The Pharma Innovation Journal 2022; SP-11(5): 1521-1528

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(5): 1521-1528

www.thepharmajournal.com
Received: 02-02-2022
Accepted: 07-03-2022

Tuybia Bilal
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Tahir Mushtaq
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Peerzada Ishtiyak Ahmad
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

SA Gangoo
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Benatul Behar
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Bilkees Ayoob
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Saima Farooq
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Irtizah Mushtaq
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Corresponding Author
Tahir Mushtaq
Faculty of Forestry, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India

Botanicals their use as antimicrobial, antifungal and anti insecticides

Tuybia Bilal, Tahir Mushtaq, Peerzada Ishtiyak Ahmad, SA Gangoo, Benatul Behar, Bilkees Ayoob, Saima Farooq and Irtizah Mushtaq

Abstract
Botanicals are naturally occurring chemicals extracted or derived from plants or minerals used as natural therapies. Thus, sound management of insect pest by other natural insecticides has more interest and is eco-friendly to nature with less reduced negative effects on the environment. Based on the physiological activity, there are six groups of botanical insecticides, namely; repellents, feeding deterrents/antifeedants, toxicants, natural grain protectants, chemosterilants/reproduction inhibitors and insect growth, and development inhibitors. These natural botanicals have many advantages over synthetic ones and may be more cost-effective as a whole, considering the environmental cost of chemical alternatives. There is increasing both in the industry and in the scientific research for aromatic and medicinal plants because of their potential applications in medicine and plant disease control measure. The antimicrobial, antifungal and anti insecticidal properties of plant essential oils are well established against wide spectra of organisms such as fungi, bacteria and insects. These properties are mainly due to many active phytochemicals including vitamins, flavonoids, terpenoids, essential oils etc and hence they are of great importance in food industry and offer the possibility to substitute natural for synthetic preservation and other natural products.

Keywords: Botanicals, anti insecticides, antimicrobial, antifungal

Introduction
Plants are naturally God gifted for the synthesis of medicinal compound their isolation from medicinal plants and the characterizations of the active compound they contain provide a great help in the preparation of new drugs to treat many diseases and have a high therapeutic value (Huie, 2000) [36]. The plant extract, which is also called natural product, provided a great help in a new discovery in the area of chemical diversity because of the unknown availability either as standardized extract or as pure compound (Cos *et al*., 2006) [15]. According to pharmaceutical studies, approximately 10 to 20% of plants are used in a positive way in health care to treat harmful diseases such as cancer (Naczk *et al*., 2006) [50]. The classical example is reported on the bark of yew tree, which mainly contains taxol and is used in ovarian cancer and breast cancer (Cos *et al*., 2006) [15]. Isolation or extraction of medicinal plants mainly produced one or several substances that are responsible for any activity and are closely related to each other (Kibwage *et al*., 2006) [41]. Plants are the main source of drugs in modern medicinal system, folk medicinal system, traditional medicinal system, food supplement, and for synthetic drug (Hammer *et al*., 1999) [29].
According to the report of the World Health Organization, about 80% people used traditional medicine for primary health care treatment. In Asia, plants as medicine show long history with human involvement in the environment. Herbal medicines contain different types of novel and unique substances to treat infectious and chronic diseases (Duraipandiyan *et al*., 2006) [21]. The tradition of using plant products to treat a number of diseases starts with the beginning of human civilization earliest document shedding light on the use of medicinal plants is Hindu Culture, written between 4500 and 1600 BC (Rastogi *et al*., 2002) [71]. The use of traditional medicine or natural products is oldest as with the human civilization medicine from plants has therapeutic properties and history write that from long time the main source of drug was plants, minerals, and animal products (De Pasquale, 1984) [17]. The synthetic chemical drugs show bad health-related side effects, microbial resistance man tend to ethnopharmacognosy obtained thousands of phytochemical from plant with less or, no side effect, safe and mainly effective with many biological activities such as analgesic, antimicrobial, wound-healing, antioxidant, anticancer, antidiarrheal activities (De Pasquale, 1984) [17].

According to the report of the World Health Organization, 12 mega biodiversity countries nearly have 20,000 medicinal plants (Sasidharan, 2010) [76].

Botanicals

Plant extracts are commonly referred to as plant botanicals and are the secondary plant metabolites synthesized by the plant for the protective purposes. Botanicals are also commonly used to maintain health and prevent diseases. Some botanicals such as:

1. Immune active botanicals: Such as echinacea strengthen and tone immune functions.
2. Antioxidant botanicals: Such as green tea, prevent cancer, slow aging, and maintain cardiovascular functions.
3. Botanicals such as st. John's wort alleviate common psychological symptoms such as insomnia, anxiety, or mild depression. It has also been used in combination with black cohosh to relieve mood symptoms associated with menopause.
4. Valerian can also help with insomnia, and kava can help reduce anxiety
5. Botanicals such as ginger treat or prevent a variety of gastrointestinal problems from nausea to constipation.

Antimicrobial

The word antimicrobial was derived from the Greek words anti (against), micro (little) and bios (life) and refers to all agents that act against microbial organisms. Antimicrobial agent is a general term that is mainly concerned with antibiotics, antibacterial, antifungals, antivirals and ant protozoans. Antimicrobial agents are drugs, chemicals or other substances that are capable of acting by two modes either kill (microbiocidal) or slow the growth of microbes (microbiostatic). Antimicrobial medicines can be classified according to the microorganisms they act primarily against. For example, antibacterials are used against bacteria and antifungals are used against fungi.

Table 1: Some important medicinal plant extracts compounds with antimicrobial activity

Botanical name	Family	compounds	Reference
Ocimum basilicum	Lamiaeae	Essential oils	Wan *et al*., 1998 [97]
Piper nigrum	Piperaceae	Piperine	Ghoshal *et al*., 1996 [27]
Berberis vulgaris	Berberidaceae	Berberine	Omulokoli *et al*., 1997 [60]
Vaccinium spp.	Ericaceae	Fructose	Ofek *et al*., 1996 [54]
Matricaria chamomilla	Asteraceae	Anthemic acid	Bose, 1958 [11]
Allium sativum	Amaryllidaceae	Allicin	Naganawa *et al*., 1996 [51]
Hydrastis canadensis	Ranunculaceae	hydrastine	Freiburghaus *et al*., 1996 [25]
Camellia sinensis	Theaceae	Catechin	Vijaya *et al*., 1995 [94]
Lawsonia	Lytheraceae	Lawsone	Suresh *et al*., 1997 [87]
Melissa officinalis	Lamiaceae	Tannins	Wild, 1994 [99]
Olea europaea	Oleaceae	Hexanal	Kubo *et al*., 1995 [45]
Allium cepa	Amaryllidaceae	Allicin	Vohora *et al*., 1973 [96]
Curcuma longa	Zingiberaceae	Curcumin	Apisariyakul *et al*., 1995 [5]
Artemisia dracunculus	Asteraceae	Caffeic acids, tannins	Wild, 1994 [99]

Table 2: List of plants having antifungal activity

Botanical name	Family	compounds	Reference
Simmondsia chinensis	Simmondsiaceae	Glucosides	Abbassy *et al*., 2007 [1]
Thymus zygis sub *sp. sylvestris*,	Lamiaceae	Carvacrol	Gonçalves *et al*., 2010 [28]
C. biebersteinii	Asteraceae	Camphor, 1,8-cineole, piperitone, borneol and α-terpineol, n-eicosane, n-heneicosane, n-tricosane, linoleic acid	Kordali *et al*., 2009 [42]
Larrea tridentata	Zygophyllaceae	lignans, methyl-nordihydroguaiaretic acid and nordihydroguaiaretic acid	Vargas-Arispuro *et al*., 2005 [93]
Aloe vera	Asphodelaceae	Crude extracts	Jasso de Rodríguez *et al*., 2005 [38]
Catharanthus roseus	Apocynaceae	5-hydroxy flavones	Roy & Chatterjee, 2010 [73]
Salvia officinalis	Lamiaceae	essential oil	Pinto *et al*., 2007 [66]
Punica granatum	Punicaceae	polyphenolic extracts	Osorio *et al*., 2010 [61]
Bulnesia sarmientoi	Zygophyllaceae	bulnesol, hanamyol	Rodilla *et al*., 2011 [72]
Piper longum	Piperaceae	Eugenol, piperine, piperlongumine and piperettine)	Lee *et al*., 2001 [46]
Datura metel	Solonaceae	Enzymes, peroxidase, β-1,3-glucanase and chitinase	Devaiah *et al*., 2009 [18]
Robinia pseudoacacia	Fabaceae	Crude extracts	Zhang *et al*., 2008 [2]
Cassia sp	Fabaceae	cassia oil	Feng *et al*., 2008 [23]
Hypericum perfoliatum and *Hypericum tomentosum*	Hypericaceae	α-pinene, allo-aromadendrene, germacrene-D, n-octane, α-selinene and β-selinene. Menthone, n-octane, βcaryophyllene, α-pinene, lauric acid and β-pinene	Hosni *et al*., 2008 [33]
Allium sativum	Amaryllidaceae	essential oil	Pyun and Shin 2006 [69]
Cymbopogon flexuosus	Poaceae	essential oil	Pattnaik *et al*., 1996 [62]
Cymbopogon martini	Poaceae	essential oil	Pattnaik*et al*., 1996 [62]
Mentha piperita	Lamiaceae	essential oil	Pattnaik*et al*., 1996 [62]
Pelargonium graveolens	Geraniaceae	essential oil	Pattnaik*et al*., 1996 [62]
Pimpinella anisum	Apiaceae	essential oil	Kosalec *et al*., 2005 [43]
Piper angustifolium	Piperaceae	essential oil	Tirillini *et al*., 1996 [90]

Salvia officinalis	Lamiaceae	essential oil	Hili *et al*., 1997 [32]
Salvia sclarea	Lamiaceae	essential oil	Pitarokili *et al*., 2002 [67]
Tagetes patula	Asteraceae	essential oil	Romagnoli *et al*., 2005
Thymbra capitata	Lamiaceae	essential oil	Salgueiro *et al*., 2004 [75]
Lavandula angustifolia	Lamiaceae	essential oil	D'Auria *et al*., 2005 [16]
Dictamnus dasycarpus	Rutaceae	Dictamnine	Zhao *et al*., 1998 [103]
Ficus septic	Moraceae	Antofine, Ficuseptine	Baumgartner *et al*., 1990 [9]
Olea europaea	Oleaceae	Hexanal, E-2-Hexanal, E-2-Heptanal, Nonanal and E-2-Octenal	Battinelli *et al*., 2006
Eupatorium riparium	Oleaceae	Methylripariochromene A	Bandara *et al*., 1992 [7]
Zingiber officinale	Zingiberaceae	Gingerenone A	Endo *et al*., 1990 [22]
Coleonema pulchellum	Rutaceae	Precolpuchol	Brader *et al*., 1997 [12]
Bidens cernua	Asteraceae	Cernuol	Smirnov *et al*., 1998 [86]
Cistus incanus	Cistaceae	Geraniol	Chinou *et al*., 1994 [14]
Thymus pulegioides	Lamiaceae	Carvacrol, p-Cymene and γ - Terpinene	Pinto *et al*., 2006 [65]
Calycodendronmilnei	Rubiaceae	Isopsychotridine E, Hodgkinsine A, Quadrigemine C, Quadrigemine H, Psychotridine E, Vatine, VatineA, Vatamine, Vatamidine,	Saad *et al*., 1995 [74]

Table 3: List of plants having anti insecticidal activity

Botanical name	Family	Mode of Action
Azadirachta indica	Meliaceae	
Asparagus africanus	Asparagaceae	Leaf is crushed, mixed with milk and taken one coffee cup every morning until the individual back to the malarious area. Leaf pounded and mixed with the leaf of Aloe species is drunk.
Allium sativum	Alliaceae	Crushing and applying the juice on the skin
Discopodium penninervium Hochst	Solanaceae	Fresh leaf is crushed and rubbed on the skin
Ziziphus spinachristi	Rhamnaceae	Leaf/root is added on fire and fumigates to eradicate flies
Warburgia ugandensis	Cannaleaceae	Aqueous extract show effect as larvicidal
Verbascumsinaiticum Benth	Scrophulariaceae	Fresh leaves powdered and mixed in water then apply topically
Stephania abyssinica	Menispermacea	Placed on bed against bed pests
Senna singueana	Fabaceae	Fresh leaves are put with crops in order to prevent from destroying by wheels

Major groups of antimicrobial compounds from plants

Plants have an almost limitless ability to synthesize aromatic substances, most of which are phenols or their oxygen-substituted derivatives (Geissman, 1963) [26]. Most are secondary metabolites, of which at least 12,000 have been isolated, a number estimated to be less than 10% of the total (Schultes, 1978) [80]. In many cases, these substances serve as plant defense mechanisms against predation by microorganisms, insects, and herbivores. Some, such as terpenoids, give plants their odors; others (quinones and tannins) are responsible for plant pigment. Many compounds are responsible for plant flavor (e.g., the terpenoids capsaicin from chili peppers), and some of the same herbs and spices used by humans to season food yield useful medicinal compounds.

Alkaloids

Heterocyclic nitrogen compounds are called alkaloids. The first medically useful example of an alkaloid was morphine, isolated in 1805 from the opium poppy *Papaver somniferum* (Fessenden *et al*., 1982) [24] the name morphine comes from the Greek Morpheus, god of dreams. Codeine and heroin are both derivatives of morphine. Diterpenoid alkaloids, commonly isolated from the plants of the Ranunculaceae, or buttercup family are commonly found to have antimicrobial properties (Omulokoli *et al*., 1997) [60]. Solamargine, a glycol-alkaloid from the berries of *Solanum khasianum*, and other alkaloids may be useful against HIV infection (Sethi, 1979) [83] as well as intestinal infections associated with AIDS (McDevitt *et al*., 1996) [49]. While alkaloids have been found to have microbiocidal effects (including against Giardia and Entamoeba species (Ghoshal *et al*., 1996) [27], the major antidiarrheal effect is probably due to their effects on transit time in the small intestine. Berberine is an important representative of the alkaloid group. It is potentially effective against trypanosomes and plasmodia (Omulokoli *et al*., 1997) [60]. The mechanism of action of highly aromatic planar quaternary alkaloids such as berberine and harmane is attributed to their ability to intercalate with DNA (Phillipson and Neill, 1987) [63].

Flavones, flavonoids, and flavonols

Flavones are phenolic structures containing one carbonyl group (as opposed to the two carbonyls in quinones). The addition of a 3-hydroxyl group yields a flavonols (Fessenden *et al*., 1982) [24]. Flavonoids are also hydroxylated phenolic substances but occur as a C6-C3 unit linked to an aromatic ring. Since they are known to be synthesized by plants in response to microbial infection (Dixon *et al*., 1983) [19], it should not be surprising that they have been found *in vitro* to be effective antimicrobial substances against a wide array of microorganisms. Their activity is probably due to their ability to complex with extracellular and soluble proteins and to complex with bacterial cell walls, as described above for quinones. More lipophilic flavonoids may also disrupt microbial membranes (Tsuchiya *et al*., 1996) [91].

Terpenoids and Essential Oils

The fragrance of plants is carried in the so called quinta essentia, or essential oil fraction. These oils are secondary metabolites that are highly enriched in compounds based on an isoprene structure. They are called terpenes, their general chemical structure is C10H16, and they occur as diterpenes, triterpenes, and tetraterpenes (C20, C30, and C40), as well as hemiterpenes (C5) and sesquiterpenes (C15). When the compounds contain additional elements, usually oxygen, they

are termed terpenoids. Terpenoids are synthesized from acetate units, and as such they share their origins with fatty acids. They differ from fatty acids in that they contain extensive branching and are cyclized. Examples of common terpenoids are methanol and camphor (monoterpenes) and farnesol and artemisin (sesquiterpenoids). Artemisin and its derivative a-art ether, also known by the name qinghaosu, find current use as antimalarial (Vishwakarma, 1990) [95]. In 1985, the steering committee of the scientific working group of the World Health Organization decided to develop the latter drug as a treatment for cerebral malaria. It was reported that 60% of essential oil derivatives examined to date were inhibitory to fungi while 30% inhibited bacteria (Chaurasia and Vyas, 1977) [13]. The triterpenoid betulinic acid is just one of several terpenoids which have been shown to inhibit HIV. The mechanism of action of terpenes is not fully understood but is speculated to involve membrane disruption by the lipophilic compounds.

Quinones

Quinones are aromatic rings with two ketone substitutions. They are ubiquitous in nature and are characteristically highly reactive. These compounds, being colored, are responsible for the browning reaction in cut or injured fruits and vegetables and are an intermediate in the melanin synthesis pathway in human skin (Schmidt, 1988) [79]. Their presence in henna gives that material its dyeing properties (Fessenden *et al*., 1982) [24]. The switch between diphenol (or hydroquinone) and diketone (or quinone) occurs easily through oxidation and reduction reactions. The individual redox potential of the particular quinone-hydroquinone pair is very important in many biological systems; witness the role of ubiquinone (coenzyme Q) in mammalian electron transport systems. Vitamin K is a complex naphthoquinone. Its ant hemorrhagic activity may be related to its ease of oxidation in body tissues (Harris, 1963) [30]. Hydroxylated amino acids may be made into quinones in the presence of suitable enzymes, such as a polyphenol oxidase (Thastrup *et al*., 1985) [88].

Phenolics and Polyphenols

Simple phenols and phenolic acids. Some of the simplest bioactive phytochemicals consist of a single substituted phenolic ring. Cinnamic and caffeic acids are common representatives of a wide group of phenyl propane-derived compounds which are in the highest oxidation state. The common herbs tarragon and thyme both contain caffeic acid, which is effective against viruses (Wild, 1994) [99], bacteria (Thomson, 1978) [89], and fungi (Duke, 1985). Catechol and pyrogallol both are hydroxylated phenols, shown to be toxic to microorganisms. Catechol has two (2-OH) groups, and pyrogallol has three. The site(s) and number of hydroxyl groups on the phenol group are thought to be related to their relative toxicity to microorganisms, with evidence that increased hydroxylation results in increased toxicity (Geissman, 1963) [26]. In addition, some authors have found that more highly oxidized phenols are more inhibitory (Scalbert, 1991) [77]. The mechanisms thought to be responsible for phenolic toxicity to microorganisms include enzyme inhibition by the oxidized compounds, possibly through reaction with sulfhydryl groups or through more nonspecific interactions with the proteins (Mason and Wasserman, 1987) [48].

Tannins

"Tannin" is a general descriptive name for a group of polymeric phenolic substances capable of tanning leather or precipitating gelatin from solution, a property known as astringency. Their molecular weights range from 500 to 3000 and they are found in almost every plant part: bark, wood, leaves, fruits, and roots (Scalbert, 1991) [77]. They are divided into two groups, hydrolysable and condensed tannins. Hydrolysable tannins are based on gallic acid, usually as multiple esters with D-glucose; while the more numerous condensed tannins (often called proanthocyanidins) are derived from flavonoid monomers. Tannins may be formed by condensations of flavan derivatives which have been transported to woody tissues of plants. Alternatively, tannins may be formed by polymerization of quinone units (Geissman, 1963) [26]. This group of compounds has received a great deal of attention in recent years, since it was suggested that the consumption of tannin-containing beverages, especially green teas and red wines, can cure or prevent a variety of disorders (Serafini, 1994) [82]. Many human physiological activities, such as stimulation of phagocytic cells, host-mediated tumor activity, and a wide range of anti-infective actions, have been assigned to tannins (Haslam, 1996) [31]. One of their molecular actions is to complex with proteins through so-called nonspecific forces such as hydrogen bonding and hydrophobic effects, as well as by covalent bond formation (Haslam, 1996) [31].

Coumarins

Coumarins are phenolic substances made of fused benzene and a-pyrone rings (Kennedy and Thornes, 1997) [53]. They are responsible for the characteristic odor of hay. As of 1996, at least 1,300 had been identified (Hoult and paya, 1996) [34]. Their fame has come mainly from their antithrombotic Thastrup *et al*., 1985) [88], anti-inflammatory (Piller, 1975) [64], and vasodilatory (Namba *et al*., 1988) [52] activities. Warfarin is a particularly well-known coumarin which is used both as an oral anticoagulant and, interestingly, as a rodenticide (Keating and Kennedy, 1997) [53]. It may also have antiviral effects. Coumarins are known to be highly toxic in rodents and therefore are treated with caution by the medical community. However, recent studies have shown a "pronounced species-dependent metabolism". So that many *in vivo* animal studies cannot be extrapolated to humans. It appears that toxic coumarin derivatives may be safely excreted in the urine in humans (Weinmann, 1997) [98].

Lectins and Polypeptides

Peptides which are inhibitory to microorganisms were first reported in 1942 (Balla *et al*., 1942) [6]. They are often positively charged and contain disulfide bonds (Zhang and Lewis, 1997) [1]. Their mechanism of action may be the formation of ion channels in the microbial membrane or competitive inhibition of adhesion of microbial proteins to host polysaccharide receptors (Sharon and Ofek, 1986) [85]. Recent interest has been focused mostly on studying anti-HIV peptides and lectins, but the inhibition of bacteria and fungi by these macromolecules, such as that from the herbaceous Amaranthus, has long been known (Bolle *et al*., 1996) [10]. Thionins are peptides commonly found in barley and wheat and consist of 47 amino acid residues. They are toxic to yeasts and gram-negative and gram-positive bacteria. Thionins AX1 and AX2 from sugar beet are active against fungi but not bacteria (Kragh *et al*., 1995) [44]. Fabatin, a newly identified 47- residue peptide from fava beans, appears to be structurally related to g-thionins from grains and inhibits *E. coli, P.*

aeruginosa, and *Enterococcus hirae* but not Candida or Saccharomyces. The larger lectins molecules, which include mannose-specific lectins from several plants, MAP30 from bitter melon (Huang *et al*., 1995), GAP31 from *Gelonium multiflorum* and *jacalin* are inhibitory to viral proliferation (HIV, cytomegalovirus), probably by inhibiting viral interaction with critical host cell components.

Table 4: List of plants, Family, Plant part used and Therapeutic uses in anti-microbial, anti-fungal and anti-insecticides

Scientific name	Family	Plant part used	Therapeutic uses	Earlier supported studies
Arnebia benthamii	(Boraginaceae)	Root, Leaves	Antimicrobial	Shamim *et al*., 2015
Rumex dentatus	(Polygonaceae)	Leaves, Roots	Antimicrobial	Nisa *et al*., 2013
Nepeta cataria	(Lamiaceae)	Dried leaves and flowers	Antimicrobial	Bandh *et al*., 2011 [8]
Euphorbia helioscopia	Euphorbiaceae	Above ground part	Antimicrobial	Lone *et al*., 2013 [47]
Euryale ferox	(Liliaceae)	Seeds	Antimicrobial	Parray *et al*., 2010
Euphorbia wallichii	(Euphorbiaceae)	Above ground part	Antimicrobial	Parray *et al*., 2009
Fumaria Indica	(Fumariaceae)	Aerial parts	Antimicrobial	Khan *et al*., 2014
Iris kashmiriana	(*Iridaceae*)	Whole plant	Antimicrobial	Khan, 2015 [40]
Chrysanthellum americanum	(*Asteraceae*)	Leaf	Antifungal	Ofodile *et al*., (2010) [55]
Cocus nucifera	(*Asteraceae*)	Coconut oil	Antifungal	Ogbilu *et al*., (2007)
Plumbago zeylanica	(*Plubagiaceae*)	Leaf and root	Antifungal	Ogbebor and Adekunle (2005) [56]
Vernoniaten oreana	*Compositae*	Bark	Antifungal	Ogundare *et al*., (2006) [6]
Acalphya fimbriata	*Euphorbiaceae*	Leaf	Antifungal	Adodo (2005) [3]
Seena podocarpa	(*Leguminosae*)	Leaf	Antifungal	Ogundare (2009) [58]
Ageratum conyzoides	(*Asteraceae*)	Leaf	Antifungal	Ogbebor and Adekunle (2005) [56]
Azadirachta indica	Meliaceae		Anti-insecticidal	Isman, (2006); Xu *et al*. (2010; Ahmad *et al*., (2015) [37, 100]
Chrysanthemum cinerariifolium	Asteraceae	Flowers	Anti-insecticidal	Schleier and Peterson (2011) [78]
Allium sativum	Alliaceae	Blub	Anti-insecticidal	Yang *et al*., (2010) [100]
Lantana camara	Verbenaceae	Leaves	Anti-insecticidal	Rajashekhar *et al*.,(2014) [70]
Ocimum basilicum	Lamiaceae	Leaves	Anti-insecticidal	Prajapati *et al*., (2005); Martinez Velazquez *et al*., (2011) [68, 72]
Datura stramonium	Solanaceae	Seeds	Anti-insecticidal	Senthilkumar *et al*., (2009); Jawalkar *et al*., (2016) [81]
Tagetesminuta	Asteraceae	Flowers and tender leaves	Anti-insecticidal	Amer and Mehlhorn (2006) [4]
Nicotiana tabacum	Solanaceae	Leaves	Anti-insecticidal	Isman (2006); Vanderborre *et al*., (2010) [37]

Conclusion

- Medicinal plant antimicrobial activity is a new hope to combat the dangerous threats posed by increasing evidence of antimicrobial resistance.
- Antimicrobial activities of plant oils and extracts have formed the basis of many applications including raw and processed food preservation, pharmaceuticals, alternative medicine and natural therapies.
- It is concluded that medicinal plants can be used as antimicrobial agents in new drugs for therapy of infectious diseases in humans.
- Plant bioactive with antifungal activity can be considered as an option for development of new improved alternative formulations in antifungal therapy.

References

1. Abbassy MA, Abdelgaleil SAM, Belal ASH, Abdel RMAA. Insecticidal, antifeedant and antifungal activities of two glucosides isolated from the seeds of Simmondsia chinensis, Industrial Crops and Products. 2007;26(3):345-350.
2. Adekunle AA, Ikumapayi AM. Antifungal property and phytochemical screening of the crude extracts of *Funtumia elastica* and *Mallotus oppositifolius*. West Indian Medical Journal. 2006;55(4):219-223.
3. Adodo A. New frontiers in African medicine. Metropolitan publishers' Ltd, 2005, 79-117.
4. Amer A, Mehlhorn H. Larvicidal Effects of Various Essential Oils Against *Aedes*, *Anopheles*, and *Culex larvae* (Diptera, Culicidae). Parasitology Research. 2006;99:466-472.
5. Apisariyakul A, Vanittanakom N, Buddhasukh D. Antifungal activity of turmeric oil extracted from *Curcuma longa* (Zingiberaceae). Journal of Ethnopharmacology. 1995;49:163-169.
6. Balla AK, Hale WS, Harris TH. A crystalline protein obtained from a lipoprotein of wheat flour. Cereal Chemistry. 1942;19:279-288.
7. Bandara BM, Hewage CM, Karunaratne V, Wannigama CP, Adikaram NK. An antifungal chromene from *Eupatorium riparium*. Phytochemistry. 1992;31(6):1983-1985.
8. Bandh SA, Kamili AN, Ganai BA, Lone BA, Saleem S. Evaluation of antimicrobial activity of aqueous extracts of *Nepeta cataria*. Journal of Pharma Research. 2011;4(9):3141-3142.
9. Baumgartner B, Erdelmeier CA, Wright AD, Ralli T, Sticher O. An antimicrobial alkaloid from *Ficus septica*. Phytochemistry. 1990;29(10):3327-3330.
10. Bolle De MF, Osborn RW, Goderis IJ, Noe L, Acland D, Hart CA, *et al*. Antimicrobial properties from *Mirablisjalapa* and *Amaranthus caudalus*: Expression, processing, localization and biological activity in transgenic tobacco. Plant Molecular Biology. 1996;31:993-1008.
11. Bose PK. On some biochemical properties of natural coumarins. Journal of Indian Chemical Society. 1958;58:367-375.
12. Brader G, Bacher M, Hofer O, Greger H. Prenylated phenylpropenes from *Coleonema pulchellum* with antimicrobial activity. Phytochemistry. 1997;45(6):1207-1212.

13. Chaurasia SC, Vyas KK. *In vitro* effect of some volatile oil against *Phytophthora parasitica* var. piperina. Journal of Research Indian Medical Yoga Homeopathy, 1977, 24-26p.
14. Chinou I, Demetzos C, Harvala C, Roussakis C, Verbist JF. Cytotoxic and antibacterial labdane-type diterpenes from the aerial parts of *Cistus incanus* subsp. Creticus. Planta Medica. 1994;60(1):34-6.
15. Cos P, Vlietinck AJ, Berghe DV, Maes L. Antiinfective potential of natural products: How to develop a stronger *in vitro* proof-of-concept. Journal of Ethnopharmacology, 2006, 106pp.
16. D'Auria FD, Tecca M, Strippoli V, Salvatore G, Battinelli L, Mazzanti G. Antifungal activity of *Lavandula angustifolia* essential oil against *Candida albicans* yeast and mycelial form. Medical Mycology. 2005;43(5):391-396.
17. De Pasquale A. Pharmacognosy: The oldest modern science. Journal of Ethnopharmacology. 1984;11(1):1-16.
18. Devaiah SP, Mahadevappa GH, Shetty HS. Induction of systemic resistance in pearl millet (*Pennisetum glaucum*) against downy mildew (*Sclerospora graminicola*) by Daturametel extract. Crop Protection. 2009;28(9):783-791.
19. Dixon RA, Dey PM, Lamb CJ. Phytoalexins: enzymology and molecular biology. Advances in Enzymology. 1983;55:1-69.
20. Duke JA. Handbook of medicinal herbs. CRC Press, Inc., Boca Raton, Fla, 1985.
21. Duraipandiyan V, Ayyanar M, Ignacimuthu S. Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. BMC Complementary and Alternative Medicine. 2006;6(1):35.
22. Endo K, Kanno E, Oshima Y. Structures of antifungal diarylheptenones, gingerenones A, B, C and isogingerenone B, isolated from the rhizome of *Zingiber officinale*. Phytochemistry. 1990;29(3):797-799.
23. Feng W, Zheng X, Chen J, Yang Y. Combination of cassia oil with magnesium sulphate for control of postharvest storage rots of cherry tomatoes. Crop Protection. 2008;27(1):112-117.
24. Fessenden RJ, Fessenden JS. Organic chemistry, 2nd ed. Willard Grant Press, Boston, Mass, 1982.
25. Freiburghaus F, Kaminsky R, Nkunya MHH, Brun R. Evaluation of African medicinal plants for their *in vitro* trypanocidal activity. Journal of Ethnopharmacology. 1996;55:1-11.
26. Geissman TA. Flavonoid compounds, tannins, lignins and related compounds. In M. Florkin and E. H. Stotz (ed.), Pyrrole pigments, isoprenoid compounds and phenolic plant constituents. Elsevier, New York, N.Y. 1963;9:265.
27. Ghoshal S, Krishna Prasad BN, Lakshmi V. Antiamoebic activity of *Piper longum* fruits against *Entamoeba histolytica in vitro* and *in vivo*. Journal of Ethnopharmacology. 1996;50:167-170.
28. Gonçalves MJ, Cruz MT, Cavaleiro C, Lopes MC, Salgueiro L. Chemical, antifungal and cytotoxic evaluation of the essential oil of *Thymus zygis* subsp. sylvestris, Industrial Crops and Products. 2010;32(1):70-75.
29. Hammer KA, Carson CF, Riley TV. Antimicrobial activity of essential oils and other plant extracts, Journal of Applied Microbiology. 1999;86(6):985-990.
30. Harris RS. Vitamins K. In M. Florkin and E. Stotz (ed.), Pyrrole pigments, isoprenoid compounds and phenolic plant constituents. Elsevier, New York, N.Y. 1963;9:192-198.
31. Haslam E. Natural polyphenols (vegetable tannins) as drugs: possible modes of action. Journal of Natural Products. 1996;59:205-215.
32. Hili P, Evans CS, Veness RG. Antimicrobial action of essential oils: the effect of dimethyl sulphoxide on the activity of cinnamon oil. Letters in Applied Microbiology. 1997;24(4):269-75.
33. Hosni K, Msaâda K, Ben Taârit M, Ouchikh O, Kallel M, Marzouk B. Essential oil composition of *Hypericum perfoliatum* L. and *Hypericum tomentosum* L. growing wild in Tunisia. Industrial Crops and Products. 2008;27(3):308-314.
34. Hoult JRS, Paya M. Pharmacological and biochemical actions of simple coumarins: Natural products with therapeutic potential. General Pharmacology. 1996;27:713-722.
35. Huang-Lee S, Huang PL, Chen HC, Huang PL, Bourinbaiar A, Huang HI, *et al*. Anti-HIV and anti-tumor activities of recombinant MAP30 from bitter melon. Gene (Amsterdam). 1995;161:151-156.
36. Huie CW. A review of modern sample-preparation techniques for the extraction and analysis of medicinal plants, Analytical and Bioanalytical Chemistry. 2000;373(1-2):23-30.
37. Isman Botanical MB. Insecticides, Deterrents, and Repellents in Modern Agriculture and an Increasingly Regulated World. Annual Review Entomology. 2006;51:45-66.
38. Jasso de Rodríguez D, Hernández-Castillo D, Rodríguez-García R, Angulo-Sánchez JL. Antifungal activity *in vitro* of Aloe vera pulp and liquid fraction against plant pathogenic fungi. Industrial Crops and Products. 2005;2(1):81-87.
39. Keating GJ, Kennedy RO. The chemistry and occurrence of coumarins. In R. O'Kennedy and R. D. Thornes (ed.), Coumarins: biology, applications and mode of action. John Wiley & Sons, Inc., New York, N.Y., 1997, 348p.
40. Khan A. Anthelmintic and Specific Activity of Some Medicinal Plants of Kashmir. Thesis, University of Kashmir, 2015, 55-60p.
41. Kibwage IO, Mwangi JW, Oithi GN. Quality control of herbal medicines. East and Central African Journal of Pharmaceutical Sciences. 2006;8(2):27-30.
42. Kordali S, Cakir A, Aytas AT, Mete E, Akcin A, Aydin T, *et al*. Antifungal and herbicidal properties of essential oils and n-hexane extracts of *Achillea gypsicola*. And *Achillea biebersteinii*. Industrial Crops and Products. 2009;29(2-3):562-570.
43. Kosalec I, Pepeljnjak S, Kustrak D. Antifungal activity of fluid extract and essential oil from anise fruits (*Pimpinella anisum* L). Acta Pharmaceutica. 2005;55(4):377-85.
44. Kragh KM, Nielsen JE, Nielsen KK, Dreboldt S, Mikkelsen JD. Characterization and localization of new antifungal cysteine-rich proteins from Beta vulgaris. Molecular Plant-Microbe Interactions. 1995;8:424-434.
45. Kubo A, Lunde CS, Kubo I. Antimicrobial activity of the olive oil flavor compounds. Journal of Agriculture Food Chemistry. 1995;43:1629-1633.
46. Lee SE, Park BS, Kim MK, Choi WS, Kim HT, Cho KY,

et al. Fungicidal activity of pipernonaline, a piperidine alkaloid derived from long pepper, *Piper longum* L., against phytopathogenic fungi. Crop Protection. 2001;20:523-528.
47. Lone BA, Bandh SA, Chishti MZ, Bhat FA, Tak H, Nisa H. Anthelmintic and antimicrobial activity of methanolic and aqueous extracts of *Euphorbia helioscopia* L. Tropical Animal Health Production. 2012;45:743-749.
48. Mason TL, Wasserman BP. Inactivation of red beet betaglucan synthase by native and oxidized phenolic compounds. Phytochemistry. 1987;26:2197-2202.
49. McDevitt JT, Schneider DM, Katiyar SK, Edlind TD. Berberine: A candidate for the treatment of diarrhea in AIDS patients, abstr. 175. In Program and Abstracts of the 36th Inter science Conference on Antimicrobial Agents and Chemotherapy. American Society for Microbiology, Washington, D.C., 1996.
50. Naczk M, Shahidi F. Phenolics in cereals, fruits and vegetables: occurrence, extraction and analysis, Journal of Pharmaceutical and Biomedical Analysis. 2006;41(5):1523-1542.
51. Naganawa R, Iwata N, Ishikawa K, Fukuda H, Fujino T, Suzuki A. Inhibition of microbial growth by ajoene, a sulfur-containing compound derived from garlic. Applied and Environmental Microbiology. 1996;62:4238-4242.
52. Namba T, Morita O, Huang SL, Goshima K, Hattori M, Kakiuchi N. Studies on cardio-active crude drugs. Effect of coumarins on cultured myocardial cells. Planta Medica. 1988;54:277-282.
53. O'Kennedy R, Thornes (ed.) RD. Coumarins: biology, applications and mode of action, 1997.
54. Ofek I, Goldhar J, Sharon N. Anti-*Escherichia coli* adhesin activity of cranberry and blueberry juices. Advances in Experimental Medicine and Biology. 1996;408:179-183.
55. Ofodile LN, Kanife UC, Arojojoye BJ. Antifungal activity of a Nigerian herbal plant. *Chrysanthellum americanum* acta SATECH. 2010;3(2):60-63.
56. Ogbebor N, Adekunle AT. Inhibition of conidial germination and mycelial growth of *Corynespora cassiicola* (Berk and Curt) of rubber (*Hevea brasiliensis* muell. Arg.) using extracts of some plants. African Journal of Biotechnology. 2005;4(9):996-1000.
57. Ogbolu DO, Oni AA, Daini AO, Oloko AP. *In vitro* antimicrobial properties of coconut oil on Candida species in Ibadan. Nigerian Journal of Medicines Foods. 2007;10(2):173-184.
58. Ogundare AO. The antimicrobial pattern and phytochemical properties of the leaf extract of *Senna podocarpa*. African Journal of Microbiology Research. 2009;37(7):400-406.
59. Ogundare AO, Adetuyi FC, Akinyosoye FA. Antibacterial activities of *Vernonia tenomeena*. African Journal of Biotechnology. 2006;5(18):1663-1668.
60. Omulokoli E, Khan B, Chhabra SC. Antiplasmodial activity of four Kenyan medicinal plants. Journal of Ethnopharmacology. 1997;56:133-137.
61. Osorio E, Flores M, Hernández D, Ventura J, Rodríguez R, Cristóbal Aguilar N. Biological efficiency of polyphenolic extracts from pecan nuts shell (*Carya illinoensis*), pomegranate husk (*Punica granatum*) and creosote bush leaves (*Larrea tridentata* Cov.) against plant pathogenic fungi. Industrial Crops and Products. 2010;31(1):153-157.
62. Pattnaik S, Subramanyam VR, Kole CR. Antibacterial and antifungal activity of ten essential oils *in vitro*. Microbios. 1996;86(349):237-46.
63. Phillipson JD, O'Neill MJ. New leads to the treatment of protozoal infections based on natural product molecules. Acta Pharmaceutica Nordica. 1987;1:131-144.
64. Piller NB. A comparison of the effectiveness of some anti-inflammatory drugs on thermal oedema. Br. Journal of Experimental Pathology. 1975;56:554-559.
65. Pinto E, Pina-Vaz C, Salgueiro L, Goncalves MJ, Costa-de-Oliveira S, Cavaleiro C, *et al*. Antifungal activity of the essential oil of *Thymus pulegioides* on *Candida*, *Aspargillus* and dermatophyte species. Journal of Medical Microbiology. 2006;55(10):67-73.
66. Pinto E, Ribeiro SL, Cavaleiro C, Palmeira A, Gonçalves MJ. *In vitro* susceptibility of some species of yeasts and filamentous fungi to essential oils of *Salvia officinalis*. Industrial Crops and Products. 2007;26(2):135-141.
67. Pitarokili D, Couladis M, Petsikos-Panayotarou N, Tzakou O. Composition and antifungal activity on soil-borne pathogens of the essential oil of *Salvia sclarea* from Greece. Journal of Agricultural and Food Chemistry. 2002;50(23):6688-6691.
68. Prajapati V, Tripathi AK, Aggarwal KK, Khanuja SPS. Insecticidal, Repellent and Oviposition-deterrent Activity of Selected Essential Oils Against *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus*. Bioresource Technology. 2005;96:1749-1757.
69. Pyun MS, Shin S. Antifungal effects of the volatile oils from Allium plants against Trichophyton species and synergism of the oils with ketoconazole. Phytomedicine. 2006;13(6):394-400.
70. Rajashekar Y, Ravindra KV, Bakthavatsalam N. Leaves of *Lantana camara* Linn.as a Potential Insecticide for the Management of Three Species of Stored Grain Insect Pests. Journal of Food Science and Technology. 2014;51(11):3494-3499.
71. Rastogi R, Mehrotra B. Glossary of Indian Medicinal Plants. National Institute of science communication, New Delhi, India. 2002, 20-25.
72. Rodilla JM, Silva LA, Martinez N, Lorenzo D, Davyt D, Castillo L, *et al*. Advances in the identification and agrochemical importance of sesquiterpenoids from *Bulnesia sarmientoi* essential oil. Industrial Crops and Products. 2011;33(2):497-503.
73. Roy S, Chatterjee P x. A non-toxic antifungal compound from the leaves of *Catharanthus roseus* characterized as 5-hydroxy flavone by UV spectroscopic analysis and evaluation of its antifungal property by agar-cup method. Industrial Crops and Products. 2011;32(3):375-380.
74. Saad HE, El-Sharkawy SH, Shier WT. Biological activities of pyrrolidinoindoline alkaloids from *Calycodendronmilnei*. Planta Medica. 1995;61(4):313-6.
75. Salgueiro LR, Pinto E, Goncalves MJ, Pina-Vaz C, Cavaleiro C, Rodrigues AG, *et al*. Chemical composition and antifungal activity of the essential oil of *Thymbra capitata*. Planta Medica. 2004;70(6):572-575.
76. Sasidharan S, Chen Y, Saravanan D, Sundram KM, Latha LY. Extraction, isolation and characterization of bioactive compounds from plants' extracts, African Journal of Traditional, Complementary and Alternative Medicines, 2010, 8(1).
77. Scalbert A. Antimicrobial properties of tannins. Phytochemistry. 1991;30:3875-3883.

78. Schleier JJ, Peterson RK. Pyrethrins and Pyrethroid Insecticides. Green Trends Insect Control, 2011, 94-131pp.
79. Schmidt H. Phenol oxidase (E.I.14.18.1), a marker enzyme for defense cells. Progress in histochemistry and cytochemistry. Gustav Fischer, New York, N.Y., 1988, 17pp.
80. Schultes RE. The kingdom of plants. In W. A. R. Thomson (ed.), Medicines from the Earth. McGraw-Hill Book Co., New York, N.Y., 1978, 208.
81. Senthilkumar N, Varma P, Gurusubramanian G. Larvicidal and Adulticidal Activities of Some Medicinal Plants Against the Malarial Vector, Anopheles stephensi (Liston). Parasitology Research. 2009;104:237-244.
82. Serafini M, Ghiselli A, Ferro-Luzzi A. Red wine, tea and anti-oxidants. Lancet. 1994;344:626.
83. Sethi ML. Inhibition of reverse transcriptase activity by benzophenanthridineal, 1979.
84. Shameem N, Kamili AN, Parray JA, Hamid R, Bandh SA. Antimicrobial and antioxidant activity of methanol extracts of *Arnebia benthamii* (Wall ex. G. Don) Johnston—a critically endangered medicinal plant of North western Himalaya. Journal of Analytical Science and Technology. 2015;6:36.
85. Sharon N, Ofek I. Mannose specific bacterial surface ectins. In D. Mirelman (ed.), Microbial lectins and agglutinins. John Wiley & Sons, Inc., New York, N.Y., 1986, 55-82pp.
86. Smirnov VV, Bondarenko AS, Prikhodko VA. Antimicrobial activity of sesquiterpene phenol from Bidenscernua, Fitoterapia. 1998;69(1):84-5.
87. Suresh B, Sriram S, Dhanaraj SA, Elango K, Chinnaswamy K. Anticandidal activity of *Santolinacha maecyparissus* volatile oil. Journal of Ethnopharmacology. 1997;55:151-159.
88. Thastrup O, Knudsen JB, Lemmich, J, Winther K. Inhibitions of human platelet aggregation by dihydropyrano- and dihydrofuranocoumarins, a new class of cAMPphosphodiesterase inhibitors. Biochemical Pharmacology. 1985;34:2137-2140.
89. Thomson WAR (ed.). Medicines from the Earth. McGraw-Hill Book Co., Maidenhead, United Kingdom, 1978.
90. Tirillini B, Velaquez ER, Pellegrino R. Chemical composition and antimicrobial activity of essential oil of *Piper angustifolium*. Planta Medica. 1996;62(4):372-3.
91. Tsuchiya H, Sato M, Miyazaki T, Fujiwara S, Tanigaki S, Ohyama M, *et al*. Comparative study on the antibacterial activity of phytochemical flavanones against methicillin-resistant *Staphylococcus aureus*. Journal of Ethnopharmacology. 1996;50:27-34.
92. Vandenborre G, Groten K, Smagghe G, Lannoo N, Baldwin IT, VanDamme EJM. *Nicotiana tabacum* Agglutinin is Active Against Lepidopteran Pest Insects. Journal of Experimental Botany. 2010;61(4):1003-1014.
93. Vargas-Arispuro I, Reyes-Báez R, Rivera-Castañeda G, Martínez-Téllez MA, RiveroEspeje I. Antifungal lignans from the creosotebush (*Larrea tridentata*), Industrial Crops and Products. 2005;22(2):101-107.
94. Vijaya K, Ananthan S, Nalini R. Antibacterial effect of theaflavin, polyphenon 60 (*Camellia sinensis*) and Euphorbia hirta on Shigella spp.—a cell culture study. Journal of Ethnopharmacology. 1995;49:115-118.
95. Vishwakarma RA. Stereoselective synthesis of a-arteether from artemisinin. Journal of Natural Products. 1990;53:216-217.
96. Vohora SB, Rizwan M, Khan JA. Medicinal uses of common Indian vegetables. Planta Medica. 1973;23:381-393.
97. Wan J, Wilcock A, Coventry MJ. The effect of essential oils of basil on the growth of *Aeromonas hydrophila* and *Pseudomonas fluorescens*. Journal of Applied Microbiology. 1998;84:1.
98. Weinmann I. History of the development and applications of coumarin and coumarin-related compounds. In R. O'Kennedy and R. D. Thornes (ed.), Coumarins: biology, applications and mode of action. John Wiley & Sons, Inc., New York, N.Y., 1997.
99. Wild R (ed.). The complete book of natural and medicinal cures. Rodale Press, Inc., Emmaus, Pa, 1994.
100. Yang FL, Liang GW, Xu YJ, Lu YY, Zeng L. Diatomaceous Earth Enhances the Toxicity of Garlic, *Allium sativum*. Essential Oil Against Stored-product Pests. Journal of Stored Products Research. 2010;46:118-123.
101. Zhang Y, Lewis K. Fabatins: new antimicrobial plant peptides. FEMS Microbiology Letters. 1997;149:59-64.
102. Zhang ZY, Dai GH, Zhuge YY, Li YB. Protective effect of *Robinia pseudoacacia* Linn1 extracts against cucumber powdery mildew fungus, *Sphaerotheca fuliginea*. Crop Protection. 2008;27(6):920-925.
103. Zhao W, Wolfender JL, Hostettmann K, Xu R, Qin G. Antifungal alkaloids and limonoid derivatives from *Dictamnus days carpus*. Phytochemistry. 1998;47(1):7-11.