Chapter 3
Antibacterial, Antifungal, and Antiviral Properties of Medical Plants

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Abstract There is evidence of medicinal plants having been used in the treatment of human disease caused by various pathogenic microorganisms in many countries of the world. Plants with known antimicrobial activities were used for therapeutic treatments. They contain various biological compounds which could be used in the development of novel drugs for human well-being. Their phytochemical constituents include alkaloids, saponins, tannins, flavonoids, and glycosides, which serve as defense mechanisms against various microbes including insects. These compounds may include antibacterial, antifungal, and anticancer activities. The search for new antimicrobial compounds from medicinal plants from many continents is an important line of research because of the increased number of multidrug resistance pathogenic microorganisms. However, the therapeutic ability of a number of medicinal important plants is still unknown. Considering the importance of medicinal plants as sources for antimicrobial drugs, in this review, we report on progress to date in antimicrobial activities of medicinal plants.

Keywords Medicinal plants · Antibacterial · Antifungal · Bioactive compounds

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D. Egamberdieva, A. Tiezzi (eds.), *Medically Important Plant Biomes: Source of Secondary Metabolites*, Microorganisms for Sustainability 15,
https://doi.org/10.1007/978-981-13-9566-6_3

3.1 Introduction

The increasing incidence of multidrug resistance microorganisms has constantly become a scientific community concern (Compean and Ynalvez 2014). The members of gram-negative and gram-positive bacteria such as *Escherichia coli*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Bacillus cereus* were known as the causal agents of food-borne diseases (Pandey and Singh 2011; Braga et al. 2005). The dermatophytes and also *Candida* spp. are considered an important group of skin pathogens which cause many skin disorders. Many of the medicinal plant species are used for the treatment of various diseases (Bussmann et al. 2010; Duraipandiyan and Ignacimuthu 2011; Mamedov and Egamberdieva 2018). To date many plant secondary metabolites known to contain various antimicrobial compounds were screened against human pathogenic microbes (Egamberdieva and Teixeira da Silva 2015). Several scientists studied the biological activity of medicinal plants and their metabolites with antimicrobial activity against food spoilage bacteria (Gnat et al. 2017; David et al. 2010; Egamberdieva and Jabborova 2018). The phytochemical constituents of medicinal plants play a major role in plant biological activity, e.g., saponins (Lacaille-Dubois and Wagner 1996), flavonoids (David et al. 2010), and alkaloids (Omulokoli et al. 1997) were reported for their antiviral and antibacterial properties (Egamberdieva et al. 2017). The screening of medicinal plants for their biological active metabolites might lead to the isolation of compounds that are effective as antifungal, antiviral, or antibacterial agents (Cushnie and Lamb 2005; Shrivastava et al. 2015). In previous work it has been observed that alkaloids and phenolic compounds have strong interaction with microbial cells through enzymes and proteins (Burt 2004; Gill and Holley 2006). Antimicrobial activity of Indian medicinal plants broadly reported based on folklore knowledge (Duraipandiyan and Ignacimuthu 2011). The Middle East has thousands of year's history in traditional medicine, which has been used for treatment of various ailments. The flora of Uzbekistan covers more than 4500 species of vascular plants, of them around 20% has showed positive effect on various ailments (Mamedov et al. 2005; Shurigin et al. 2018).

3.2 Antimicrobial Activities of Medicinal Plants

The antimicrobial activities of medicinal and aromatic plants from various countries were described, and some results (Ahmad and Beg 2001; Kokoska et al. 2002; Alzoreky and Nakahara 2003; Rios and Recio 2005; Sher 2009; Pirbalouti et al. 2010; Verma et al. 2012; Akinpelu et al. 2015) were listed in Table 3.1. Tajkarimi et al. (2010) described antimicrobial activities of aromatic plants. In another study, Gupta et al. (2010) reported antibacterial activity of *Achyranthes aspera*, *Tagetes patula*, and *Lantana camara* plant extracts against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Bacillus subtilis*.

Table 3.1 Antimicrobial activity of medicinal plants

Plant species	Antimicrobial properties	References
Cinnamomum cassia, *Rumex nervosus*, *Ruta graveolens*, *Thymus serpyllum*	Antibacterial	Alzoreky and Nakahara (2003)
Allium sativum	Antibacterial	Verma et al. (2012)
Punica granatum		
Persea americana	Antibacterial	Akinpelu et al. (2015)
Achyranthes aspera	Antibacterial	Gupta et al. (2010) and Beaulah et al. (2011)
Lantana camara	Antibacterial	Gupta et al. (2010)
Tagetes patula		
Lavandula multifida	Antibacterial	Guesmi et al. (2017)
Annona squamosa	Antibacterial	Patel and Kumar (2008) and Padhi et al. (2011)
Punica granatum	Antibacterial, antifungal	Silva et al. (2008a, b), Alzoreky (2009), Mangang and Chhetry (2012), Mangang and Chhetry (2012), Mahboubi et al. (2015), Guesmi et al. (2017), Mishra et al. (2017), and Mostafa et al. (2018)
Ocimum gratissimum, *Eugenia uniflora*, *Murraya koenigii*, *Cynodon dactylon*, *Lawsonia inermis*, *Adha-thoda vasica*	Antibacterial	Fadeyi and Alcapan (1989)
Cuminum cyminum	Antibacterial	Arora and Kaur (1999). Shan et al. (2007), Shan et al. (2007), Chaudry and Tariq (2008), Dua et al. (2013), and Mostafa et al. (2018)
Zingiber officinale	Antibacterial	Alzoreky and Nakahara (2003), Betoni et al. (2006), Ushimaru et al. (2007), Sapkota et al. (2012), Qader et al. (2013), and Mostafa et al. (2018)
Syzygium aromaticum	Antibacterial	Mostafa et al. (2018)
Thymus vulgaris		
Psidium guajava	Antibacterial	Farjana et al. (2014)
Calendula officinalis	Antibacterial	Chakraborthy (2008) and Farjana et al. (2014)
Azadirachta indica	Antibacterial, antifungal	Alzoreky and Nakahara (2003), El-Mahmood et al. (2010), Koona and Budida (2011), Sapkota et al. (2012), Jabeen et al. (2013), Farjana et al. (2014), Rakholiya et al. (2014), and Mishra et al. (2017)
Camellia sinensis	Antibacterial	Farjana et al. (2014)
Tussilago farfara	Antibacterial	Hleba et al. (2014)
Aesculus hippocastanum		
Equisetum arvense		

(continued)

Table 3.1 (continued)

Plant species	Antimicrobial properties	References
Terminalia arjuna	Antimicrobial	Gupta et al. (2016)
Polyalthia longifolia		
Momordica charantia	Antifungal	Wang et al. (2016)
Alstonia boonei	Antibacterial	Ogueke et al. (2014)
Solanum coagulans	Antifungal	Qin et al. (2016)
Pituranthos tortuosus	Antibacterial	Mighri et al. (2015)
Anogeissus acuminata	Antibacterial	Mishra et al. (2017)
Boerhavia diffusa	Antibacterial	Mishra et al. (2017)
Bauhinia variegata	Antibacterial	Mishra et al. (2017)
Soymida febrifuga	Antibacterial	Mishra et al. (2017)
Aristolochia indica	Antibacterial	Kumar et al. (2011)
Terminalia chebula	Antibacterial	Mishra et al. (2017)
Tinospora cordifolia	Antibacterial	Mishra et al. (2017)
Tribulus terrestris	Antibacterial	Mishra et al. (2017)
Annona squamosa	Antifungal	Kalidindi et al. (2015)
Rhanterium epapposum	Antibacterial, antifungal	Adam et al. (2011), Akbar and Al-Yahya (2011), and Demirci et al. (2017)
Lumnitzera littorea	Antibacterial, antifungal	Saad et al. (2011)
Alternanthera sessilis	Antibacterial	Johnson et al. (2010)
Cinnamomum zeylanicum	Antifungal	Ajay et al. (2009)
Dahlia pinnata	Antibacterial	Bissa et al. (2011)
Piper nigrum	Antibacterial	Karsha and Bhagyalakshmi et al. (2010)
Plumeria rubra	Antibacterial	Baghel et al. (2010)
Achillea millefolium, *Ipomoea pandurata*, *Hieracium pilosella*, and *Solidago canadensis*	Antibacterial	Frey and Meyers (2010)
Glycyrrhiza glabra	Antibacterial, antifungal	Patil et al.(2009)
Allium sativum	Antibacterial	Betoni et al. (2006), Ushimaru et al. (2007), and Sapkota et al. (2012)
Phyllanthus niruri	Antibacterial	Selvamohan et al. (2012)
Baccharis dracunculifolia	Antibacterial	Ferronato et al. (2007)
Chamaecyparis obtuse, *Chrysanthemum boreale*, *Cryptomeria japonica*	Antibacterial, antiviral	Lee and Choi (2015)
Cynara scolymus,	Antibacterial	Asolini et al. (2006)
Achyrocline satureioides		
Dennettia tripetala	Antibacterial, antifungal	Ejechi and Akpomedaye (2005) and Oyemitan et al. (2019)
Rosmarinus officinalis	Antibacterial	Silva et al. (2008a, b) and Adam et al. (2014)

(continued)

Table 3.1 (continued)

Plant species	Antimicrobial properties	References
Cyclocarya paliurus	Antibacterial, antifungal	(Xie et al. 2012)
Malva aegyptiaca	Antibacterial	Fakhfakh et al. (2017)
Blepharis cuspidata, *Boswellia ogadensis*, *Thymus schimperi*	Antibacterial	Gadisa et al. (2019)
Periploca laevigata	Antibacterial	Hajji et al. (2019)
Tridax procumbens	Antibacterial	Bharati et al. (2012) and Andriana et al. (2019)
Prunus domestica	Antibacterial	Islam et al. (2017) and El-Beltagi et al. (2019)
Artemisia nilagirica, *Artocarpus integrifolia*, *Citrus maxima*, *Coix lacryma-jobi*, *Hedychium coronarium*, *Lantana camera*, *Michelia champaca*, *Passiflora foetida*, *Strobilanthes flaccidifolius*	Antifungal	Mangang and Chhetry (2012)
Helicteres hirsuta	Antibacterial	Pham et al. (2018)
Syzygium aromaticum	Antibacterial	Vizhi et al. (2016)
Anagallis arvensis	Antifungal	Soberón et al. (2017)
Cichorium intybus	Antibacterial, antifungal	Mares et al. (2005), Nandagopal and Kumari (2007), Verma et al. (2013), Rehman et al. (2014), and Shaikh et al. (2016)
Polygonum hydropiper	Antibacterial, antifungal	Hasan et al. (2009)
Kigelia africana	Antibacterial, antifungal	Owolabi et al. (2007)
Cnicus benedictus	Antibacterial	Szabó et al. (2009)
Seriphidium kurramense	Antibacterial, antifungal	Ahmad et al. (2018) and Mahmoud et al. (2011)
Rosmarinus officinalis	Antifungal	Adam et al. (2014)
Salvia bicolor	Antifungal	Taghreed (2012)

In another study Guesmi et al. (2017) reported that *Lavandula multifida* showed the most powerful activity against *Bacillus cereus* strain. The extract of *Punica granatum* showed antibacterial activity against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, and *Salmonella typhi*, which cause borne diseases (Alzoreky 2009; Mahboubi et al. 2015; Guesmi et al. 2017; Mishra et al. 2017). In other reports cumin seed (*Cuminum cyminum*) extract exhibited antimicrobial activity against gram-positive and gram-negative bacteria (Shan et al. 2007; Chaudry and Tariq 2008). Dua et al. (2013) reported that extracts of cumin effective against *E. coli*, *P. aeruginosa*, *S. aureus*, and *B. pumilus* were ranged between 6.25 and 25 mg/ml. Qader et al. (2013) studied *Zingiber officinale* and *Thymus kotschyana* for their

effect on human pathogenic bacteria *S. aureus* and *E. coli*, and they found antimicrobial activity of plant extracts. Similar reports were published by other authors, where *Zingiber officinale* and *Allium sativum* extracts inhibited growth of *S. aureus* (Betoni et al. 2006; Ushimaru et al. 2007; Sapkota et al. 2012).

Mostafa et al. (2018) observed an antimicrobial activity of plant extracts of *Zingiber officinale*, *Punica granatum*, *Syzygium aromaticum*, and *Thymus vulgaris* against *Escherichia coli*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Salmonella typhi* at concentration of 10 mg/ml. Silva et al. (2008a, b) reported that extracts of *Punica granatum* fruit (pomegranate) were inhibitory against *Staphylococcus aureus.*

The plant extracts of guava (*Psidium guajava*), neem (*Azadirachta indica*), and marigold (*Calendula officinalis*) also inhibited growth of bacteria belonging to *Pseudomonas*, *Vibrio*, *Klebsiella*, *Escherichia*, *Salmonella*, and *Staphylococcus* genera (Farjana et al. 2014). Plants belonging to *T. farfara* and *Equisetum arvense* also showed antimicrobial properties against human pathogenic bacteria (Hleba et al. 2014). Gupta et al. (2016) reported that human pathogenic bacteria *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida albicans*, and *Staphylococcus aureus* were inhibited by methanol extracts of *Terminalia arjuna*, *Camellia sinensis*, and *Polyalthia longifolia*. The ethanol extract of *Alstonia boonei* inhibited growth of *E. coli* with inhibition zone of 23.73 mm (Ogueke et al. 2014).

Several crop extracts also showed antifungal activity against plant pathogenic fungi such as *Fusarium*, *Rhizoctonia*, and *Verticillium.* For example, vegetable crop extract *Momordica charantia* inhibited the mycelial growth of *Fusarium solani*, a plant pathogen which causes root rot disease (Wang et al. 2016). The extract of *Solanum coagulans* showed remarkable antifungal activity against *T. mentagrophytes*, *M. gypseum*, and *E. floccosum* (Qin et al. 2016). In another report *Annona squamosa* Linn. leaf extract showed antifungal activity against *Alternaria alternata*, *Fusarium solani*, *Microsporum canis*, and *Aspergillus niger* (Kalidindi et al. 2015). Following other reports we found that *Artemisia nilagirica*, *Artocarpus integrifolia*, *Citrus maxima*, *Hedychium coronarium*, *Lantana camera*, *Passiflora foetida*, and *Strobilanthes flaccidifolius* showed also antifungal activity against *R. solani* (Mangang and Chhetry 2012). Similar results were obtained by Mahmoud et al. (2011) where ethanol extract of *S. kurramense* was effective against *A. flavus*.

Mighri et al. (2015) reported the antibacterial activity of *P. tortuosus* on *E. coli* and *Klebsiella pneumoniae*, moderate activity against S. *aureus*, and high activity against *Streptococcus pyogenes* and *Enterobacter aerogenes*. Methanol extract of plants such as *Anogeissus acuminata*, *Boerhavia diffusa*, *Soymida febrifuga*, and *Tribulus terrestris* showed antimicrobial activity against *Enterococcus faecalis*, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella oxytoca*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* (Mishra et al. 2017).

Annona squamosa Linn. is cultivated throughout America, Brazil, and India and is used as traditional medicine in treatment of various diseases (Kaleem et al. 2008; Raj et al. 2009).

The antimicrobial properties of *Rhanterium epapposum* were positive against *B. cereus*, *S. aureus*, and *P. vulgaris* (Adam et al. 2011; Akbar and Al-Yahya 2011). Furthermore several biological active compounds with antimicrobial properties such as flavonoids, tannins, sterols, triterpenes, and essential oils were found (Al-Yahya et al. 1990; Akbar and Al-Yahya 2011).

Demirci et al. (2017) evaluated the antimicrobial potential of *R. epapposum* essential oil against *Bacillus subtilis*, *Enterobacter aerogenes*, *Proteus vulgaris*, *Salmonella typhimurium*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, and the yeast *Candida parapsilosis.* The essential oil was able to inhibit growth of microbial strains. In another study the extracts from different mangrove plants have been reported to possess inhibition action against human and plant pathogens (Chandrasekaran et al. 2009; Sivaperumal et al. 2010; Ravikumar et al. 2010; Hu et al. 2010; Khajure and Rathod 2010). Saad et al. (2011) investigated the antimicrobial properties of ethyl acetate and methanol extracts of *Lumnitzera littorea* leaves against *Staphylococcus aureus*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Escherichia coli*, and two fungal strains *Candida albicans* and *Cryptococcus neoformans*.

Mathabe et al. (2006) reported that methanol, ethanol, and acetone extracts from *Indigofera daleoides*, *Punica granatum*, *Elephantorrhiza burkei*, *Ximenia caffra*, *Schotia brachypetala*, and *Spirostachys africana* showed antimicrobial activity against *Vibrio cholerae*, *Escherichia coli*, *Staphylococcus aureus*, *Shigella* species, and *Salmonella typhi.* Some plants such as *Ocimum gratissimum* and *Eugenia uniflora* have been reported to be rich in volatile oils, which have antimicrobial effect against *Staphylococcus* sp., *Escherichia coli*, and *Shigella* sp. and are mainly used in the treatment of diarrhea and ear infection in human beings. However, the ethanol and aqueous extracts of *Murraya koenigii*, *Cynodon dactylon*, *Lawsonia inermis*, and *Adha-thoda vasica* showed least inhibitory activity (Fadeyi and Alcapan 1989). Frey and Meyers (2010) reported antimicrobial properties of *Achillea millefolium*, *Ipomoea pandurata*, *Hieracium pilosella*, and *Solidago canadensis* against *Salmonella typhimurium*. Similarly, Patil et al. (2009) reported a significant antifungal and antibacterial activity against *Candida albicans*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Escherichia coli* by the diethyl ether fraction of ethanolic extract of *Glycyrrhiza glabra*. The methanolic extract *Phyllanthus niruri* (stone breaker) showed the maximum activity against *Staphylococcus* sp. (Selvamohan et al. 2012). In another study *Baccharis dracunculifolia* oil at a 10-μL dose prevented microbial growth of *E. coli*, *S. aureus*, and *P. aeruginosa* in antimicrobial assays (Ferronato et al. 2007). The methanolic extracts of *Chamaecyparis obtusa* and *Cryptomeria japonica* possessed strong antiviral activity against HRV3 at a concentration of 100 μg/mL with no cytotoxicity. Similarly, methanolic extract of *Chrysanthemum boreale* possesses strong antimicrobial activity against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, and *Yersinia enterocolitica* (Lee and Choi 2015). Asolini et al. (2006) reported that ethanol extracts of artichoke (*Cynara scolymus*) inhibited the growth of *Bacillus cereus*, *B. subtilis*,

Pseudomonas aeruginosa, and *S. aureus.* The essential oil of *Dennettia tripetala* fruit possesses antimicrobial activities against bacterial and fungal isolates (Ejechi and Akpomedaye 2005). The hydroalcoholic extract of *Rosmarinus officinalis* Linn. showed antibacterial activity against *Streptococcus* spp. and *Lactobacillus casei* (Silva et al. 2008a, b). Adam et al. (2014) reported high antifungal activity of aqueous extract of *Rosmarinus officinalis* toward *Candida albicans* and *Aspergillus niger.* In another study Fakhfakh et al. (2017) reported the highest inhibitory effect of polysaccharide extract of *Malva aegyptiaca* against gram-negative bacteria. Polysaccharides derived from plants *Cyclocarya paliurus* (Batal.) showed antifungal activity against *Saccharomyces cerevisiae* and *Candida* sp. and antibacterial activity against *E. coli*, *S. aureus*, and *B. subtilis* (Xie et al. 2012).

The essential oils of medicinal plants that contain phenols also possess antimicrobial activities. For example, the essential oils from *Blepharis cuspidata*, *Boswellia ogadensis*, and *Thymus schimperi* showed antimicrobial activity against multidrug *resistance E. coli*, *K. pneumoniae*, and *S. aureus* (Gadisa et al. 2019).Essential oil extracted from *B. cuspidate* had elicited high antibacterial effect on tested *Enterobacteriaceae*. A novel water-soluble polysaccharide isolated from root barks of *Periploca laevigata* demonstrated antioxidant potential and high antibacterial activity against several gram-positive and gram-negative bacteria (Hajji et al. 2019). *Tridax procumbens* L. showed effective inhibition on the growth of *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis*, and *Proteus mirabilis* (Bharati et al. 2012; Andriana et al. 2019). El-Beltagi et al. (2019) evaluated the phytochemical composition of *Prunus domestica* fruit and their antimicrobial activity. They found that ethanol extract of fruit exhibited antibacterial activity against *Staphylococcus aureus* (ZI = 18.51 mm). Islam et al. (2017) reported antimicrobial potential, gram-positive and gram-negative bacteria have been found susceptible to the *P. domestica* extract, for example, strain of *S. aureus* (19.7 ± 0.4 mm) and *E. coli* (14.4 ± 0.7 mm). There are other plants with antimicrobial potential; however, they were not fully studied yet. For example, *Helicteres hirsuta* Lour. known with wide pharmacological properties showed antimicrobial activity against *E. coli* (MIC values of 2.5 and 5.0 mg/mL) and *S. lugdunensis* (MIC values of 0.35 and 0.50 mg/mL) (Pham et al. 2018).

In another study Vizhi et al. (2016) tested the antibacterial activity of methanol, ethyl acetate, and acetone extracts of *Syzygium aromaticum* medicinal plant against *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus.* Methanol extract of *S. aromaticum* showed good antimicrobial activity against *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus.* The antifungal compounds derived from plant *Anagallis arvensis* L. showed higher inhibitory activity against human pathogenic yeast *Candida albicans* (Soberón et al. 2017). Mares et al. (2005) reported antifungal activity of *C. intybus* against anthropophilic fungi *Trichophyton tonsurans*, *T. rubrum*, and *T. violaceum*. *Cichorium intybus* leaf extracts showed antimicrobial activity against *S. aureus*, *P. aeruginosa*, *E. coli*, and *C. albicans.* Root extracts had pronounced effects on *B. subtilis*, *S. aureus*, *Salmonella typhi*, *Micrococcus luteus*, and *E. coli* (Nandagopal and Kumari 2007).

Cichorium intybus crude extract exhibited wide range of antimicrobial activity against *E. coli*, *K. pneumoniae*, *P. aeruginosa*, *S. epidermidis*, *S. aureus*, and *B. subtilis* (Rehman et al. 2014). Moreover, the growth of fungi such as *Aspergillus flavus*, *Fusarium solani*, *Aspergillus fumigatus*, and *Aspergillus niger* was inhibited by plant extract.

Shaikh et al. (2016) tested seed extract of *Cichorium intybus* showed antimicrobial activity against several human pathogenic bacteria such as *Staphylococcus aureus*. Ethyl acetate and ethanol extract were found to be significant against *P. aeruginosa.* The biological active compounds such as lactucin and lactucopicrin derived from *C. intybus* exhibited antibacterial activity (Verma et al. 2013). *Polygonum hydropiper* (L.) root extract showed significant antibacterial activities against four gram-positive (*Bacillus subtilis*, *Bacillus megaterium*, *Staphylococcus aureus*, and *Enterobacter aerogenes*) and four gram-negative (*Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, and *Shigella sonnei*) bacteria (Hasan et al. 2009). The ethanolic and aqueous extract of *Kigelia africana* showed antimicrobial activity against both bacteria and fungi (Owolabi et al. 2007). Other plants such as *Cnicus benedictus* L. showed antibacterial activity against ten pathogens such as *Salmonella typhimurium*, *Salmonella enteritidis*, *Staphylococcus aureus* ssp., *Escherichia coli*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *Shigella sonnei* (Szabó et al. 2009). Ahmad et al. (2018) investigated the antimicrobial activity of crude ethanolic and aqueous extracts of *Seriphidium kurramense* by agar well diffusion assays against five bacterial species such as *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Bacillus subtilis*, and *Salmonella typhi*, and six fungal species such as *Aspergillus niger*, *Aspergillus flavus*, *Alternaria solani*, *Rhizoctonia solani*, *Fusarium solani*, and *Pleurotus florida*. The ethanol extract showed its highest growth inhibition (74.4%) toward *B. subtilis* and its lowest inhibition (32.2%) toward *K. pneumoniae*. A petroleum ether extract and a methanolic extract of aerial parts of *Salvia bicolor* against *Staphylococcus epidermidis* and *Candida albicans*.

3.3 Conclusion

From published reports, it is evident that antimicrobial properties of medicinal plants were reported based on folklore information. They synthesize various biological active compounds that possess antimicrobial properties. The compounds contain alkaloids, saponins, coumarins, steroids, flavonoids, glycosides, phenols, and tannins. A number of essential oils that contain aldehydes or phenols were also used as antimicrobial agents. These reports provide an insight into the antibacterial properties of medicinal plants used in traditional medicine and justification for the use of medicinal plants in medicine to treat infectious diseases. It will also lead to the development of some new biologically active compounds which can be formulated as antimicrobial agents.

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