Environment Conservation Journal 18(1&2) 49-62, 2017
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

A review on antimicrobial and phytochemical screening of traditionally used Himalayan medicinal plants

Prashant Arya ✉ and J.P. Mehta

Received: 15.11.2016 **Revised:20.01.2017** **Accepted: 25.03.2017**

Abstract

Plant drug Rasayana has always played an essential role to treat several diseases of human beings. Moreover, medicinal plants are the prime source of potentially useful structures for the development of novel chemotherapeutic agents. Historically, plants have provided a basis of the development for novel drugs and plant derived drugs which have made large contributions to human health and well being. Till now few plants have been scientifically proved by different researchers for their medicinal potential but the therapeutic ability of number of plants are still unknown. The regeneration of medicinal potential of such plants is thus strongly required. Several researchers have carried out bioassay for antimicrobial, antioxidant and phytochemical screening of various extracts of certain plants. Such works should be brought in the knowledge of every concern man. Present study is therefore an attempt for review on some of such medicinal plants.

Keywords: Medicinal plants, Herbs, Antibacterial, Antimicrobial, Phytochemical

Introduction

Plants are the roadway bricks of all the living organisms on the earth. They transform solar energy into chemical energy and supply it to different tropic levels to carry on all kind of life activities. Human and civilization developed through ages in the lap of nature and flourished with plants.

"The essence of all being is earth. The essence of the earth is water.The essence of water is plants. The essence of plants is the human being."

(Chandogya Upanisad, 1.12)

Plant based drug has always played a vital role to treat several diseases of human beings. According to World health organization (WHO) more than 80% of the world population relies on traditional medicine for their primary health care needs (Diallo *et al.*,1999).The use of medicinal plants as a source for relief from illness can be traced back over five millennia to written documents of the early civilization in India, china and the north east, but it is thoughtless as art as old as mankind (Mahesh *et al.*,2008). The potential of higher plants as a source for new drugs is still largely unexplored. Among the estimated 250'000-500,000 plant species, only a small percentage have been investigated phytochemically and the fraction submitted to biological or pharmacological screening. Compound of natural or synthetic origin has been the source of innumerable therapeutic agents (Gerhartz *et al.*, 1985 and Kroschwitz *et al.*, 1992).

Author's Address
Department of Botany and Microbiology, H.N.B. Garhwal University Srinagar (Garhwal)
E-mail:prashantarya09@gmail.com

Antimicrobial potential of medicinal plants

Medicinal plants are rich sources of antimicrobial agents. Plants are used medicinally in different countries are the source of potential and powerful drugs (Shrivastava and Lambart,1997). A wide range of medicinal parts are used to get different rasayanas (Chemicals) which possess different medicinal properties against different microbes. Although hundred of plants species have been tested for antimicrobial properties, the majority of these have not been adequately evaluated (Balandrin*et al.*, 1985). There is evidence of medicinal plants have been used in the treatment of diseases and for revitalizing body systems in Indian, the Egyptian, the Chinese, the Greek and the Roman civilizations. Plants have a vast potential for their use as curative medicine. In India, medicinal plants are widely used by all sections of people both directly as folk medicines in different indigenous systems of medicine like

Siddha, Ayurveda and Unani and indirectly in the pharmaceutical preparations (Srinivasan *et al.*, 2001). India has about 4.5 million plant species and among them, several thousands have been claimed to possess medicinal properties against human diseases. Although traditional medicinal healers have used medicinal plants for treatment of ailments for hundreds of years, there has always been a lingering question in scientific circles about their therapeutic efficacy. As a consequence, the pharmacological activity of many medicinal plants has been studied, even though the vast majority of medicinal plants remain to be studied for their phytochemical components and pharmacological effects.In the past few decades, the search for new anti-bacterial agents has occupied many research groups in the field of ethno pharmacology (Recio *et al.*, 1989). Reviewed the most relevant articles on this subject published between 1978 and 1988, compiling a list of 75 species. Approximately 115 articles published on the antimicrobial activity of medicinal plants in online website PubMed during the period between 1966 and 1994, however, in the following decade between 1995 and 2004, this number doubled to 307. Focusing the search specifically on the antimicrobial activity of essential oils and crude extract, 187 references appeared in PubMed between 1971 and 2005; however, in a search processed by the ISI web of knowledge, the number of references for essential oils was much higher 323 between 1986 and 2005. These figures demonstrate the increased interest for this type of research among that portion of the scientific community dedicated to the investigation of the medicinal properties of plants. Many focus on determining the antimicrobial activity of plant extracts found in folk medicine (Ngwendson*et al.*, 2003), essential oils (Alma *et al.*, 2003) or isolated compounds such as alkaloids (Klausmeyer*et al.*, 2004), flavonoids (Sohn*et al.*, 2004), sesquiterpene lactones (Lin *et al.*, 2003), diterpenes (El-Seedi*et al.*, 2002), triter-penes (Katerere *et al.*, 2003) or naphtoquinones (Machado *et al.*, 2003) among others. Some of these compounds were isolated or obtained by bio-guided isolation after previously detecting antimicrobial activity on the part of the plant.The second block of studies focus on the natural flora of a specific region or country. There are many examples of such articles that have been published recently. In 2005, Duarte *et al.* reported anti-*Candida* activity of Brazilian medicinal plants. Similar studies include determination of antibacterial properties of essential oils from Thai medicinal plants (Wannissorn *et al.*, 2005). Likewise, Lopez *et al.* (2001) also described antiviral and antimicrobial activities of Colombian medicinal plants. In India, Jeevan Ram *et al.* (2004) reported *in vitro* antimicrobial activity of certain medicinal plants from Eastern Ghats, India, used for skin diseases. Worldwide, a lot of work is done to determine antimicrobial activity of medicinal plants. For example determination of antimicrobial activity of six medicinal plants traditionally used for the treatment of dysentery and diarrhoea in Congo (Otshudi *et al.*, 2000), Mahasneh (2002) screened some indigenous Qatari medicinal plants for antimicrobial activity and Atindehou *et al.* (2002) worked on evaluation of the antimicrobial potential of medicinal plants from the Ivory Coast. Tshibangu *et al.* (2002) screened African medicinal plants for antimicrobial and enzyme inhibitory activity. Kokoska *et al.* (2002) and Tosun *et al.* (2006) described antimicrobial activity of medicinal plants from Siberia and Turkey respectively. Yogesh *et al.* (2007) demonstrated potential antibacterial activity of medicinal plants against *Staphylococcus* and *Salmonella* spp. The antibacterial activity of methanol extract and its petroleum ether, chloroform and ethyl acetate fractions from the root bark of Akanda (*Calotropis gigantea*) was investigated by Ashraful *et al.* (2008). The use of plant extracts and phytochemicals, both with known antimicrobial properties, are of great significance for therapeutic treatments (Nagesh and Shanthamma, 2009). The effect of plant extracts on bacteria has been studied by a large number of researchers in different parts of the world (Reddy *et al.*, 2001; Ateb and Erdo, 2003). Agarry *et al.* (2005) have shown the potent antimicrobial activities of the gel and leaf of *Aloe vera* against a wide range of bacteria and fungi. Bearberry and cranberry juice have been used to treat urinary infections while plant species such as lemon balm, garlic and tea tree are described as broad-spectrum antimicrobial agents (Rios and Recio, 2005).Mathabe *et al.* (2006) reported that methanol, ethanol, acetone and hot water extracts from different plant parts (leaves, roots, bark and stem rhizome), of *Elephantorrhiza burkei*, *Elephantorrhiza elephantina*, *Gymnosporia*

senegalensis, *Indigo feradaleoides*,*Ozoroa insignis*, *Punica granatum*, *Schotia brachypetala, Spirostachys africana, Syzygium cordatum* and *Ximenia caffra* showed remarkable antibacterial activity against *Escherichia coli,Salmonella typhi, Shigella* species, *Staphylococcus aureus*, and *Vibro cholera.* Crude extracts of some well known medicinal plants are used to control plant pathogens (Kubo *et al.*, 2001). Many species of *Acacia caesia* are found to have diverse phytochemical compounds having medicinal properties (Lee *et al.*, 2000). The methanol extracts of forty nine different plant extracts were screened for antifungal activity, out of which forty three plant extracts exhibited varying degrees of inhibition activity against the fungi (Varaprasad *et al.*, 2009). Girish and Satish (2008) reported the antibacterial activities of aqueous and methanol extracts of some medicinal plants against some human pathogenic bacteria. The methanol extracts exhibited more activity against these organisms than the aqueous extracts, which indicate that the methanol extracts of all selected plants may contain the active components. Senthilkumar and Reetha (2009) reported that methanol extract of *Aegle marmelos* and *Cassia auriculata* extract showed higher antibacterial activity to a group of bacterial pathogens. The functions of triterpenesaponin in plants for its antimicrobial, fungicidal, antibacterial, antiviral, analgesic, anti-inflammatory, antitumor, cytotoxic, immunostimulant, antihelmintic, expectorant and antitussive activities, have been known for many years (Hostettmann and Marston, 1995).*In vitro* anti-bacterial activity of a glycoside, phenyl ethyl β-D-glucopyranoside from the plant *Sidarhombi folia* was studied by Ekramul *et al.* (2002). These compounds exhibited significant anti-bacterial activity against most of the tested bacteria. *In vitro* antifungal activity of saponins from *Tribulusterr estris* L. against *Candida albicans*, *C. glabrata*, *C. parapsilosis*, *C. tropicalis* and *Cryptococcus neoformans* was studied using micro broth dilution assay. The saponins exhibited significant antifungal activity by weakening the virulence of *C. albicans*and killing fungi by destroying the cell membrane (Zhang *et al.,* 2006). The compounds isolated from *Verbas cumlasianthum*and *V. pterocalycinummutense* were evaluated for their *in vitro* antifungal activity by TLC bioautographic assay and the triterpenoidsaponins, were found to exhibit potent *in vitro* antifungal activity against *Colletotrichum acutatum*, *C. fragariae* and *C. gloeosporioides*. Some saponins and phenylethanoid glycosides possessed a dose-dependent antimicrobial activity against several bacteria and fungi (Zhang *et al.*, 2006). Mandal*et al.* (2005) investigated the potent antimicrobial activity of two triterpenesaponins isolated from the funicles of *Acacia auriculiformis* against various pathogenic organisms. Flavonoids may act through inhibiting cytoplasmic membrane function as well as by inhibition of DNA gyrase and β-hydroxyacyl-acyl carrier protein dehydratase activities (Cushnie and Lamb, 2005; Zhang *et al.*, 2008) A phytochemical like isoflavonegenistein was able to change cell morphology (formation of filamentous cells) and inhibited the synthesis of DNA and RNA of *Vibrio harveyi* (Ulanowska *et al.,* 2006). It has been suggested that terpenes promote membrane disruption, coumarins cause reduction in cell respiration and tannins act on the membranes of microorganism as well as bind to polysaccharides or enzymes promoting inactivation (Ya *et al.,* 1988; Chung *et al.,* 1998; Cowan 1999).

Extracts of plants were used for the treatment of various diseases and this forms the basis for all Indian systems of Medicine. However, this area is not much developed when compared to modern system of medicine, mainly because of the lack of scientific documentation in this field. Mostly the pharmacological activity of medicinal plants resides in its secondary metabolites which are comparatively smaller molecules in contrast to the primary molecules such as proteins, carbohydrates and lipids. These natural products provide clues to synthesize new structural types of antimicrobial and antifungal chemicals that are relatively safe to man (Kalimuthu*et al.*,2010). Antimicrobial activity of plants like *Adhatoda vasika, Bacopa monnieri, Biden spilosa, Boswellia* (Luban) Species, *Carica papaya, Cissampelo spareira, Combretum micranthum Cynodondactylon, Harunganama dagascariensis, Ocimum gratissimum* and *Phyllanthus niruri,* has been demonstrated against various pathogenic micro-organisms (Hasson *et al.*, 2011; T Selvamohan *et al.*, 2012; Yaouba *et al.*, 2012; Hema *et al.*, 2013). Gautam *et al.* (2012) reported antibacterial and phytochemical aspects of *Viola odorata Linn.* against respiratory tract pathogens. They also screened *Nepeta ciliaris*

Benth. for antibacterial activity against respiratory tract pathogens. Mrina*et al.* (2013) demonstrated comparative study on *in vitro* antibacterial and antifungal properties medicinal plants. Gautam*et al.* (2013) assessed antibacterial and phytochemical analysis of *Lagenaria vulgaris* Ser. against respiratory tract pathogens as *Haemophilus influenza, Pseudomonas aeruginosa, Staphylococcus aureus*, *Streptococcus pneumoniae*, *Streptococcus pyogenes.* Gautam *et al.* (2015) demonstrated that Antimicrobial efficacy of *Althaea officinalis* Linn. seed extracts and essential oil against respiratory tract pathogens.

Herbal Drugs

Medicinal plants have been found as important contributors to the pharmaceutical, agriculture and food industries. With the onset of the synthetic era, pharmaceutical industries are producing a lot of synthetic drugs that help to alleviate the chronic diseases. With the passage of time many problems associated with frequent use of synthetic drugs are becoming prominent like severe side effects and resistance of microbes against these drugs. On the other side synthetic drugs are expensive and a large population cannot afford these drugs. In recent times research on medicinal plants has been intensified all over the world. The natural pharmaceuticals are receiving extra ordinary importance and popularity as safe, efficacious and cost effective medicines with extraordinary benefits due to combination of medicinal ingredients with vitamins and minerals (Ahmad and Husain, 2008). Recently there is an emerging trend in research to support the biological activities of medicinal plants. Many scientific researchers have been reported about the efficacious and chemotherapeutic role of medicinal plants in the treatment of diverse diseases. Cancer is one of such field where scientists are expecting new molecules from herbs that can provide an important tool for fighting against this dreaded disease. *Terminalia arjuna* (Vaidya *et al.*, 2008) and flavonoids extracted from different sources have shown significant inhibiting effect on cancer cells (Jiangrong and Jiang, 2007; Zhao *et al.*, 2007). Diabetes mellitus is another area for herbal research, as large number of the population in developing countries is suffering from this problem. Many plants showed tremendous hypoglycemic potential. *Allium cepa, Allium sativum, Eugenia jambolan* and *Trigonella foenum,* are some famous hypoglycemic plants (Grover *et al.*, 2002; Vats *et al.*, 2002). Cardiovascular diseases have been become the number one cause of death throughout the world (Thippeswamy *et al.*, 2009); can be controlled by herbal medicines. Many immune modulatory agents are of plant origin (Arul kumaran *et al.*, 2007). Hepatic and arthritis are painful diseases and no satisfactory cure of these diseases is present in modern medicines. Many plants have shown their marvelous capability to lower the raised level of liver enzymes in viral hepatitis (Oshima *et al.*, 1995; Bhawna and Kumar, 2009). Many plants have shown immense potential as anti-peptic ulcer (Ibrahim *et al.*, 2006), antimicrobial and antioxidant properties (Ali *et al.*, 2008). With widespread the interest in the research of the herbal medicines, these have become an alternate health care system to solve the health problems of world in today's synthetic allopathic era. India is blessed with rich herbal sources which are being used for medicinal and aromatic purposes. The proper medicinal use of some of plants is well known, and many more have to be still explored (Khan, 2003). There is a need to facilitate the herbal research and its application to solve the problem of health seeking population. With the advancement of research in medicine, it was concluded that plants are Biosynthetic laboratories for chemical compounds, which are responsible for curative action of plants. Table 1 describes some Himalayan folk medicinal important plants.

The scientists isolate phytochemicals from medicinal plants and many of them are found very active against many diseases. Aconitine, atisine, nicotine, atropine, and morphine are some famous examples of such phytochemicals. Infectious diseases resulting from the presence of pathogenic microbial agents including bacteria, fungi, andviruses have become a major healthcare problem in current century. Infectious diseases are main reason of deaths in developing countries (Okusa *et al.*, 2007; Mojab *et al.*, 2008). Incidence of new and re-emerging infectious diseases and development of resistance to antibiotic is alarmingly increasing. In modern time treatment of infectious diseases

Table 1- Some important medicinal plants traditionally used for health care system

Local name	Botanical name	Part used	Used to cure
Jhilla, Rai,Rei	*Abies pindrow*	Leaf, Rasin, Bark	Cough, cold, rheumatism, ulcer
Bhindi	*Abelmoschus esculentus*	Root	Venereal diseases
Khair	*Acacia catechu*	Bark	Diarrhoea
Pyaz	*Allium cepa*	Bulb, Leaf	Ear trouble, earache, vomiting, piles, jaundice, anthelmintic, asthma, nose bleeding, blisters, boils, bronchitis, diuretic,expectorant, eye trouble, giddiness, insect bites, itching, skin diseases, wounds
MeethaAties, Bhuaa	*Aconitum voilaceum*	Tuber, Tuber	Stomachache, fever, abdominal pain, bronchitis, cough, epilepsy, headache, inflammation, neck pain, snake-bite, lice killer, Gastrointestinal troubles, renal pain, rheumatism
Atees	*Aconitum heterophyllum*	Root, Tuber	Diarrhoea, fever, vomiting, cough, chills, stomach ache, gastrointestinal disorders, digestive disorders, fever,colic pain, wormicide headache, dyspepsia, piles, gastric, dysentery
Kala Bansha, Bansa, Adosa, Banfasha	*Adhatoda vasica*	Leaf, Root, Whole plant	Fever, Cough, eye diseases, blood diseases
Chukalai	*Alysicarpus vaginalis*	Root	Cough, Asthma, Bronchitis, Skin problem
Kumari, Ghirita, Gawarpaltra	*Aloe vera*	Pulp	Inflammation of the body
Choru	*Angelica glauca*	Root, Stem, Fruit	Flatulence, colic, constipation, digestive disorder, stomachache, constipation, dvspepsia, cough, indigestion, vomiting, eye diseases, power tonic, dysentery, gastric troubles, menorrhea
Babool	*Acacia nilotica*	Flower	Urinary trouble
Lahsun (Garlic)	*Allium sativum*	Bulb	Cholera, treat abscesses, rheumatic pain, gout, scorpion, bruises
Dhatura	*Dhatura stramonium*	Leaves and fruits	Asthma, cardiac pains
Amla	*Emblica officinalis*	fruit	As Purgative, diuretic, digestive trouble, Hair problems
Peepal	*Ficus religiosa*	Bark, leaves, fruit, seeds, latex	Skin diseases, neuralgia, constipation and gynecological diseases
Gurhal	*Hibiscus rosa-sinensis*	Flower	Delivery
Lantana	*Lantana indica*	Leaf	Chicken pox, cuts, wounds
Pudina	*Mentha longifolia*	Leaf	Cholera, dysentery

Jatamansi, Muskroot	*Nardostachys jatamansi*	Root	Epilepsy, hysteria, skin diseases, throat trouble, lumbago, ulcers, rheumatism, paralysis, cough, diuretic, snake-bite
Kalonji	*Nigella sativa*	Seeds	Diarrhoea, dysentery
Tulsi	*Ocimum sanctum*	Leaves	Antiallergic, antidiabetic
Kaknada	*Peristrophebi calyculata*	Leaf	Skin disorder, Anti cancerous, Asthma, Antidote, Bronchitis, Cough
Paiya	*Prunus cerasoides*	Bark, fruit	Antipyretic, leprosy
Anar	*Punica granatum*	Seeds, flowers	Syphilis, bronchitis, stomachic
Chir	*Pinus roxburghii*	Resin	Swelling, sprains, boils, bone fractures, urine trouble, concussions, heel cracks, eye,bone fracture
Chilla, Pine, Kail	*Pinus wallichiana*	Resin, Bark, Leaf	Hurt, bone fracture, headache, waist pains, internal injury, heel crack, skin diseases abscess, ulcers
Burans, Bras	*Rhododendron arboreum*	Flower	Mental retardation, dysentery, headache, eye cataract, wounds, rheumatism
Thuner, Talispatta, Talispatr	*Taxusbaccata*	Leaf	Asthma, bronchitis, lumbago, indigestion, cancer
Methi	*Trigonella foenum*	Seeds	Constipation, diabetes
Ajwain	*Thymus vulgaris*	Seeds	Antiseptic, antispasmodic

becomes a big problem due to the side effects of some antibiotics which includes hypersensitivity allergic reaction and immune suppression. There is need of time to discover new paramount antimicrobial compounds with different chemical structures and novel mechanism of action. Diverse antibiotics of synthetic and microbial origins have been produced. Indiscriminate use of antimicrobial drugs has created very dangerous drug resistance to microbial strains; many bacterial strains have developed resistance against antibiotics, such as penicillin resistant *streptococcus pneumoniae*, methicillin resistant *staphylococcus aureus*. Due to the development of bacterial super resistant strains, currently used antibiotic failed to cure the infectious diseases (Sieradzki *et al.*, 1999; Janovoyska *et al.*, 2003; Karaman *et al.*, 2003; Turkoglu, *et al.*, 2007). Solution of antibiotic resistance is the development of new drugs from synthetic or natural sources. Therefore discovery of new antibiotic sources that can act either by direct antimicrobial activity or by preventing resistance of microorganism with minimal side effects is emerging and is of principal need (Khan *et al.*, 2009). However previous records showed that even new families of synthetic antimicrobial agent will have short life expectancy. Researchers turned their attention towards herbal drugs, which is most promising area in search of new biologically active compounds with better activity against multi drug resistant strains and reduced antibiotic related side effects (Nickavar *et al.*, 2002; Cock, 2008; Khan *et al.*, 2009). Antimicrobial potential of some plants had been accepted long before mankind discovered the presence of microbes (Anwar *et al.*, 2006). The healing power of plants is usually due to presence of secondary metabolites. Plant extracts and large number of phytochemicals exhibited strong inhibiting effect on a broad spectrum of microorganisms (Fungi, bacteria) (Cowan, 1999; Nascimento *et al.*, 2000; Anwar *et al.*, 2009). Bacterial and fungal infections are also a big threat to the life of the human beings. Only few antifungal drugs are available and long use of these drugs caused resistance. Plant might contain antifungal component not yet explored. Plants produce a great variety of chemical compound (phytoconstituents) as in their defense system these defense molecules are secondary metabolites, and used in formulation of herbal drugs.

Phytochemical screening of medicinal plants (Bioactive compounds):

The medicinal value of plants lies in some chemical substances that produce a definite physiological action on the human body and these chemical substances are called phytochemicals. These phytochemicals were used to cure the disease in herbal and homeopathic Medicines (Chitravadivu *et al.,* 2009).These are non-nutritive substances, have protective or disease preventive property (Ahmed *et al.,* 2009). There arises a need and therefore to screen medicinal plants for bioactive compounds as a basis for further pharmacological studies. With advances in phytochemical techniques, several active principles of many medicinal plants have been isolated and introduced as valuable drug in modern systems of medicine. The most important of these bioactive compounds are alkaloids, flavonoids, tannins and phenolic compounds (Purkayastha *et al.,* 2012). These are the important raw materials for drug production (Tullanithi *et al.,* 2010). Most plants contain several compounds with antimicrobial properties for protection against attacker agents, especially microorganisms (Silva *et al.,* 2010). Plants are rich in secondary metabolites such as tannins, alkaloids, saponins and flavones, which have been shown antimicrobial properties. Plant's antimicrobials are categorized into two classes:

Phytoalexins: These are lower molecular weight compounds which are produced in response to microbial, herbivorous and environmental stimuli. Phytoalexins are including simple phenylpropanoid derivative, flavonoids, isoflavonoids and terpenoids (Bailey and Mansfield, 1982; Grayer and Harborne, 1994).

Phytoanticipins: These include phenolic glycosides and saponins which are stored in vacuoles of plant cells. When the microorganisms disturb the integrity of the cell, glycosides react with hydrolyzing enzymes and release toxic aglycones (Osbourn, 1996).The Plants derived compounds with antimicrobial effect are described below:

(1) Polyphenols- Simple phenolics such as caffeic acid (Bowles and Miller, 2006), cinnamic acid, chlorogenic acid, gallic acid and hydroxyl benzoic acid, catechol, pyrogallol are known antimicrobial agents (Noriaki *et al.*, 2005). Phenolic compounds showed their inhibitory effect by enzyme inhibition through oxidation reaction with sulphydryl groups, or through more non specific interaction with proteins. The site and number of hydroxyl groups on phenols are directly related to their toxicity to microorganism. Phenol with greater number of-OH groups showed high inhibitory effect (Mason and Wasserman, 1987; Cowan, 1999). Many studies have been reported about the antimicrobial potential of phenolic acids. Caffeic acid was quantified in sweet potato HPLC. High caffeic acid content inhibited the growth of sweet potato pathogenic fungi (Harrison *et al.*, 2003). Seven phenolic compounds were identified and quantified by reverse by HPLC in olive leaves, caffeic acid, verbascoside, oleuropein, luteolin,7-*O*-glucoside, rutin, apigenin 7- *O*-glucoside and luteolin 4'-*O*-glucoside were present in the leaves extract, which showed very good combined antibacterial as well as antifungal effect, and which suggested the great nutraceutical potential of Phenolic acids (Pereira *et al.*, 2007). High yield of caffeic acid and rosemaric acid in leaves of *Basilicum polystachyon* extract inhibited growth of five bacterial strains and three fungal strains. Highest activity was observed against gram positive strain, amongst the fungal strains maximum activity was observed against *Aspergillus niger* (Chakraborty *et al.*, 2007). Many studies are reported about the antimicrobial potential of Polyphenolics like; caffeic acid from coffee (Amelia *et al.*, 2006), phenolic acid fraction of *scrophulariafrutescens* and *scrophularia sambucifotia* (Fernandez *et al.*, 1996). Ferrazzano *et al.*, 2009 showed antimicrobial activity of Mangiferin is major polyphenol of mango (*Magnifera indica*) and showed broad spectrum antimicrobial activity against bacterial and fungal strains (Stoilova *et al.*, 2005). Some studies have reported the relationship between the antioxidant and antimicrobial activity (Wang *et al.*, 2013; Reddy *et al.*, 2010; Turkoglu, *et al.*, 2007; Hamid *et al.*, 2010; Mokbel and Hashinaga, 2005). Phenolic compounds with C3 side chain at lower level of oxidation and containing no oxygen are known as essential oils. Essential oils of many plant showed strong antimicrobial potential and have been used for treatment of infectious diseases all over the word. Essential oils showed broad spectrum biological activity which increased the interest of scientist. Extensive research has been conducted on

essential oil to explore their antimicrobial activity. Most important essential oils with antimicrobial activity are extracted from clove (Eugenol) and *Thymus vulgaris* (Thyme) (Imelouane *et al.*, 2009; Faleiro *et al.*, 2003). Essential oils of many other species of plants have been also explored for antimicrobial activity against fungi and bacteria which includes, *Origanum* sp. and *Schinus molle* (Bayramoglu *et al.*, 2008), *Ageratum fastigiatum* (Vieira *et al.*, 2009), *Allium sativum* (Garlic) *Myristica fragrans* (nutmeg), *Zingiber officinale* (ginger), *Allium capa* (Onion) *Piper nigrum* (pepper) (Indu *et al.*, 2006), yellow pine (Yang and Clausen, 2007).

(2) Flavonoids- Flavonoids are phenolic substances which exist as C6-C3-C6 system. They are synthesized by plants in response to microbial infections (Dixon, 2001). They have been form complexed with proteins of cell walls and found to be very effective against microorganism (Cowan, 1999). Flavonoids showed broad spectrum antimicrobial activity. Catechin is reduced form of C3 unit, and has gained special attention, and is one of the most important extensively studied flavonoids. Different types of teas are major sources of mixture of catechins. Tea catechin inhibited microbial growth and are very effective against *staphylococcus aureus* (MRSA) and fungal strains (*Candida albicans)* (Hirasawa and Takada, 2004). Quercetin is also proven as a potential antimicrobial agent for many microorganisms. Quercetin extracted from lotus leaves showed inhibitory effect on bacterial strains (Li and Xu, 2008). Many flavonoids showed a synergic effect with conventional antibacterial and with combination of different flavonoids and flavones (Alvarez *et al.*, 2008).

(3) Tannins- The tannins name is given to polymeric phenolic substances which are capable of tanning leather or precipitate proteins. They are divided as hydrolysable and condensed tannin. Hydrolysable tannin contains gallic acid usually as an ester with D-glucose and condensed tannins are derived from a flavonoids monomer (Proanthocyanidin). Tannins have the ability to inactivate microbial adhesions, enzymes, cell envelop transport proteins and form complexes with polysaccharides. Many studies have been reported about the antimicrobial activity of tannins. Five isolated tannins from the fruit of *Terminalia citrina* showed inhibitory effect on microbial strains (Burapadaja and Bunchoo, 1995). *Helicobacter pylori* bacteria are a major disease causing agent in gastrointestinal disorders. Hydrolysable tannins have a potential as a new and safe therapeutic agent against *H. pylori* infections (Funatogawa *et al.*, 2004).

(4) Alkaloids- Alkaloids are heterocyclic nitrogen compounds having very good antimicrobial potential. Aqueous extract, different solvents and isolated fractions of alkaloids from *Samanea saman* showed highly significant antibacterial activity against human pathogenic bacterial strains (Raghavendra *et al.*, 2008). Four isolated alkaloids from *Chelidonium majus* lin. inhibited the growth of methicillin-resistant *Staphylococcus aureus* (Zuo *et al.*, 2008). Alkaloids from *sida acuta* (Karou *et al.*, 2006), *Lupinus angustifolius* alkaloid (Erdemoglu *et al.*, 2006), pyrrolizidine alkaloids from *Heliotropium subulatum* (Singh *et al.*, 2002) showed significant inhibitory effect on a large number of microbes. Water is the most universally used solvent. Alcoholic extraction followed by various organic solvents can also be used. Mostly antimicrobial compounds are aromatic and saturated organic compounds. They may often extracted with ethanol or methanol (Erdemgil *et al.*, 2004) and purified compounds are obtained by active fractions of different solvents (Chloroform, acetone, dichloromethane, butanol) (Parekh and Chandra, 2006; Morales *et al.*, 2008,). Different methods may be used for assessment of antimicrobial activity. Two most commonly used methods are the disc diffusion method (Pelttari *etal.*, 2002; Khan *et al.*, 2009), and the agar well diffusion method (Ahmad *et al.*, 1998). It is common to use medicinal plants as such, without isolating the active ingredients. Now a day interest is again diverted toward the use of crude plant extracts, since plants contains many secondary metabolite which act synergistically and may not show good activity with compounds isolated in pure form (Eloff, 2004 and McGraw, 2008). Isolation and purification of alkaloids from medicinal plants by HPLC techniques methanolic extracts of medicinal plants Gujpatta (*Abrus precabrius*), Sadapatta, shankhapushpi *(Canscorade cussate)* and makka *(Zea mays)* were concentrated and use for purification of secondary metabolites were purified by HPLC (Borde *et al.,*

2014). It has been observed that the plant is very rich in alkaloids and the modified method employed for the extraction of alkaloid is efficient and selective, where the interference of other secondary metabolites is negligible. The identification of each compound was made through gas chromatography-mass spectrometry (GC-MS). A total of twenty six structurally different alkaloids were identified for the first time from this medicinal plant. *E. aureum* is highly rich in alkaloids and twenty six different alkaloids were characterized (Meshram *et al.*, 2015).

Summary and Conclusion:

Since ancient times, plants have been used by several communities to treat a large number of diseases, including infections. Numerous studies on the pharmacology of medicinal plants have been accomplished, since they constitute a potential source for the production of new medicines and may enhance the effects of conventional antimicrobials, which will probably decrease costs and improve the treatment quality. However, several plants may present antagonistic effects during antibiotic therapy. An important aspect comprises the search for new compounds that have antimicrobial action and synergism with currently available antimicrobial drugs, since bacteria resistant to conventional medicines are increasingly frequent; consequently, medicinal plants constitute an alternative for infection treatment.The antimicrobial activity of plants was proven by various examples, in the form of both essential oils and extracts. Thus, this property can be a promising ally in the development of medicines necessary to combat the increasing number of bacterial strains that become resistant to conventional antibiotics. Therefore, given that the literature on tests for the antimicrobial action of plant products is broad, including an increasing number of publications per year, it is highly difficult to relate the countless reports on the antimicrobial action of these products in this review article about a subject of such a great complexity, which requires a multidisciplinary approach.

Acknowledgement

This work was supported by U G C, New Delhi and Department of Botany and Microbiology, H N B Garhwal University (A Central University) Srinagar (Garhwal). The authors are thankful to Curator of Garhwal University Herbarium (GUH), H. N. B. Garhwal University Srinagar (Garhwal) for medicinal plant identification.

References

Agarry, O. O., Olaleye, M. T. and Bello, M., 2005. Comparative antimicrobial activities of Aloe vera gel and leaf. ***African Journal of Biotechnology***, 4(12):1413−1414.

Ahmad, S. S. and Husain, S. Z., 2008. Ethno medicinal survey of plants from salt range (Kallar Kahar) of Pakistan. ***Pakistan Journal of Botany***, 40(3):1005−1011.

Ahmed, F. and Urooj, A., 2009. Glucose-lowering, hepatoprotective and hypolipidemic activities of stem bark of Ficus racemosa in streptozotocin induced diabetic rats. ***Journal of Young Pharmaceutical*****,** 1(2):160−164.

Ali, S. S., Kasoju, N., Luthra, A., Singh, H., Sharanabasava, A., Sahuand and Bora, U., 2008. Indian medicinal herbs as source of antioxidants. ***Food Research International*** 41:1–15.

Alma, M. H., Mavi, A., Yildirim, A., Digrak, M. and Hirata, T., 2003. Screening chemical composition and in vitro antioxidant and antimicrobial activities of the essential oilsfrom *Origanum syriacum* L. growing in Turkey. ***Biological and Pharmaceutical Bulletin****,* 26:1725–1729.

Alvarez, M. A., Debattista, N. B. and Pappano. N. B., 2008.Antimicrobial activity and synergism of some substituted flavonoids.***Folia of Microbiology,*** 53:23–28.

Ameälia, Ana P., Almeida, Adriana F. D., Silva, A. M., Elziäria, A. Nunan. and M. Beatriz A. Gloaria., 2006. Antibacterial Activity of Coffee Extracts and Selected Coffee Chemical Compounds against Enterobacteria. ***American chemical society Journal of Agriculture and food chemistry***, 10:10−21.

Anwar, F., Hussain, A. I., Sherazi, S. T. H. and Bhanger, M. I., 2009. Changes in composition and antioxidant and antimicrobial activities of essential oil of fennel (Foeniculumvulgare Mill.) fruit at different stages of maturity. ***Journal of Herbs Spices Med Plants*****,** 15:1−16.

Anwar, F., Jamil, A., Iqbal, S. and Sheikh, M. A., 2006. Antioxidant activity of various plant extracts under ambient and accelerated storage of sunflower oil. ***Grasas Aceites Sevilla****,*57:189−197.

Arulkumaran, S., Ramprasath, V., Shanthhi, P. and Sachdanandam, P., 2007. Alteration of DMBA-induced oxidative stress by additive action of a modified indigenous preparation-Kalpaamruthaa. ***Chemical-Biology Interaction*****,** 167:99−106.

Ashraful, A. M., Habib, M. R. and Farjana, N.,2008. Antimicrobial Activity of Akanda (*Calotropis gigantea* L.) on Some Pathogenic Bacteria. ***Bangladesh Journal of Scientific and Industrial Research*****,** 43(3):397−404.

Ateb, D. A. and Erdo, U. O. T., 2003. Antimicrobial activities of various medicinal and commercial plant extracts. ***Turkish Journal of Biology,*** 27:157−162.

Atindehou, K. K., Kone, M., Terreaux, C., Traore, D., Hostettmann, K. and Dosso, M., 2002. Evaluation of the antimicrobial potential of medicinal plants from the Ivory Coast. ***Phytotherapy Research****,* 16:497–502.

Bailey, J. A. and Manspeld, J. W., 1982. Phytoalexins. *Blackie,* Glasgow.

Balandrin, M. F., Holke, J. K., Wurtele, E. S. and Bollinger, W. H., 1985. National plant chemicals. ***Source of industrial and Medicinal material Science*****,** 228:1154−1160.

Bayramoglu, B., Sahin, S. and Sumnu, G., 2008. Solvent-free microwave extraction of essential oil from oregano. ***Journal of Food Engineering*****,** 88:535−540.

Bhawna, S. and Kumar, S. U., 2009. Hepatoprotective activity of some indigenous plants**.** ***International Journal of Pharma Technology Research*****,** 4:1330–1334.

Burapadaja, S. and Bunchoo, A., 1995. Antimicrobial activity of tannins from Terminalia citrina. ***Planta Medical,*** 61(4):365−366.

Chakraborty, D., Mandal, S. M., Chakraborty, J., Bhattacharyaa, P. K., Bandyopadhyay, A., Mitra, A. and Gupta, K., 2007. Antimicrobial activity of leaf extract of Basilicum polystachyon (L) Moench. ***Indian Journal of Experimental Biology****,* 45:744−748.

Chitravadivu, C., Manian, S. and Kalaichelvi, K., 2009. Antimicrobial studies on selected medicinal plants, Erode region, Tamilnadu, India. Middle-East. ***Journal of Science Research****,* 4(3):147−152.

Chung, K. T., Wong, T. Y., Huang, Y. W. and Lin, Y., 1998. Tannins and human health: a *review*. ***Critical Review of Food Science and Nutrition*****,** 38:421–464.

Cock, I. E., 2008. Antibacterial Activity of Selected Australian Native Plant Extracts, ***Internet Journal of Microbiology*****,** 4:02−05.

Cowan, M. M., 1999. Plant products as antimicrobial agents. ***Clinical Microbiology Review***, 12(4):564–582.

Cushnie, T. P. and Lamb, A. J., 2005. Antimicrobial activity of flavonoids. ***International Journal of Antimicrobial Agents***, 26:343–356

Diallo, D., Hveem, B., Mahmoud, M. A., Betge, G., Paulsen, B. S. and Maiga, A., 1999. An ethanobotanical survey of herbal drugs of Gourma district. ***Mali Pharmaceutical Biology***, 37:80–91.

Dixon, Richard A., 2001. Natural products and plant disease resistance. ***Nature*** 411: 843−847.

Duarte, M. C., Figueira, G. M., Sartoratto, A., Rehder, V. L. and Delarmelina, C., 2005. Anti *Candida* activity of Brazilian medicinal plants.***Journal of Ethnopharmacology****,* 97:305–311.

Ekramul, I. M., Naznin, K. A. and Ekramul, H. M., 2002. In vitro antibacterial activity of the extracts and glycoside from Sida rhombilfolia Linn. ***Journal of Medical Science*****,** 2(3):134−136.

Eloff, J. N., 2004. Quatification of the bioactivity of plant extracts during screening and bioassay guided fractionation. ***Journal of Phytomedicine*****,** 11:370−371.

El-Seedi, H. R., Sata, N., Torssell, K. B. and Nishiyama, S., 2002. New labdene diterpenes from *Eupatorium glutinosum*. ***Journal of Natural Products,***65:728–729.

Erdemgil, F., Telejenetskaya, M., Baser, K. and Kirimer, N., 2004. "Alkaloids of *Thalictrum orientale* Growing in Turkey. ***Chemistry of Natural Compounds,***36:223–224.

Erdemoglu, N., Turan, N. N., Cakici, I., Sener, B. and Aydin, A., 2006. Antioxidant activities of some Lamiaceae plant extracts. ***Phytotherapy Res***earch, 20:9−13.

Faleiro, M. F., Miguel, M. G., Venancio, F., Taveares, R., Brito, G. T., Figueiredo, A. C. and Pedro, L. G., 2003. Antibacterial activity of the essential oils from Portugues endemic spices of thymus. ***Letter in applied Microbiology,*** 36−40.

Fernandez, M. A., Garcia, M. D. and Saenz, M. T., 1996. Antibacterial activity of phenolic acid fraction of *Scrophularia frutescens*and *Scrophularia sambucifolia*. ***Journal of Ethnopharmacologie,*** 53(1):11−14.

Ferrazzano, G. F., Amato, I., Ingenito, A., De, Natale A. and Pollio, A., 2009. Anti-cariogenic effects of polyphenols from plant stimulant beverages (cocoa, coffee, tea). ***Fitoterapia,*** 80:255–262.

Funatogawa, K., Hayashi, S., Shimomura, H., Yoshida, T., Hatano, T., Ito, H. and Iria, Y., 2004. Antibacterial activity of hydrolysable tannins derived from medicinal plants against Helicobacter pylori. ***Microbiolal Immunology****,* 48 (4):251−261.

Gautam, S. S., Navneet and Kumar, S., 2012. The Antibacterial and Phytochemical Aspects of *Viola odorata Linn.* Against Respiratory Tract Pathogens. ***Proceedings of National Academy of Sciences, India Section B, Biological Sciences****,* 82:567−572.

Gautam, S. S., Navneet and Kumar, S., 2013. Assessment of Antibacterial and Phyto chemical analysis of *Lagenaria vulgaris*Ser. against Respiratory Tract Pathogens.***Indian Journal of Biotechnology and Pharmaceutical Research,***1(1):23−26.

Gautam, S. S., Navneet and Kumar, S., 2015. Appraisal of antimicrobial properties of Onosma bracteatum Wall. fruit extracts against respiratory tract pathogens. ***Journal of Medicinal Herbs and Ethnomedicine,*** 1:108−112.

Gerhartz, W., Yamamota, Y. S., Campbell, F. T., Pfefferkorn, R. and Rounsaville, J. F., 1985. Ullmann's ***Encyclopedia of Industrial***.

Grayer, R. J. and Harborne, J. B., 1994. A survey of antifungal compounds from higher plants 1982-1993. ***Phytochemistry,*** 37:19−42.

Grover, J. K., Yadav, S. and Vats, V., 2002. Medicinal plants of India with hypoglycemic potentials. ***Journal of Ethnopharmacology*****,** 81:81–100.

Guo, Y. Z., Fan, Y. M., Xiao, Y. H., Yun, L. Z., Gen, C. W. and Gui, Li. Xu., 2008. Antibacterial Alkaloids from Chelidonium majus Linn (Papaveraceae) against clinical isolates of methicillin-resistant Staphylococcus aureus. ***Journal of Pharma and Pharmaceutical Science*****,** 11(4):90−94.

Hamid, N., Bukhari, N. and Jawaid, F., 2010. Physiological responses of phaseolus vulgaris to different lead concentrations. ***Pakistan Journal of Botany,*** 42(1):239−246.

Harrison, D., Griendling, K. K., Landmesser, U., Homig, B. and Drexler, H., 2003. Role of oxidative 738 stress in atherosclerosis. ***American Journal of Cardiology,***91**:**7A−11A.

Hasson, S. S., Balushi, M. S., Sallam, T. A., Idris, M. A., Habbal, O. and Jabri, A. A., 2011. *In vitro* antibacterial activity of three medicinal plants-*Boswellia (Luban)* species. ***Asian Pacific Journal of Tropical Biomedicine,***S178−S182.

Hema, T. A., Arya, A. S., Suseelan, S., John, Celestinal R. K. and Divya, P. V., 2013.Antimicrobial Activity of Five South Indian Medicinal Plants Against Clinical Pathogens.***International Journal of Pharma and Bio Sciences*****,** 4(1):70–80.

Hirasawa, M. and Takada, K., 2004. Multiple effects of green tea catechin on the antifungal activity of antimycotics against *Candida albicans*. ***Journal of Antimicrobial Chemotherapy,*** 53:225−229.

Ibrahim, M. M., 2006. Energy allocation patterns in *B. alexandrina* snails in response to cadmium exposure and *S. mansoni* infection.***Experimental parasitology*****,** 122:31−36.

Imelouane, B., Amhamdi, H., Wathelet, J. P., Ankit, M., Khedid, K. and Bachiri, A., 2009. Chemical composition and antimicrobial activity of essential oil of thyme (Thymus vulgaris) from Eastern Morocco. ***International Journal of Agriculture & Biology***, 11:205–208.

Indu, M. N., Hatha, A. A., Abirosh, M. C., Harsha, U. and Vivekanandan, U., 2006. Antimicrobial Activity of Some of the South-Indian Spices Against Serotypes of E*escherichia coli*, *Salmonella*, *Listeria monocytogenes* and *Aeromonas hydrophil.* ***Brazilian Journal of Microbiology,*** 37:153−158.

Janovska, D., Kubikova, K. and Kokoska, L., 2003. Screening for antimicrobial activity of some medicinal plants species of traditional Chinese medicine. ***Czech Journal of Food Science,***21(2):107–110.

Jeevan Ram, A., Bhakshu, L. M. and Venkata, Raju R. R., 2004. In vitro antimicrobial activity of certain medicinal plants from Eastern Ghats, India, used for skin diseases. ***Journal of Ethnopharmacology,***90:353–357.

Jiangrong, Li. and Yueming, J., 2007. Litchi Flavonoids: Isolation, Identification and Biological Activity. ***Molecules,***12:745−758.

Kalimuthu, K., Vijayakumar, S. and Senthil, K. R., 2010. Antimicrobial activity of the biodiesel plant, *Jatropha curcas*. ***International Journal of Pharma and Bio Sciences*****,**1:01−05.

Karaman, M., Jovin, E., Malbasa, R., Matavuly, M. and Popovic, M., 2003. Medicinal and Edible Lignicolous Fungi as Natural Sources of Antioxidative and Antibacterial agents. ***Phytotherapy Research*****,** 24(10):1473−1481.

Karou, D., Aly, S., Antonella, C., Saydou, Y., Carla, M., Jacques, S., Vittorio, C. and Alfred, S. T., 2006. Antibacterial activity of alkaloids from *Sida acuta.****African Journal of Biotechnology***, 5(2):195−200.

Katerere, D. R., Gray, A. I., Nash, R. J. and Waigh, R. D., 2003. Antimicrobial activity of pentacyclic triterpenes isolated from African Combretaceae. ***Phytochemistry,*** 63:81−88.

Khan, A., Safdar, M., Ali Khan, M. M., Khattak, K. N. and Anderson, R. A., 2003. Cinnamon improves glucose and lipids of people with type 2 diabetes. **Diabetes Care**, 26:3215–3218.

Khan, R., Islam, B. and Akram, M., 2009 Antimicrobial Activity of Five Herbal Extracts Against Multi-Drug Resistant (MDR) Strains of Bacteria and Fungus of Clinical Origin. ***Molecules***, 14:586−597.

Klausmeyer, P., Chmurny, G. N., McCloud, T. G., Tucker, K. D. and Shoe-maker, R. H.,2004. A novel antimicrobial

indolizinium alkaloid from *Aniba panurensis*. ***Journal of Natural Products*****,** 67:1732−1735.

Kokoska, L., Polesny, Z., Rada, V., Nepovim, A. and Vanek, T., 2002. Screening of some Siberian medicinal plants for antimicrobial activity. ***Journal of Ethnopharmacology,***82:51–53.

Kroschwitz, J. I. and Howetgrant, M. K., 1992. ***Encyclopedia of chemical technology***, 2:893.

Kubo, K., Kanehisa, H. and Fukunaga, T., 2001. Is passive stiffness related to the elasticity of tendon structures?. ***European Journal of Applied Physiology*****,** 85:226–232.

Lee, T. H., Qiu, F., Walle, G. R. and Chou, C. H., 2000. Three new flavanol galloyglycosides from leaves of *Acacia confuse*. ***Journal of Natural Product*****,** 10:125−130.

Li, M. and Xu, Z., 2008. Quercetin in a lotus leaves extract may be responsible for antibacterial activity. ***Archeological Pharmaceutical Research*****,** 31:640–644.

Lin. F., Hasegawa, M. and Kodama, O., 2003. Purification and identification of antimicrobial sesquiterpene lactones from yacon (*Smallanthussonchifolius*) leaves. ***Bioscience*****, *Biotechnology and Biochemistry,*** 67:2154–2159.

Lopez, A., Hudson, J. B. and Towers, G. H., 2001. Antiviral and antimicrobial Shibata, activities of Colombian medicinal plants. ***Journal of Ethnopharmacology,***77:189−196.

Machado, T. B., Pinto, A. V., Pinto, M. C., Leal, I. C., Silva, M. G., Amaral, A. C., Kuster, R. and Netto-dos Santos, K. R., 2003. In vitro activity of Brazilian medicinal plants, naturally occurring naphthoquinones and their analogues, against methicillin-resistant *Staphylococcus aureus*. ***International Journal of Antimicrobial Agents,*** 21:279–284.

Mahasneh, A. M., 2002. Screening of some indigenous Qatari medicinal plants for antimicrobial activity. ***Phytotherapy Research,***16:751–753.

Mahesh, B. and Satish, S., 2008. Antimicrobial Activity of Some Important Medicinal Plant Against Plant and Human Pathogens. ***World Journal of Agricultural Sciences*****,** 4 (S):839−843.

Mandal, P., Babu, S. S. P. and Mandal, N. C., 2005. Antimicrobial activity of saponins from *Acacia auriculiformis*. ***Fitoterapia.*** 76(5):462−465.

Marina, Z., Mariana, P., Aline, A. B., Thiele, F., Luana, R., Sydney, H. A., Tanise, V. D., Marli, M. A., De, C. and Margareth, L. A., 2013. *In Vitro* Evaluation of the Antimicrobial and Antimycobacterial Activities of *Solanum guaraniticum* A. St.-Hil. Leaves. ***Journal of Applied Pharmaceutical Science,*** 3:(09)19−23.

Mason, T. L. and Wasserman, B. P., 1987. Inactivation of red beet beta-glucan synthase by native and oxidized phenolic compounds. ***Phytochemistry,*** 26:2197−2202.

Mathabe, M. C., Nikolova, R. V., Lall, N. and Nyazema, N. Z., 2006. Antibacterial activities of medicinal plants used for the treatment of diarrhoea in Limpopo province. **S.** ***African Journal of Ethnopharmocology*****,** 105:286−293.

McGaw, L. J., Van der Merwe, D. and Eloff, J. N., 2007. *In vitro* anthelmintic, antibacterial and cytotoxic effects of extracts from plants used in South African ethnoveterinary medicine. ***Veterinary Journal,*** 173:366−372.

McGraw, L. J. and Eloff, J. N., 2008. Ethno veterinary use of Southern African plants and scientific evaluation of their medicinal properties. ***Journal of Ethnopharmacology***, 119:559−574.

Meshram, A., Ajai, K. and Nidhi, S., **2015**. Gas Chromatography-Mass Spectrometry (GC-MS) analysis of alkaloids isolated from *Epipremnum aureum* (Linden and Andre) Bunting. ***International Journal of Pharma Sciences and Research,*** 6(2):337−342.

Miller, K. B., Stuart, D. A., Smith, N. L., Lee, C. Y., McHale, N. L., Flanagan, J. A. and Hurst, W. J., 2006. Antioxidant activity and polyphenol and procyanidin contents of selected commercially available cocoa-containing and chocolate products in the United States. ***Journal of Agric Food Chemical,*** 31(11):4062−4068.

Mojab, F., Poursaeed, H., Mehrgan and Pakdaman, S., 2008. Antibacterial activity of *Thymus daenensis* methanolic extract. ***Pakistan Journal of Pharmaceutical Sciences***, 21: 210–213.

Mokbel, M. S. and Fumio, H., 2005. Antibacterial and Antioxidant Activities of Banana (*Musa*, AAA cv. Cavendish) Fruits Peel. ***American Journal of Biochemistry and Biotechnology,*** 1(3):125−131.

Morales, M. A., Frederick, A., Erick, C., Rafael, B., Philippe, C., Viviana, B. and Orlando, M., 2013. Inhibition of Cholinergic Contractions of Rat Ileum by Tropane-Type Alkaloids Present in *Schizanthus hookeri*.***Journal of Nature Research*****,** 68:203–209.

Nagesh, K. S. and Shanthamma, C., 2009. Antibacterial activity of *Curculigo orchioides* rhizome extract on pathogenic bacteria. ***African Journal of Microbiology Research***, 3(1):05–09.

Nascimento, G. G. F., Locatelli, J., Freitas, P. C. and Silva, G. L., 2000. Antibacterial activity of plant extracts and phytochemicals on antibiotic resistant bacteria. ***Brazil Journal of Microbiology,*** 31:247−256.

Ngwendson, J. N., Bedir, E., Efange, S. M., Okunji, C. O., Iwu, M. M. and Schuster, B. G., 2003. Constituents of

Peucedanum zenkeri seeds and their antimicrobial effects. ***Pharmamazine*****,** 58:587–589.

Nickavar, B., Amin, G. and Ghavamian, P.,2002. Antimicrobial activity of *Pulicaria dysenterica* L. ***Iran Journal of Pharmaceutical Research,*** 1:31–32.

Nkuo-Akenji, T., Ndip, R., McThomas, A. and Fru, E. C., 2001. Anti- Salmonella activity of medicinal plants from Cameroon. ***Central Africa Journal of Medicine,*** 47:155–158.

Noriaki, K.,Yukari, I., Kazuya, M. K. and Tokio, F., 2005. *In vitro* antibacterial, antimutagenic and anti-Influenza virus activity of caffeic acid phenyl ethyl esters. ***Biocontinuous Sci*ence,** 10:155−161.

Okusa, P. N., Penge, O., Deuleeschouwer, M. and Dvez, P., **2007.** Direct and indirect antimicrobial effect and antioxidant activity of *Cardiagilldii*. ***Journal of Ethnopharmacology,*** 112:476–481.

Osbourn, E. Anne., 1996. Preformed Antimicrobial Compounds and Plant Defense against Fungal Attack. American Society of Plant Physiologists***The Plant Cell,*** 8:1821−1831.

Oshima, Y., 1995. Postcolumn derivatization liquid chromatography method for paralytic shellfish toxins. ***Journal of Association Of Anal Chemical International,*** 78:528−532.

Otshudi, A. L., Foriers, A., Vercruysse, A., Van Zeebroeck, A. and Lauwers, S., 2000. *In vitro* antimicrobial activity of six medicinal plants traditionally used for the treatment of dysentery and diarrhoea in Democratic Republic of Congo (DRC).***Phytomedicine,*** 7:167–172.

Parekh, J. and Sumitra, C.,2006. Antibacterial and phytochemical studies on twelve species of Indian medicinal plants. ***African Journal of Biomedical Research,*** 10:175–181.

Pelttari, E., Jorma, M. and Hannu, Elo., 2002. Antimicrobial Activity of the Marine Alkaloids Haminol and Pulo'upone and Related Compounds. ***Journal of Nature Research,*** 57:548−552.

Pereira, J. A., Oliveira, I., Sousa, A., Valentao, P., Andrade, P. B. and Ferreira, I. C. F. R., 2007. Walnut (Juglans regia L.) leaves: Phenolic compounds, antibacterial activity and antioxidant potential of different cultivars. ***Food and Chemical Toxicology*****,** 45:2287–2295.

Purkayastha, S. and Dahiya, P., 2012. Phytochemical analysis and antibacterial efficacy of babchi oil (Psoralea corylifolia) against multi-drug resistant clinical isolates. ***International Conference on Bioscience, Biochemistry and Bioinformatics*****,** 3(1):64−68.

Raghavendra, M. P., Satish, S. and Raveesha, K. A., 2008. *In vitro* antibacterial potential of alkaloids of *Samanea saman* (Jacq.) Merr. against *Xanthomonas* and human pathogenic bacteria. ***World Journal of Agricultural Sciences,*** 4:100−105.

Recio, M. C., Rıos, J. L. and Villar, A., 1989. A review of some antimicrobial compounds isolated from medicinal plants reported in the literature 1978–88. ***Phytotherapy Research,*** 3:117–125.

Reddy, C. V. K., Sreeramulu, D. and Raghunath, M., 2010. Antioxidant activity of fresh and dry fruits commonly consumed in India. ***Food Research International,*** 43(1):285−288.

Reddy, P. S., Jamil, K. and Madhusudhan, P., 2001. Antibacterial activity of isolates from *Piper longum* and *Taxus baccata*. ***Pharmaceutical Biology*****,** 39:236−238.

Rıos, J. L. and Recio, M. C., 2005. Medicinal plants and antimicrobial activity. ***Journal of Ethnopharmacology,*** 100:80–84.

Selvamohan, T. V., Ramadas, S. and Kishore, S. S., 2012.Antimicrobial activity of selected medicinal plants against some selected human pathogenic bacteria. **Pelagia Research Library** ***Advances in Applied Science Research*****,** 3(5):3374−3381.

Senthilkumar, P. and Reetha, D., 2009. Screening of antimicrobial properties of certain Indian medicinal plants. ***Journal of Phytology,*** 1(3):193−198.

Sieradzki, K., Roberts, R. B. and Haber, S. W., 1999. The development of vancomycin resistance in a patient with methicillin-resistant Staphylococcus aureus infection. ***National Engl Journal of Medicine,*** 340:517–523.

Silva, N. C. C. and Junior, A. F., 2010. Biological properties of medicinal plants: a review of their antimicrobial activity. ***Journal of Veno Ani Tox Including Tropical Diseases*****,** 16(3):402−431.

Singh, B., Sahu, P. M., Jain, S. C. and Singh, S., 2002. Antineoplastic and antiviral screening of pyrrolizidine alkaloids from *Heliotropium subulatum invivo* and *in vitro*. ***Pharmaceutical Biol*ogy,** 40:581−590

Sivastava, J., Lambart, J. and Vietmeyer, T., 1997. Medicinal plants, an expanding role in development word bank technical paper No. 320.

Sohn, H. Y., Son, K. H., Kwon, C. S. and Kang, S. S., 2004. Antimicrobial and cytotoxic activity of 18 prenylated flavonoids isolated from medicinal plants: *Morusalba* L., *Morus mongolica* Schneider, *Broussnetia papyrifera* (L.) Vent, *Sophora flavescens* Ait and *Echinosophora koreensis* Nakai. ***Phytomedicine,*** 11:666–672.

Srinivasan, D., Perumalsamy, L .P., Nathan, S. and Sures, T., 2001. Antimicrobial activity of certain Indian medicinal

plants used in folkloric medicine. ***Journal of Ethnopharmocology***, 49:217–222.

Stoilova, S., Gargova, A. and Stoyanova, L. H., 2005. Antimicrobial and Antioxident activity of polyphenol mangiferin. ***Herba polonica*****,** 51:37−44.

Thippeswamy, B. S., Thakker, S. P., Tubachi, S., Kalyani, G. A., Netra, M. K., Patil, U., Desai, S., Gavimath, C. C. and Veerapur, V. P., 2009. Cardioprotective Effect of *Cucumis trigonus* Roxb on isoproterenol-induced myocardial infarction in rat. ***American Journal of Pharmacology Toxicology*****,** 4:29−37.

Tosun, A., Bahadir, O. and Altanlar, N., 2006. Antimicrobial activity of some plants used in folk medicine in Turkey.***Turkish Journal of Pharmaceutical Sciences*****,** 3 (3):167−176.

Tshibangu, J. N., Chifundera, R., Kamunsky, A. D. and Wright Konig, G. M., 2002. Screening of African medicinal plants for antimicrobial and enzyme inhibitory activity. ***Journal of Ethnopharmacology,*** 80:25−35.

Tullanithi, K. M., Sharmila, B. and Gnanendra, T. S., 2010. Preliminary phytochemical analysis and antimicrobial activity of Achyranthes aspera Linn. ***International Journal of BioTechnology,*** 1(3):35−38.

Turkoglu, A., Duru, M. E. and Mercan, N., 2007. Antioxidant and antimicrobial activity of *Russula delica* Fr: An Edidle wild mushroom. ***Eurasian Journal of Anal Chemistry,***1:54−67.

Turkoglu, A., Duru, M. E., Mercan, N., Kivrak, I. and Gezer, K., 2007. Antioxidant and antimicrobial activities of Laetiporus sulphureus (Bull) Murrill. ***Food Chemistry,***101: 267−273.

Ulanowska, K., Traczyk, A., Konopa, G. and Wegrzym, G., 2006. Differential antibacterial activity of genistein arising from global inhibition of DND, RNA and protein synthesis in some bacterial strains. ***Arch. Microbiology,*** 184(5):271−278.

Vaidya, K. S., Viswanatha, G. L., Ramesh, C., Nandakumar, K. and Srinath, R.,2008. Antimutagenic (anticlastogenic) and antioxidant activities of bark extract of *Terminalia arjuna*. ***Journal of Genetic Toxicology*****,** 1:1−7.

Varaprasad, B., Varahalarao, V. and Chendrashekara, K. N., 2009. Mangrove plant Sonneratia apetala antimicrobial activity on selected pathogenic microorganisms. ***Oriental Journal of Chemistry*****,** 25(2):445−447.

Vats, V., Grover, J. K. and Rathi, S. S., 2002. Evaluation of anti-hyperglycemic and hypoglycemic effect of *Trigonella foenum-graecum* Linn, *Ocimum sanctum* Linn and *Pterocarpus marsupium* Linn in normal and alloxanized diabetic rats. ***Journal of Ethnopharmacology,*** 79:95–100.

Vieira, F. G. K., Graciele, S., Campelo, B., Cristiane, C., Luciano, V. G., Eduardo, C. N. and Roseane, F., 2009. Activity and contents of polyphenolic antioxidants in the whole fruit, flesh and peel of three apple cultivars. ***Archivos Latinoamericanos de Nutricion***, 59 (1):101−106

Vinod, B., Babasaheb, S., Vrushali, S. and Bharthi, S., 2014. Isolation and purification of alkaloids from medicinal plants by HPLC. ***International journal of current microbiology and applied Science***, 3(1):414−423.

Von, K. H. and Marston, A., 1995. Saponins (Chemistry and Pharmacology of Natural Products) ***Cambridge University Press, Cambridge*** (engl.).

Wang, X., Zhang, M., Zhao, Y., Wang, H., Liu, T. and Xin. Z., 2013. Pentadecyl ferulate, a potent antioxidant and antiproliferative agent from the halophyte *Salicorniaherbacea*. ***Food Chemistry,***141(3):2066−2074.

Wannissorn, B., Jarikasem, S., Siriwangchai, T. and Thubthimthed, S., 2005. Antibacterial properties of essential oils from Thai medicinal plants.***Fitoterapia*****,** 76:233–236.

Ya, C., Gaffney, S. H., Lilley, T. H. and Haslam, E., 1988. Carbohydrate-polyphenol complexation. In: Hemingway RW, Karchesy, editors. Chemistry and Significance of Condensed Tannins. ***New York, N.Y: Plenum press***, pp. 553.

Yang, V. W. and Carol, A. Clausen., 2007. Antifungal effect of essential oils on southern yellow pine. ***International Biodeterioration & Biodegradation,*** 59:302–306.

Yaouba, A. L. N., Tatsadjieu, P. M. D., Jazet, X. F. E. and Mbofung, C. M., 2010. Antifungalproperties of essential oils and some constituents to reduce food borne pathogen. ***Journal of yeast and fungal research***, 1(1):01−08.

Yogesh, M. and Mohan, S. S.,2007. Screening of plants for their potential antibacterial activity. ***National Product Radiance,*** 6 (4):301−305.

Zhang, L., Liu, W., Hu T Du, L Luo C, Chen K, Shen, X. and Jiang, H., 2008. Structural basis for catalytic and inhibitory mechanisms of β-hydroxyacyl-acyl carrier protein dehydratase (FabZ). ***Journal of Biology,*** 283:5370–5379.

Zhang, S. L., Yeromin, A. V., Zhang, X. H., Safrina Yu Y, O., Penna, A., Roos, J., Stauderman, K. A. and Cahalan, M. D., 2006. Genome-wide RNAi screen of Ca(2+) influx identifies genes that regulate Ca(2+) release-activated Ca(2+) channel activity. ***Proceedings of Natlional Academy of Science*** *U.S.A*, 103(24):9357−9362.

Zhao, M., Yang, B., Wang, J. S., Li, B. Z. and Jiang., 2007. Y.M. Identification of the major flavonoids from pericarp tissues of lychee fruit in relation to their antioxidant activities. ***Food Chemistry,***98:737−742.