jojart, R.; Wolfling, J.; Schneider, G.; Herman, B.E.; Szecsi, M.; Mernyak, E. 2017. Synthesis of novel 13α-estrone derivatives by Sonogashira coupling as potential 17β-HSD1 inhibitors. Beilstein Journal of Organic Chemistry. 13,1303–1309.

Joshi, D., and Gohil, K.J. 2023. A Brief Review on *Murraya paniculata* (Orange Jasmine): Pharmacognosy, phytochemistry and ethanomedicinal uses. Journal of Pharmacopuncture. 26 (1). 10-17.

Li, J.J., Carson, K.G., Trivedi, B.K., Yue, W.S., Ye, Q., Glynn, R.A., Millar, S.R., Connor, D.T.,Roth, B.D., Luly, J.R., Low, J.E., Heilig, D.J., Yang, W., Qin, S., Hunt, S. 2003. Synthesis and structure-activity relationship of 2-amino-3-heteroaryl-quinoxalines as non-peptide, small-molecule antagonists for interleukin-8 receptor. Bioorganic & Medicinal Chemistry. 11(17):3777-3790. DOI: 10.1016/s0968-0896(03)00399-7.

Lu, M., Du, Z., Yuan, S., Ma, Q., Han, Z., and Tu, P, 2021. Comparison of the preventive effects of Murraya exotica and *Murraya paniculata* on alcohol-induced gastric lesions by pharmacodynamics and metabolomics.

Journal of Ethnopharmacology. 281:114567.

Nguyen, C.H., Beattie, G.A.C., Haigh, A.M. Astuti, I.P., Mabberley, D.J., Weston, P.H., and Holford, P. 2019. Molecular differentiation of the *Murraya paniculata* Complex (Rutaceae: Aurantioideae: Aurantieae). BMC Evolutionary Biology 19, 236. https://doi.org/10.1186/s12862-019-1555-4

Odion, E.E., Ogboru, R.O. and Ighene, M.O. 2020. Identification of Compounds in *Elaeis guineensis* Fruits using GC-MS. Dhaka University Journal of Pharmaceutical Science. 19 (2): 153-159, DOI: https://doi.org/10.3329/dujps.v19i2.50631.

Odion, E.E., Ambe, .D.A., Idiakose, G.O. and Odiete, E.C. 2023. Phytochemical screening, proximate analysis and Chromatographic analysis of methanol leaf extract of *Chromolaena odorata* (L.) M.King & H.Rob. (Asteraceae).West Africa Journal of Pharmacy. 34 (2) 1 - 11.

Odion, E.E., Ambe D.A., Dunkwu, J., Odiete, E.C. 2023. Phytochemical analysis of the methanol leaf extract of *Ficus Sur* (Moraceae) Forssk. Journal of Pharmacy and Allied Sciences. In press

Podder, M.K., Das, B.N., Saha, A., and Ahmed, M. 2011. Analgesic activity of bark of *Murraya paniculata*. International Journal of Medicine and Medical Science. 3(4):105-8.

Pummangura, S., McLaughlin, J.L., Davis D.V., and Cooks, R.G. 1982. Cactus Alkaloids. XLIX. New Trace Alkaloids (Dehydrosalsolidine and Heliamine) From the Saguaro, Carnegiea gigantea, and Confirmation by Mikes (MS/MS), Journal of Natural Product. 45, 3, 277–282

Punasiya, R., Dindorkar, G., and Pillai, S. 2020. Antibacterial and antifungal activity of flower extract of Murraya paniculata L. Asian Journal of Research In Pharmaceutical Science.10(1):17-20.

Rahman, M.A., Hasanuzzaman, M., Uddin, N., and Shahid, I. 2010. Antidiarrhoeal and anti-inflammatory activities of *Murraya paniculata* (L.) Jack. Pharmacologyonline. 3:768-76.

Ramar, G. and Jeyasankar, A. 2016. Phytochemical Screening, Larvicidal and Pupicidal Activity of *Murraya paniculata* (L.) Jack (Rutaceae) Leaf Extracts against Three Important Vector Mosquitoes (Diptera: Culicidae). International Journal of Current Research In Bioscience and Plant Biology. 3(10): 150-156.

Ramos, Y. J., Gouvêa-Silva, J. G., de Brito Machado, D., Felisberto, J. S., Pereira, R. C., Sadgrove, N. J., and de Lima Moreira, D. 2023. Chemophenetic and chemodiversity approaches: New insights on modern study of plant secondary metabolite diversity at different spatiotemporal and organizational scales. Revista Brasileira de Farmacognosia, 33(1), 49–72.

Roush, R.A., Cooks, R.G., Sweetana, S.A., and McLaughlin, J.L.1985. Search for new alkaloids in *Pachycereus weberi* by tandem mass spectrometry. Analytical Chemistry. 57, 1, 109–114.

Saqib, F., Ahmed, M.G., Janbaz, K.H., Dewanjee, S., Jaafar, H.Z., and ZiaUl-Haq M. 2015. Validation of ethnopharmacological uses of *Murraya paniculata* in disorders of diarrhea, asthma and hypertension. BMC

Complementary and Alternative Medicine. 15:319

Seidemann, J. 2005. World Spice Plants: Economic Usage, Botany, Taxonomy. Springer; Berlin, Germany.

Shah, S., Saied, S., Mahmood, A., and Malik, A. 2014. Phytochemical Screening of Volatile Constituents From Aerial Parts of *Murraya paniculata*.Pakistan Journal of Botany. 46(6): 2051-2056.

Sharma, P., Batra, S., Kumar, A., and Sharma, A. 2017. In vivo antianxiety and antidepressant activity of *Murraya paniculata* leaf extracts. Journal of Integrated Medicine. 15(4):320-5.

Sofowora, L.A. (1993). Medicinal plants and traditional medicine in Africa.Spectrum Books Ltd, Ibadan. Harborne. 55-71.

Sonter, S., Mishra, S., Dwivedi, M.K., and Singh, P.K. 2021. Chemical profiling, in vitro antioxidant, membrane stabilizing and antimicrobial properties of wild growing Murraya paniculata from Amarkantak (M.P.). Science Report. 7;11(1):9691. doi: 10.1038/s41598-021-87404-7.

Trease, G. E., Evans, W. C. (1989). Trease and Evans Pharmacognosy. 13th Edition. London: Bailliere Tindale. 832.

Wu, T., Tsai, Y., Wu, P., Lin, F. and Lin. J. 2000.. Constituents from the Leaves of *Aristolochia elegans.* Journal of Natural Product.63, 5, 692–693.

Zhang, X., Ye, W., Zhao, S., and Che C. 2004. Isoquinoline and isoindole alkaloids from *Menispermum dauricum*. Phytochemistry. 65, 7, 929-932.

Zhu, C.H,, Lei, Z.L,, and Luo, Y.P. 2015. Studies on antioxidative activities of methanol extract from *Murraya paniculata*. Food Science and Human Wellness. 4(3):108-14.