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Natural Products: Plants as Potential Sources of Drugs

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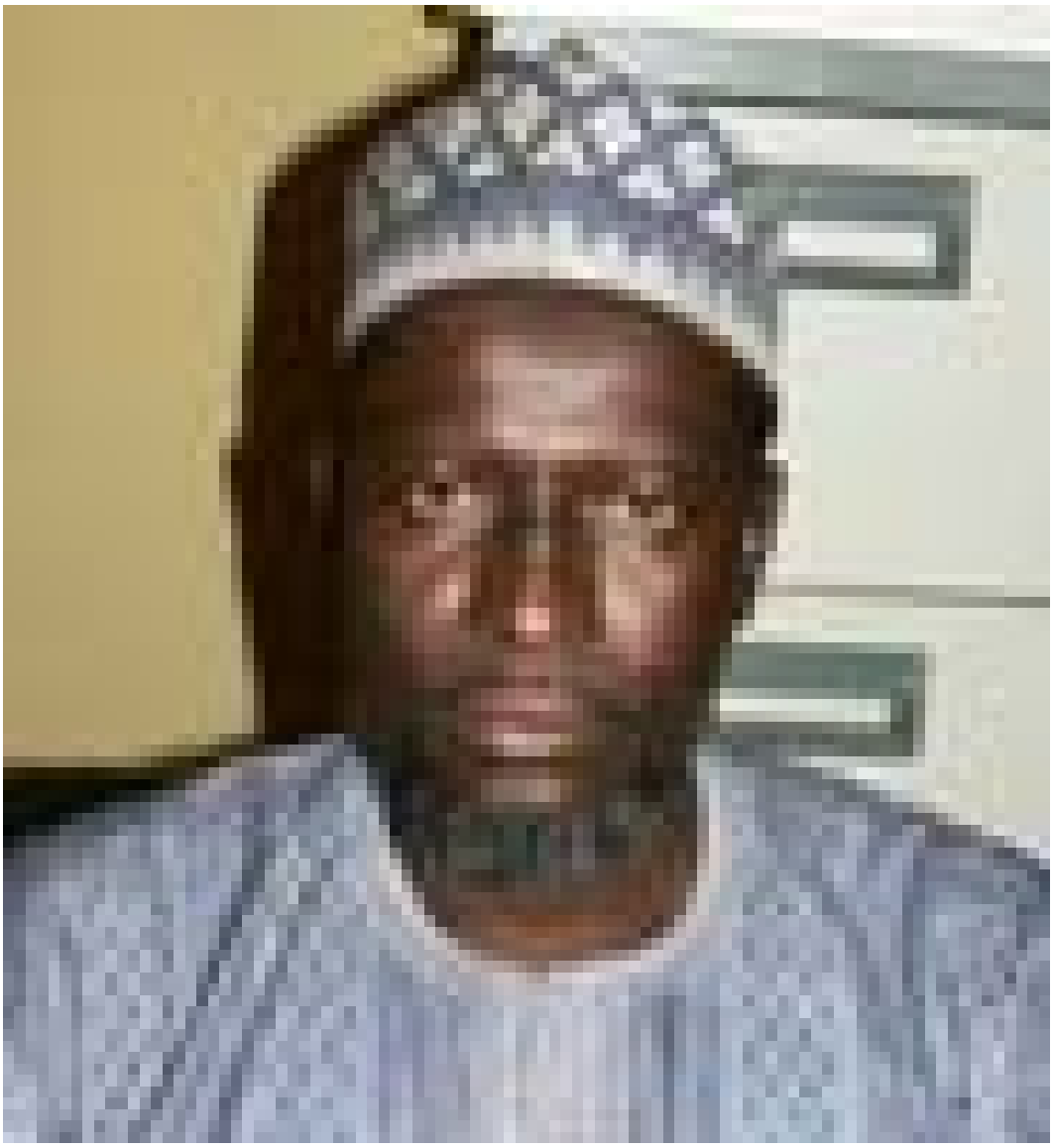


Professor Suleiman Yusuf Mudi

B Sc., M Sc. (BUK), PhD (ATBU), PICCON, MCSN, MSAN, MIPAN, MICDDD (UAE), MUSGNDD (USA), MWBC, MNSB

SUMMARY OF PRESENTER'S BIODATA

Professor Mudi is an organic chemist who specializes in natural products drug discovery as well as designs and synthesis of the isolated drug candidate compounds. He teaches at the Department of Pure and Industrial Chemistry, Bayero University, Kano where he trains both undergraduate and postgraduate students. He has supervised 25 Master of Science (M.Sc.) students in Organic Chemistry and has also served as external examiner to ten (10) M. Sc. students and 1 PhD at various Nigerian universities. Currently, he is supervising 15 Masters and 5 PhDs in Organic Chemistry. He has published 45 articles in reputable peer reviewed national and international journals.

He is member of the Editorial Board of *Bayero Journal of Pure and Applied Sciences (BAJOPAS)*, *ChemSearch* - A Journal of Chemical Society of Nigeria, Kano Chapter as well as many international and national journals. He is a member of many professional associations such as the Chemical Society of Nigeria (CSN), Institute of Chartered Chemist of Nigeria (ICCON), Institute of Public Analyst of Nigeria (IPAN), Science Association of Nigeria (SAN), United Scientific Group for Natural Products Drug Discovery (USGNDD; USA), International Congress for Drug Discovery and Developments (ICDDD), World Biotechnology Congress (WBC) and Nigerian Society for Biotechnology (NSB).

He participates as panellist in the National Universities Commission (NUC), National Board for Technical Education (NBTE) and National Commission for Colleges of Education (NCCE) accreditation exercises in Nigeria. He has participated as resource person in many state and national development projects. To date, S Y Mudi, has attended up to 25 national and international conferences with corresponding paper presentations. He has been involved as Chairman to the Local Organizing Committee (LOC) of the 3rd Mandatory Training Workshop of Institute of Chartered Chemist of Nigeria (ICCON) held at Kano in August 2008 and member LOC of 2nd International Science Conference at Northwest University, Kano in November 2016. He served as Technical Chairman at the 6th Mandatory Training Workshop of ICCON at Abuja in August 2014.

Born on 26th September 1960, Professor Mudi hails from Alfindiki, Kano Municipal. He attended Tudun-Madatai Primary School, Kano City, and then proceeded to Government College Kano presently Rumfa College, Kano where he attained his junior secondary school education. Mudi then proceeded to Science Secondary School Dawakin-Tofa, Kano where he was House Captain at Galadima House between 1980 to 1981. He finished with distinction (Division 1), carting away the prize for best student in mathematics. He had his B.Sc. and M.Sc. studies at Bayero University, Kano and PhD at Abubakar Tafawa Balewa University, Bauchi. A widely travelled man, S.Y Mudi enjoys reading, travelling and engages in community service. He has received several merit awards and special honours for his selfless service and responsibilities to his community. He is married with two wives and six children and speaks Hausa and English .

Natural Products: Plants as Potential Sources of Drugs

In the Name of Allah The Beneficent The Merciful....

And garden dense with many trees, And fruits and herbage,
To be a provision and benefits for you and your animals

- (Q 80 versus 30–32)

The Vice-Chancellor
Deputy Vice-Chancellor (Academic)
Deputy Vice-Chancellor (Administration)
Registrar
Deans and Directors
Fellow Professors
Family, Friends, Colleagues, Students
Distinguished Ladies and Gentlemen
AssalamuAlaikum,

Preamble

I feel highly pleased for the opportunity given to stand before you to present this inaugural lecture. The purpose of this lecture is to introduce to our researchers, some techniques in plants' natural products drugs discovery. The aim is to assist researchers in the field of natural products chemistry in gaining an understanding and application of compounds obtained from plants sources and their physiological and pathological values in our daily lives. The cohesive aspect of the certain advances is shown by bringing together the traditional herbalist and scientific researchers in drug research and discovery. It is my belief that this inaugural lecture will serve the following purposes:

- It will give the general public an idea on the importance of utilizing natural products from plants for treatment of ailments.
- It will give adequate procedures and protocols for establishing dosage requirements for formulation prepared by our traditional herbalist for safe consumption of our immediate community and the general public.
- It would give an inspiration on how the natural products chemistry can be utilized in developing herbal remedies and related products.

Introduction

The use of natural products together with their therapeutic properties is as ancient as human civilization (Mudi and Ibrahim, 2009). There is no doubt that plants are among the most perfect "natural laboratories" for the synthesis of various molecules ranging from simple skeleton to highly complex chemical structures as main sources of drugs (Hernedez *et al*., 2002). Clinical, pharmacological and chemical studies of traditional medicine, derived predominately from plants, were the basis of most early medicines such as asprin, morphine quinine and pilocarpine.

In recent years, there has been growing interest in alternative therapies and therapeutic use of natural products, especially those derived from plant. A survey of plant-derived pure compounds used as drugs in countries hosting World Health Organization–Traditional Medicine Centres indicated that of 122 compounds identified from only 94 plant species, 80% were used for the same or related ethno-medicinal purposes. Though discovery of drugs from natural products is a long tedious process and is associated with unpredictable results, still, with technical advancements, it is possible to screen and evaluate the pharmacological activities of constituents present in natural resources efficiently. In fact, diversified structures and ability to treat ailments without creating undesired side effects provide strong candidacy of naturally-occurring compounds for developing future drugs.

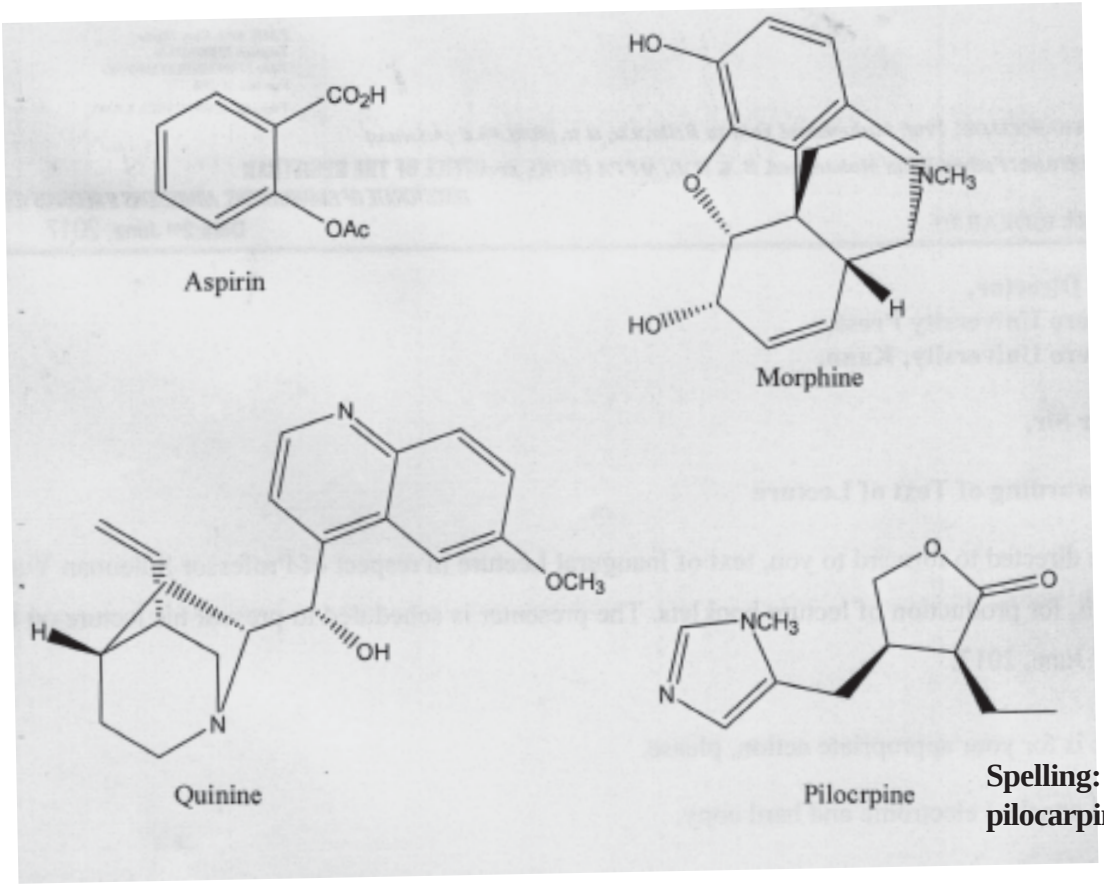
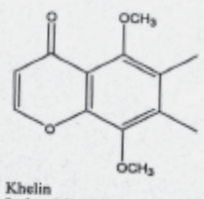


Figure 1: Structures of some early isolated drugs from plants

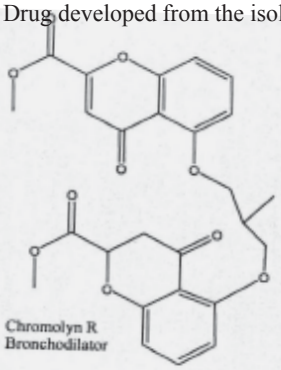
Despite these obstacles and competition from other drug discovery methods, natural products are still providing their fair share of new clinical candidates and drugs. Natural product-derived drugs were still represented in the top 35 world selling ethical drugs sales of recent years (see Table 1). Some relevant examples are khellin, from *Ammi visnaga* (L) Lamk., which led to the development of chromolyn (in the form of sodium chromoglycate) as a bronchodilator; galegine, from *Galega officinalis* L., which was the model for the synthesis of metformin and other bisguanidine-type antidiabetic drugs; and papaverine from *Papaver somniferum* which formed the basis for verapamil used in the treatment of hypertension etc. (see Figure 2). The latter plant is better known as being the source of painkillers such as morphine and codeine, but probably the best example of ethno-medicine's role in guiding drug discovery and development is that of the antimalarial drugs, particularly quinine and artemisinin.

Natural products isolated from plant

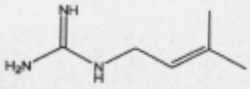


Khelin
Isolated from *Amin visnaga* LAMK
mild bronchodilator

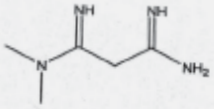
Drug developed from the isolated compounds



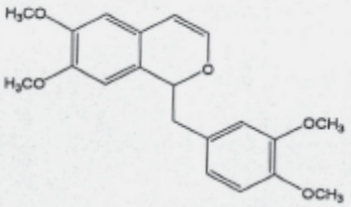
Chromolyn R
Bronchodilator



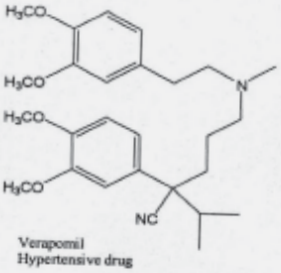
Galegine
Isolated from *Galega officinalis* L.
with Antibiotic activity



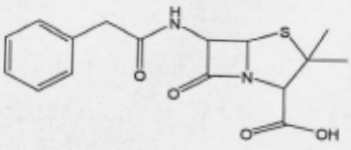
Metformin
strong Antibiotic



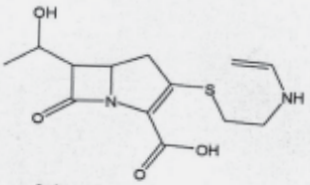
Papaverine
Isolated from *Papaver somniferum* L.



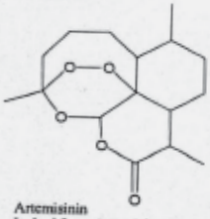
Verapomil
Hypertensive drug



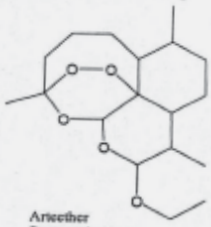
Penicillin G
Isolated from *Penicillium notatum*
antibiotics



Imipenem
Synthetic antibiotic drug



Artemisinin
Isolted from Artemisia annva
antimalaria



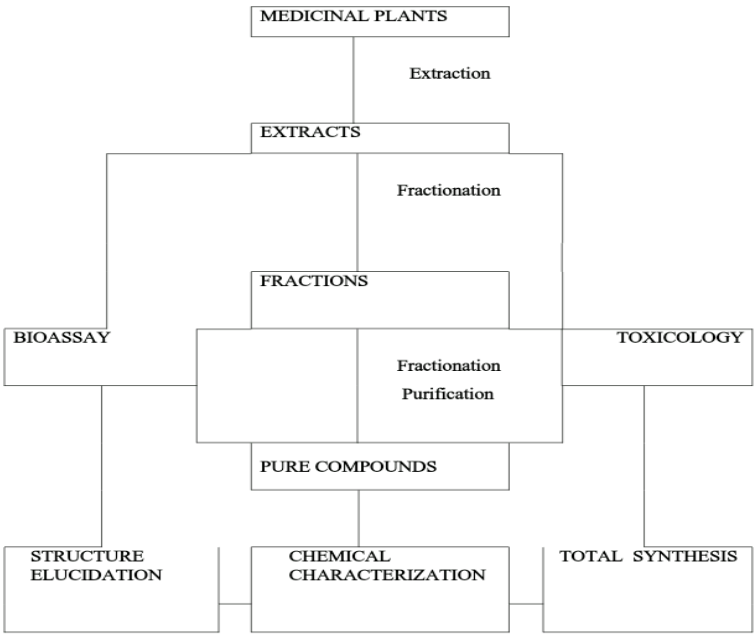
Arteether
Strog antimalaria

Table 1: *List of some natural products derived drugs from isolated drugs*

Plant	*Drug Isolated*	*Drug Derived from*	*Activity*
Achinoplanes sp	Ramoplanin	Viciron	Antibacterial
Aspergilus rugulovalvus	Echinocandin	Anidulafungin	Antifungal
Aspergilus femigatus	Fumagallin	Paromycin	Anti-parasitic
Cannabis sativa	Dronabinaol	Nabilone	Antibiotic
Nocardia orientalis	Oritavacin	Vancomycin	Antibacterial
Physostigma venenosum	Physostigmine	Hiperzine	anti-cholesterinase
Saccharopolyspora erythreae	Erythromycin	Telithomycin	Antibiotic
Artemisia annva	Artemisinin	Tehranolide	Antimalarial
Lophira lanciolata	Kerupensamine	Habiopetaline A	Antimalarial

Researches in Natural Products

Natural products and their derivatives have been recognized for many years as a source of therapeutic agents and structural diversity. They are also important sources for new drugs and also good lead compounds suitable for further modification during drug development. The following methods were followed for obtaining pure bioactive substances from ethno-medicinal plants scheme 1.



Scheme 1: Methods for Obtaining Active Substances from Plants

Sampling

The sampling processes of plant materials to search for bioactive natural products involve two main approaches: random collection and screening of material or exploitation of ethno-pharmacological knowledge of it. Then the plant parts are commonly dried thoroughly in the field at the point of collection or in an aerated room. To accelerate extraction, the dry tissue is ground to powder.

Extraction Methods

Write NCI in full

There are very few standard techniques for extraction, since choice of solvent and conditions depend on the spectrum of small molecules desired. For extraction of drug-like molecules of intermediate polarity, the NCI has found percolation at room temperature with a 1:1 v/v mixture of dichloromethane and methanol to be useful. Extraction techniques which involve heating the solvent and extracted compounds, as in a Soxhlet apparatus, are generally avoided unless the desired compounds have been shown to be heat stable. When preparing samples to be used in biological screening, this should be avoided.

The solvent must then be removed from the solutions which result from any of these extraction procedures. This is done to make it possible to obtain a weight for the extracted material, as well as to avoid reactions in solution which may alter the constituents. Aqueous solutions are lyophilized, while organic solvent mixtures are dried using rotary evaporators. A final finishing under high vacuum removes most traces of the solvent. Materials should be stored in borosilicate glass bottles or vials at "20° C to ensure stability.

Separation Technique

Once an extract has been confirmed to have activity in a biological assay, the active compounds in the extract must be identified. This is accomplished in an iterative process of separation and bioassay termed bioassay-guided separation. An extract is separated into several fractions using chromatographic techniques and the parent extract and fractions are tested in the assay. A useful technique in monitoring separations is to calculate both mass and activity recoveries for the process. Thus, if 5g of a parent extract was separated, yielding a summed fraction mass of 4.5g, the mass recovery would be 90 percent (Mudi and Muhammad, 2011). Pilot thin layer chromatography experiments can provide useful hints as to the best choice of column packing and elution conditions. Then, analytical scale

High Performance Liquid Chromatography (HPLC) may be used to define precise flow and solvent strength parameters. Even with relatively purified fractions, it is often useful to use gradient elution to obtain an optimum separation (Mudi and Muhammad, 2011). While C18 bonded phases dominate the analytical chemistry market, they are only one of the tools in the HPLC column drawer of a natural products isolation laboratory.

Structure Elucidation

Once the active compounds are obtained in pure form, they can be subjected to structure elucidation. The key technique for this is Nuclear Magnetic Resonance (NMR), specifically a series of two-dimensional experiments (COSY, HSQC, HMBC and NOESY) which makes it possible to establish the connectivity of all hydrogen and carbon atoms in a molecule. Serving a very important complementary role is high resolution mass spectrometry (MS), which is capable of providing precise mass measurements that identify the molecular formula of the compound. It is often possible to fully elucidate the structure of an unknown molecule using these two techniques alone. Other spectroscopic techniques such as UV, IR and optical rotation serve ancillary roles, though they may become critical in specific cases. As the number of atoms in a molecule increases, structure elucidation becomes more difficult, due to the exponential increase in possible structures for a given formula.

Write acronymns in full

The ability of NMR and MS to provide useful information from smaller amounts of compound has increased many folds in recent years. Advances in NMR probe design, especially gradient probes, flow probes and cryoprobes, have increased sensitivity greatly (Reynolds and Enriquez, 2002). Higher field strength magnets have increased NMR spectral dispersion so that more peaks can be resolved in a spectrum. Improved NMR pulse sequences have reduced experiment time and resolution. Similar improvements have been made in MS, with electrospray ionization and matrix assisted laser desorption being two ionization techniques which have been valuable in natural product characterization. Cutting edge techniques such as Fourier transform cyclotron resonance mass spectrometry (FTICR-MS) have been applied in industrial settings with utility in structure elucidation, but the cost of the equipment has kept it from being widely applied at this time (Feng and Siegel, 2007).

An alternative technique for structure elucidation is x-ray crystallography, which has a long history in natural product structure elucidation. It is still an important technique, especially

for determining the absolute configuration of complex chiral molecules. The obvious limitation is that the compound studied must exist in a crystalline form. If the native compound cannot be persuaded to crystallize, it can be derivatized with a variety of modifiers in an attempt to improve its ability to form crystals. Application of robotics to automatically generate many small scale crystallization experiments has increased the ability to find workable crystallization conditions (Bulter, 2004).

While the ability to perform spectroscopic methods with smaller samples is an important advance, it should be pointed out that animal testing cannot be miniaturized. Therefore, it is always necessary to carry out preparative separations to obtain sufficient material for in vivo work, if a compound is to advance as a drug lead.

Better Methods for Designing Researches in Natural Products Study

Drug discovery from natural products has reclaimed the attention of the pharmaceutical industry and is on the verge of a comeback due to new technological inputs that promise better returns on investment. The natural products research will only continue to compete with other drug discovery methods, if the speed of screening, isolation and structure elucidation processes are improved, as well as addressing the suitability of screening for natural product extracts and dealing with issues product involved with large–scale compound supply.

Pls look again

This increasing pressure to identify, optimize, develop and commercialize novel drugs more rapidly and cost effectively has led to an urgent demand for technologies that can reduce the time to source and produce new drugs from natural products. Molecular diversity, of both natural and synthetic materials provides a valuable source of compounds for identifying and optimizing new drug leads. Through the rapidly evolving technology of combinatorial chemistry, it is now possible to produce libraries of small molecules to screen for novel bioactivities. This powerful new technology has begun to help pharmaceutical companies to find new drug candidates quickly that save significant amount of money in pre-clinical developments cost and utility change their fundamental approach to drug discovery.

Direct hyphenation of an efficient separation technique with powerful spectroscopic techniques can assist in the dereplication process that involves a combination of bioassay, separation science and spectroscopic techniques. Such hyphenated systems include HPLC–

FTIR, which is useful for the detection of functional groups in major constituents' mixture. HPLC–NMR–MS is an advanced spectrometric hyphenated technique which is used in the dereplication of natural products plant extracts. Apart from its efficiency, the most important advantage of HPLC–NMR–MS is the unequivocal matching of the MS data to the NMR spectrum. Further, as HPLC–NMR does not provide information about silent functional groups (e.g. hydroxyl and amino moieties) as a result of D2O exchange, these functionalities can be readily detected by MS technique.

Our Research

The focus of our research targets the common ailments and pathogenic agents in our immediate environment in accordance with Bayero University's mission and strategic direction. The following are expressions of my researches in natural products chemistry that was carried out by me together with my colleagues and students from 2008 to 2016. I hope these researches will give an aspiration to the readers on how the design of researches in natural products can be explored or modified to make an impact on physiological system or pathological states.

Antimalarial Researches

Malaria is a vector-borne infectious disease caused by protozoan parasites. It is widespread in tropical and sub-tropical regions including part of the America, Asia and Africa (Snow *et al*., 2005). Each year, it causes diseases in approximately 515 million people and kills between one to three million people, majority of whom are young children in sub-Sahara Africa (Snow *et al*., 2005). Adults are less likely to die from malaria, but still suffer from the sickness (Adams, 2008). The resistance of the malaria parasite to conventional drugs, has led to new therapeutic challenges, particularly in the treatment of *Plasmodium falciparum*. This motivated our team to focus on identifying and screening of ethno medicinally used plants for treating malaria, in which about 45 different plants were identified and screened for the activity against malaria (Mudi and Muhammad, 2010; Mudi *et al*., 2010; Mudi and Bukar, 2011; Mudi, 2011; Mudi *et al*., 2012). We established positive activity of extracts obtained from ten plants out of the total number screened. About 35 pure compounds were isolated from these active extract, out of which 15 showed positive activities against malaria parasite (see Table 2). We were able to have full spectral data of only four isolated compounds; whose proposed structures were established as shown figure 3.

Table 2: *Number of pure active compounds isolated from indigenous medicinal plant materials used to treat malaria*

Plant	***Part(s)***	***Fraction***	***Number of pure compounds isolated***
Adansonia digitata	Stem bark	Chloroform	4
Calotropis procera	Leaf	Chloroform	3
Ficus platyphylla	Leaf	Ethyl acetate	4
Ficus syncomorus	Stem bark	Chloroform	2
Lawsonia mermis L	Leaf	Ethyl acetate	5
Mangifera indica	Leaf	Ethyl acetate	2
Terminalia catappa	Leaf	Chloroform	4
Terminalia indica	Root	Chloroform	3
Vitex doniana	Stem bark	Ethyl acetate	5

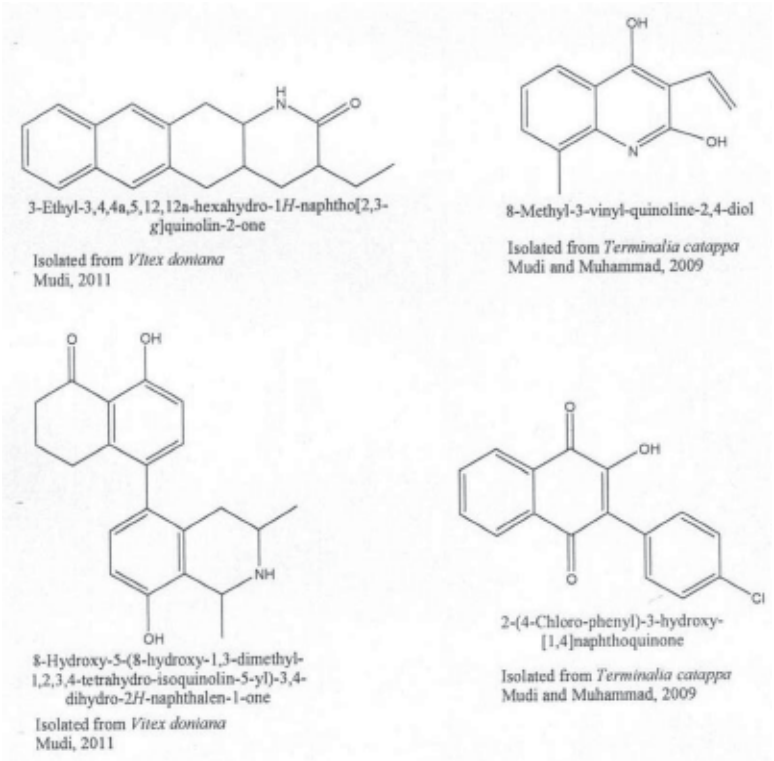


Figure 3: *Isolated compounds from natural products with promising antimalarial activity*

Food Borne Pathogens

Studies have revealed that many of the chemical food sanitizers and preservatives contain harmful substances (Smid and Gorris, 1999). Therefore the search for natural plant products that could be applicable as sanitizers and preservatives is presently intensified (Ninthoujam, 2010). This motivated us to screen 37 plants materials for antimicrobial activity against food and water borne pathogens, which is the first step in the screening of plant materials for preservative activity (Bukar and Mudi, 2011; Muhammad and Mudi, 2011; Dauda and Mudi, 2013; Mudi and Dauda, 2013; Mudi *et al*., 2015). The plant materials that prove to possess antimicrobial activity on few or many of the pathogens responsible for food spoilage as well as food and water borne illnesses were subjected to other tests to evaluate its preservative activity. These tests include evaluation of its toxicity, sanitizing and preservative activity on food system (Bukar and Mudi, 2011). Ten (out of 37 plants screened) were found to have promising activity against the tested pathogens. These plants were subjected to activity guided chromatography techniques in which 35 pure compounds were isolated (Table 3). We sent these pure compounds abroad for spectral analysis out of which only 4 compounds spectral data were complete. The structures of these compounds were elucidated as shown in figure 4.

Table 3: *Number of pure active compounds isolated from indigenous medicinal plant materials used to treat food-borne pathogens*

Plant	***Part(s)***	***Fraction***	***Number of pure compounds isolated***
Anogeissus leoicarpus	Stem bark	Chloroform	3
Aspilia Africana	Stem bark	Chloroform	5
Diospyros mespiliformis	Leaf	Ethyl acetate	3
Ficus syncomorus	Leaf/ Fruits	Chloroform	5
Laggera mollis	Whole plant	Chloroform	4
Maerua angolensis	Leaf	Ethanol	3
Mangifera indica	Stem bark	Ethanol	3
Nigella sativa	Stem bark	Chloroform	3
Terminalia catappa	Leaf	Chloroform	3
Red acalypha	Leaf	Chloroform	3

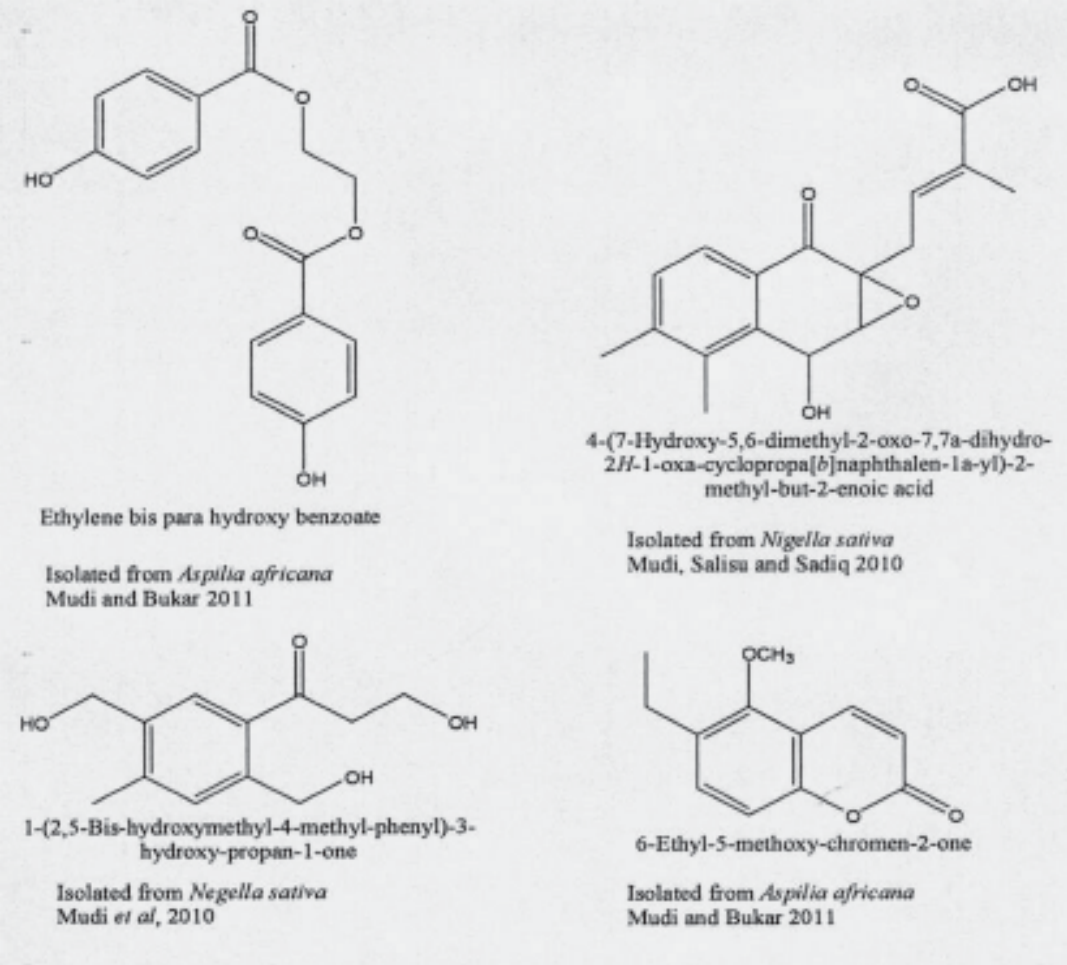


Figure 4: *Isolated compounds from natural products with promising antibacterial activity*

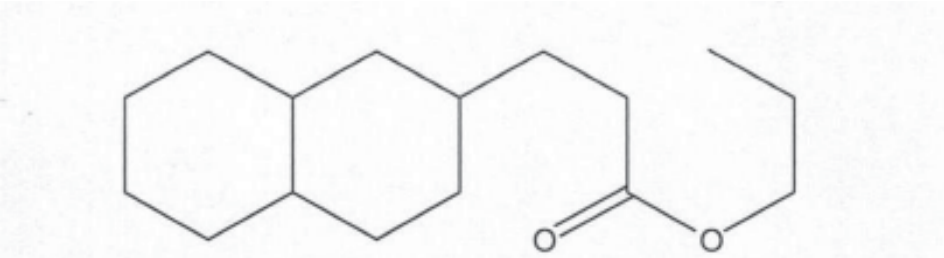
Gastrointestinal Tract Disease

Diseases of the gastrointestinal tract (GIT) are major causes of morbidity and mortality. The deaths are due in large part, to ulcer complications such as haemorrhage and perforation (Isenberg and Soll, 1996). There have been great advances in the understanding, diagnosis and management of GIT diseases. Peptic ulcer is one of the most common diseases of the GIT affecting mankind and the incidence has been estimated to range from 3 to 10% (Akimoto *et al*., 1998). However, the pathogenesis of peptic ulcer is far from clear and so is the mechanism of anti-ulcer drugs (Akimoto *et al*., 1998). Our study exploited the

safety and efficacy of 15 medicinal plants locally used as anti-ulcer remedies (Mudi and Ibrahim, 2009; Sa'idu and Mudi 2013; Mudi *et al*., 2013). Further, we screened these plants for antiulcer *in vivo* on aspirin induced gastric ulcer in Wister rats. Five of the plants extract showed promising antiulcer activity. These extracts were subjected to activity guided chromatographic techniques in which 17 pure compounds were isolated and sent abroad for spectral analysis. But only the spectral data of one pure compound was obtained and interpreted with the structure shown in figure 5.

Table 4: *Number of pure active compounds isolated from indigenous medicinal plant materials used to treat gastrointestinal tract diseases*

Plant	***Part(s)***	***Fraction***	***Number of pure***
Anogeissus leoica			
Laggera mollis			
Lawsonia mermis			
Maerua angolens			
Terminalia catapp			



3-(Decahydro-naphthalen-2-yl)-propionic acid propyl ester

Isolated from *Maerua angolensis*
Mudi and Ibrahim 2009

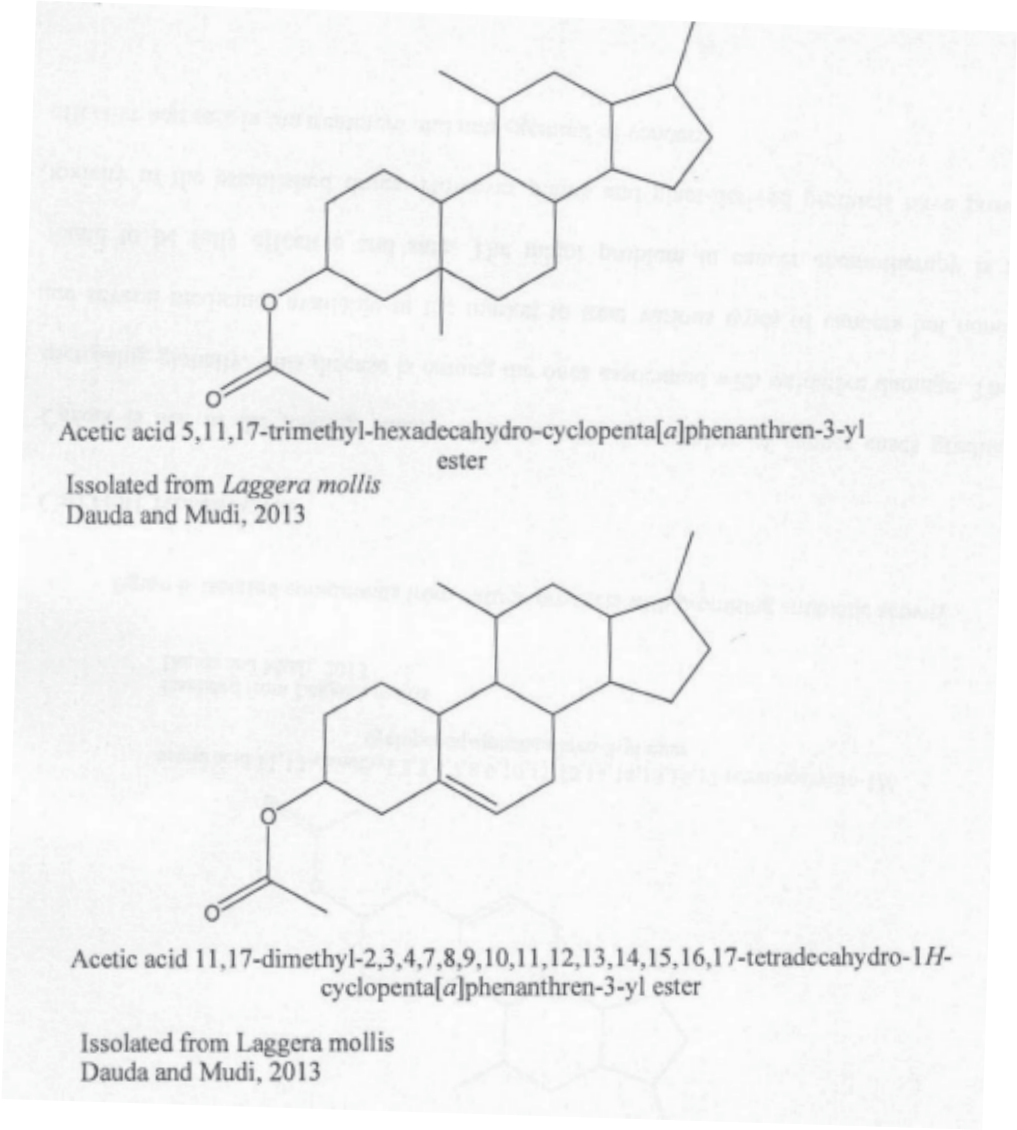
Figure 5: *Isolated compound from natural products with promising antiulcer activity*

Respiratory Tract Infections

Respiratory tract infections are clinical syndrome produced by the inflammation of the trachea, bronchi and bronchioles. These infections are caused by some bacterial pathogens, virus and fungi (Patrick, 2006). Despite the progress made in the development of drugs and antimicrobial agents, it becomes more significant to search for drugs from plants source as the current antibiotics in use are fast loosing effectiveness due to emergence of resistant microorganisms and unknown disease causing microbes that pose an enormous public health concern (Iwu, 1999). This fact motivated us to search and screen for traditionally used medicinal plants for the treatment of respiratory tract diseases. We identified and screened various parts of 35 plants out of which the crude extracts of seven of these plants were found (see Table 5) to have promising activity (Mudi and Ibrahim, 2008a; Mudi and Ibrahim, 2008b; Mudi and Salisu, 2009a; Mudi and Salisu, 2009b; Mudi *et al*., 2010). The extracts with positive activity were subjected to separation techniques that led to isolation of 21 pure compounds whose chemotherapeutic index equal or exceed the activity of drugs used to cure pneumonia and other respiratory infections. But only the spectral data of two of these pure compounds were obtained and interpreted with their structures shown figure 6.

Table 5: *Number of pure active compounds isolated from indigenous medicinal plant materials used to treat respiratory tract infections*

Plant
Acacia s
Cassia o
Bryophy
Red aca
Termina
Vernoni
Vitex do



Acetic acid 5,11,17-trimethyl-hexadecahydro-cyclopenta[*a*]phenanthren-3-yl ester

Issolated from *Laggera mollis*
Dauda and Mudi, 2013

Acetic acid 11,17-dimethyl-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1*H*-cyclopenta[*a*]phenanthren-3-yl ester

Issolated from Laggera mollis
Dauda and Mudi, 2013

Figure 6: I*solated compounds from natural products with promising antibiotic activity*

Current Researches

Cancer is one of the leading causes of death with the number of cancer cases gradually increasing globally. This disease is among the ones associated with oxidative damage. There are several medicines available in the market to treat various types of cancers but none is found to be fully effective and safe. The major problem in cancer chemotherapy is the toxicity of the established drugs. However plants and plant-derived products have proved effective and safe in the treatment and management of cancers.

Currently, we are conducting researches in searching for drugs from natural sources for curing cancer. We are putting effort to search from identified ethno-medicinal plants chemical compounds that can act as suitable antioxidants to replace the synthetic ones. These antioxidants isolated will then be subjected to *in vivo* and *in vitro* anticancer activity against various forms of tumours.

Presently, we have screened and evaluated the phytochemical constituents and antioxidant activity of 10 most frequently used ethno-medicinal plants claimed to cure cancer. We have isolated 13 pure compounds with promising antioxidant activity. We are now conducting preliminary studies on these isolates, before carrying out the *in vivo* and *in vitro* anticancer activity.

Need for Strategic Researches in Natural Products Chemistry

Historically, natural products have been used since ancient times and in folklore for treatment of many diseases and illness. This is the most frequent act in African communities due to affordable cost and easy of access. However, the method of consumption of these herbal remedies for curing the ailments poses a serious health implication. These herbal remedies are consumed without minding the required dosage or chemical components present therein. Hence, there is need for Bayero University to harness its vast resources in the field of natural products sciences and come up with strategic plans and policies that will integrate the traditional herbalists and scientific researchers. This policy should be geared towards establishing drug formulation directly from the plant materials similar to some of Asian diet supplements and drugs available in our market.

The strategic policy, among other issues, should include ways of interaction with traditional herbalists to identify and documents ethno-medicinal plants use for curing specific diseases and illnesses and to avoid losing records after the demise of the expert. The policy should

also involve scientific medicinal plants researchers in Bayero University for establishing the scientific basis as well as safety and possible dosage formulation.

Challenges

Funding is one of the major challenges we face in our research group and other groups. This is due to the fact that researches in natural products drug discovery and development require specialized equipment that are costly to purchase and maintain such as the Nuclear Magnetic Resonance (NMR), Mass–Spectrophotometer (MS), High Performance Liquid Chromatography (HPLC) and so on. These equipment require constant electricity supply and other accessories.

Another major issue bedevilling research in natural products is the difficulty associated with obtaining sufficient amounts of isolated compounds pure enough for discovery and development of its activities and structure elucidation.

The threat of losing potentially valuable natural sources of this pharmacologically active substance is constantly increasing due to the threat of extinction by deforestation of large landmasses and environmental pollution in remote areas as well as global warming.

Intellectual property right can pose a significant hurdle that is difficult to manage. In general, patent protection can be obtained if the active principles derived from natural sources have novel structure and relevant biological activity.

Conclusion

In conclusion, this presentation provides a scientific basis for establishing the safety of traditional use of ethno-medicinal plants for treatment of ailments. Our investigation has led to the identification of potent bioactive compounds from fractions of medicinal plant extracts, which in turn led to the establishment of some novel chemical structures or their analogues for more effective antibiotics for clinical usage.

Even if this presentation suggests that natural health products or dietary supplements are considered as, or are expected to be safe, they may still carry potential risks in themselves or through interactions with prescription or Over-the-Counter drugs. Therefore, the discovery and developments of natural products require scientific validation and sufficient pharmaco-epidemiological evidence to support their safety and efficacy. In this case, there

is the need for Bayero University, Kano to come up with policy guidelines towards integrating the traditional herbalists and the scientific researchers in the field of natural products sciences.

The need for a research and development policy may not be overemphasized for this will go a long way in bringing Bayero University, Kano closer to the immediate environment and make it become alive to its responsibilities. This will also serve as an avenue for Bayero University, Kano to produce natural health products or dietary supplements which will eventually translate to increased revenue.

I will want to stop by stating the motto of our great University: **"To every learned, there is always one added."**

Thank you.
Ma'assalam.
May Allah bless us.

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References

Adams, J. H. (2008). Malaria. Microsoft Student 2008 [DVD]. Redmond, WA: Microsoft Corporation.

Akimoto, M. Hashimoto, H. Shugemoto, M. and Yokoyama, I., (1998). Relationship between recurrence of gastric ulcer and the microcicurlation. *J. Cardiovasc. Pharmacol. (Suppl. I)* S507 – S508P.

Bukar, A. and Mudi, S.Y., (2011). Preliminary phytochemical screening and antimicrobial activity of *Anogiessus leiocarpus* stem bark extracts against some food-borne pathogens. *Biological and Environmental Sciences Journal for Tropics, 8*(1): 51 – 56.

Butler, M. S., (2004) The role of natural product chemistry in drug discovery. J*ournal of Natural Products, Vol. 67,* No. 12, pp. 2141-2153. doi:10.1021/np040106y.

Datti Y., Idris M. M. and Mudi, S. Y. (2014). Effect of *Hppocratea obtusifolia* extracts on lactation inducement. *Bayero Journal of Pure and Applied Sciences, 7*(1): 131 – 134.

Dauda U and Mudi, S. Y. (2013). Screening and bioassay guided isolation of antimicrobial components from *Laggera mollis*. *Bayero Journal of Pure and Applied Sciences, 6*(1): 152 – 158.

Not clear

Feng, X. and Siegel, M. M., (2007). Anal Bioanal Chem 389: 1341

Hernedez, C., Madrigal-Byaidar, A. C., Delta C. C. (2002). Inhibitory effect of chemical essential oil on the chromatid exchanged induced daurorubicin and methylmethane sulfonate in mouse bone marrow anonymous, ethno biology in India. A status report of all India coordinated research project of ethno biology. Ministry of Environment and Forestry, Government of India, New Delhi.

Confusing

Isenberg, J. L and Soll, A. H., (1996). Epidemiology, Clinical manifestations and diagnosis. In *Cesil textbook of medicine*. Bannet, J. C. and Flum, F. P. (Eds.). USA: 2(20). W. B. Publications, Saunders Company.

Iwu, M. W. (1999). New antimicrobials of plants origin. In J. Janick (Ed.). P*erspectives on new crops and their uses.* Alexandria, VA: ASHA Press. p457-462.

Mudi, S. Y. and Ibrahim, H. (2008a). Activity of bryophyllum pinnatum S. kurz extracts on respiratory tract pathogenic bacteria. *Bayero Journal of Pure and Applied Sciences, 1*(1): 43 – 48.

Mudi, S. Y. and Ibrahim, H. (2008b). Brine shrimps lethality and antimicrobial tests from the leaves extracts of bryophyllum pinnatum and cassia occidentalis on respiratory

tract pathogenic bacteria. Conference proceeding paper presented at the 31st DELTACHEM Conference 2008, Effurun – Warri, Delta State.

Mudi, S. Y. and Ibrahim, H. (2008c). Comparative extraction methods and analysis of alkaloids from the leaves of vernonia amygdalina DEL (Asteraceae). *ChemClass Journal 5:* 74 – 77.

Mudi, S. Y. and Muhammad, A., (2009). Antimalarial activity of ethanolic extracts of leaves of *Terminalia catappa L. (Combretaceae)* (Indian Almond). *Bayero Journal of Pure and Applied Sciences, 2*(1): 14 – 18.

Mudi, S. Y. and Salisu, A., (2009a). Studies on brine shrimp lethality and activity of stem berk extract of *acacia senegal L* on respiratory tract pathogenic bacteria. *International Journal of Biomedical and Health Studies, 5*(3): 139 – 143. http://www.klobex.org/ijbhs5.htm/ IJBHS 2009107/5307.

Mudi, S. Y. and Salisu, A. (2009b). antimicrobial and brine shrimp lethality test from the stem bark extract of *anogeisuss leciocarpus DC* on respiratory tract infections caused bacteria. *Journal of Scientific and Industrial Studies, 7*(4): 19 – 21.

Mudi, S. Y. and Ibrahim, H. H., (2009). Protective effect leaves extract of *maerua angolensis (cappridacea)* aspirin induced gastric ulcer in lister rats, *ChemClass Journal 6:* 63 – 69.

Mudi, S. Y., Salisu, A. and Ibrahim, H. H., (2010). Studies on brine shrimp lethality and activity from the leaves extract of Red Acalypha on Respiratory tract pathogenic bacteria. *International Journal of Pharmaceutical and Applied Sciences 1* (1): 96 – 99.

Mudi, S. Y. and Muhammad, A. (2010). Antimalarial activity of the leaf extracts of leaves of *Ficus platyphyla. Biological and Environmental Sciences Journal for Tropics, 7*(1): 197 – 200.

Mudi, S. Y., Salisu, A. and Sadiq, I. A., (2010). Mosquito repellent activity from the seeds extract of *nigella sativa* (black caraway), *International Journal of Physical Sciences 5* (3): 41 – 51.

Mudi, S. Y., Salisu, A. and Sabiu, A., (2010). phytochemical screening and anti-malaria activity from the stem bark extracts of *Diospyros mespiliformis*. *African Journal of Pure and Applied Sciences 3*(2): 122 – 125.

Mudi, S. Y. (2010). Antibacterial activity and brine shrimp lethality of *Vitex doniana* [sweet], stem bark extracts. *Bayero Journal of Pure and Applied Sciences, 3*(2): 134 – 137.

Mudi, S.Y., and Bukar, A., (2011). Anti-plasmodia activity of *Calotropis procera* Linn leaves extracts. *Biokemistri, 23*(1): 29 – 34. http://www.bioline.org.br/titles?id=bk&year=2011&vol=23&num=01&keys=V23N1

Mudi, S. Y. (2011). Naphthoquinolinone derivative with anti-plasmodial activity from *Vitex doniana* [sweet] stem bark extracts. *Bayero Journal of Pure and Applied Sciences, 4*(2): 64 – 68.

Mudi, S. Y. and Muhammad, A., (2011). A review on chiral chromatography and its application to the pharmaceutical industry. *ChemSearch Journal 2*(1): 6-7.

Mudi S. Y. and Baso A. A., (2012). Antioxidant property of leaf extract of *Tapinanthus dodoneifolius DC*. grown on *Parkia biglobosa* (Jacq) and *Tamarindus indica* trees. *Biological and Environmental Sciences Journal for Tropics, 9*(1): 8 – 12.

Mudi, S. Y., Ibrahim, H. and Bala, M. S., (2012). Acute toxicity studies of the aqueous root extract of *Lawsonia intermis* Linn in rats. *Journal of Medicinal Plants Research, 5*(20): 5123 – 5126. http;//www.academicjournals.org/article/article1380788931.

Mudi, S. Y, Salisu, A. and Sabiu, A., (2012). Phytochemical screening and antimalaria activity of extracts from the stem bark of *Adansonia digitata*. *International Journal of Biomedical and Health Sciences 8*(1): 49-53. http://www.klobex.org/ijbhs8.htm/IJBHS 2011176/8108.

Mudi, S. Y. and Dauda, U. (2013). Antimicrobial activity of isolation 5, 14 – dimethyl pentadec – 2 – ene and 5, 11, 17 – trimethylgonen – 3 – yl acetate from the leaves of *Laggera mollis*. Conference proceeding paper presented at the 36th annual international conference 2013, Minna, Niger State.

Mudi, S.Y., and Datti, Y., (2014). Repellent effect of the leaf extracts of *Euphorbia balsamifera* (AIT) against Anopheles gambiae. *Bayero Journal of Pure and Applied Sciences, 7*(2): 111 – 114.

Mudi, S. Y., Muhammad, A. Musa J. and Datti, Y., (2015). Phytochemical screening and antimicrobial Activity of Leaves and Fruits Extract of *Ficus syncomorus*. *ChemSearch Journal 6*(1): 62 – 67.

Mudi, S Y (1999). Plants as potential sources of drugs. *The Pioneer Scientist, 1*(1): 7.

Mudi, S. Y. (1999). Plants as alternative sources of pesticide. *The Pioneer Scientist, 1*(1): 13.

Muhammad, A. and Mudi, S. Y., (2011). Phytochemical screening and antimicrobial activities of *Terminalia catappa* leaf extracts. *Biokemistri, 23*(1): 35 – 39. http://www.bioline.org.br/titles?id=bk&year=2011&vol=23&num=01&keys=V23N1

Ninthoujam, S. (2010). Natural food preservatives. Retrieved from http/:www.natural-remedies-for-skin-care.com on 06/07/2010.

Reynolds, W. F. and Enriquez, R. G. (2002). Choosing the best pulse sequences, acquisition parameters, postacquisition processing strategies and probes for natural product structure elucidation by NMR spectroscopy. *J. Nat. Prod. 5*: 221-244.

Patrick, L. C. (2006). Bronchitis: Acute and chronic. Link: www.medicine.com/ped/trop

Sa'idu Y and Mudi, S. Y. (2013). Evaluation of activity *Cassia occidentalis* leaf extracts. *ChemSearch Journal 4*(2): 66-71.

Smid, E. J. and Gorris, L. G. M., (1999). Natural antimicrobial for food preservation. In *handbook of food preservation.* New York: Mercl Dekkar, p285-308.

Snow, R. W., Guerra, C. A., Noor, A. M., Myint, H. Y., and Hay, S. T. (2005). The Global distribution of clinical episodes of *Plasmodium falciparum Malaria. Nature 434,* (7030): 214-217.

Suleiman, A G., Mudi, S. Y., Ahmad, G. and Muktar M. (2015). Antisickling activity of the extract from *Phoenix dactylifera. J. Chem. Soc. Nigeria, 40*(1): 151 – 154.