Review Article

Medicinal plants as antibacterial agents: A special reference to *Emblica officinalis*, *Ocimum sanctum*, *Aloe vera* and *Aegle marmelos*

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Abstract

Plants like *Ocimum sanctum*, *Emblica officinalis*, *Aloe vera*, *Aegle marmelos, Withania somnifera Azardirchata indica* etc. have been utilized as traditional medicinal remedies to treat various diseases for many centuries, and have been included as important components of present day medications for cough, cold, burning, skin disorders, diabetes, hyper acidity, diarrrhoea, dysentry, constipation, nerve disorder, stress etc. Amongst a long list of traditional medicinal plants, *Emblica officinalis*, *Ocimum sanctum*, *Alovera*, *Aegle marmelos* have been reported as some of the extensively and commonly used plants in India. The present write up is an attempt to further highlight the scientific work carried out with special focus on antibacterial activities of the said plants. The effort would add to a consistent surveillance of existing data on plant derived antibacterial agents and the target organisms; and could be a trigger to further carve out newer strategies to explore plant wealth as antimicrobial agents. The efforts could evolve newer promising tools to eliminate the harmful *organisms.*

***Keywords*:** Medicinal plants, antibacterial, *Ocimum sanctum*, *Emblica officinalis*, *Aloe vera, Aegle mermelos*

Introduction

Plants have been utilized as traditional medications to treat various diseases for thousands of years and have been included as components of even ongoing treatments (Samuelsson, 2004; Rios and Recio, 2005). As per World Health Organization reports, more than 3/4th of the total population of world relied mostly upon the traditional medication and a significant part of the traditional therapies included the utilization of plant extracts or their active constituents (WHO, 1993). The use of number of traditional medicinal plants with recuperating potential had been acknowledged since long. Medicinal plants viz. *Ocimum sanctum*, *Emblica officinalis*, *Aloe vera*, *Aegle marmelos, Withania somnifera Azardirchata indica* etc. have been reported for their role in treatment of diseases such as cough, cold, burning, skin disorders, diabetes, hyper acidity, diarrrhoea, dysentry, constipation, nerve disorder, stress etc. *Anethum graveolens* (Dill), *Foeniculum vulgare* (Fennel), *Trachyspermum ammi* and *Elettaria cardamomum,* the queen of spices commonly called chotti elaichi in India have been commonly used to treat gastrointestinal disorders (Koochek et al., 2002). *Viola odorata* has been in use to treat respiratory diseases and as an anti-inflammatory agent (Aslam, 2002). *Syzygium aromaticum* (clove) has been reported for its application in toothache due to its local anaesthetic activity (Cai and Wu, 1996). Certain plants such as bearberry and cranberry (*Arctostaphylos and Vaccinium*) have been described for their use in treat urinary tract infections. A number of plants have been documented for their biological and antimicrobial properties (Grover et al., 2002; Gajera et al., 2005; Arora, 1998; Ahmed, 2001; Polambo and Semple, 2001). Besides this, species such as *Melaleuca alternifolia, Melissa officinalis*, commonly called lemon balm and *Allium sativum* have been described as antimicrobial agents with broad-spectrum activity (Heinrich et al., 2004). Even the extracts

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obtained from *Psidium guava* have been stated to have antibacterial activities against four different bacterial species like *S. aureus*, *B. subtilis* and *E. coli* (Abdelrahim et al., 2002).

Amongst a long list of traditional medicinal plants, *Emblica officinalis*, *Ocimum sanctum*, *Alovera*, *Aegle marmelos* have been reported as some of the extensively and commonly used plants in India. The fruit of *Emblica officinalis* generally known as amla has been documented as a highly valued Indian traditional medicine (Scartezzini et al., 2006). *Ocimum sanctum,* an aromatic plant is known as "Tulsi" in Indian folk. Its leaves have been employed in herbal teas or mixed with other herbs or honey to enhance the medicinal value (Bast et al., 2014). *Aloe vera* has been known for its health benefits especially skin care medical therapeutics since centuries. *Aegle marmelos* (bael)**,** commonly known as wood apple is a native plant of India, and has been explored for multiple medicinal uses. Thus, keeping in view the medicinal values of these plants, the present write up is an attempt to further highlight the scientific work carried out with special focus on antibacterial activities of the said plants. The effort would add to a consistent surveillance of existing data on plant derived antibacterial agents and the target organisms; and could be a trigger to further carve out newer strategies to explore plant wealth as antimicrobial agents.

Plants with medicinal and antimicrobial role: a general account

The therapeutic capability of plants could be traced back to more than 5,000 years ago. Medicinal plants are being used as traditional medicines for various human sicknesses, diseases or disorders since long. The use of the plant wealth for treatment of different ailments in humans has been said to be cited in literatures from number of ancient civilizations like India, China, Egypt, Greek and Romans (Mahesh and Satish, 2008). Plants are considered as one of the most significant source of medications and have been studied for their antioxidant anti-inflammatory, insecticidal, antiparasitic, anti-toxin, and anti hemolytic properties. The scientists have stressed on the need to explore their therapeutic worth (Chavan, 2016).

Amongst 250,000 higher plant species observed on the planet, more than 80,000 species are being utilized as medicinal purposes. It has been reported earlier that nearly 40% of the business in pharmacological arena generally depends on therapeutic plants. The majority of the plants with therapeutic values have been studied to be herbs when compared to shrubs, trees, climbers, rhizomes or other natural products. Further, it has been quoted that the plant derived medications belonged to entire plant or its parts viz. leaves, stem, bark, root, flower, seed, natural products, rhizome etc (Bamola et al., 2017). To elaborate further, it could be explained that *Swertia chiraita*, has been found to be effective against leishmaniasis and helped in digestion and regulation of blood sugar levels. It was also studied to possess anti-microbial activity against gram-negative and gram-positive bacteria (Sampath Kumar et al, 2010). *P. foetida* (stinking passion flower) has been used to treat urethritis where as *C. retusa* (rattleweed) has been employed to treat diarrhoea and skin disorders. Eye diseases and oral diseases have also been traditionally treated by using *T. indica* (Tamarind). The oral doses of *Achyranthes aspera* (Puth kanda) roots infusions have been used to treat pimples and boils (Abbasi et al., 2010) Earlier, this plant was studied to have its role in treating eye infection, toothache, dysentery, skin infections (Shah and Khan, 2006; Ahmad et al., 2007; Ahmad and Husain, 2008). The studies have also been carried out on use of crushed leaves of *Aegle marmelos* (bael) in treatment of abscess. *Azadirachta indica* (neem) oil has been quoted for its application on eczematous lesions (Saikia et al., 2006). Another plant *Cordia africana* (local name "Wanza") has been mentioned with its role in treatment of skin disease, wound, diarrhea and ascaris infection in human and animals (Yonathan et al., 2015).

With the advancement of technical resources and the subsequent interest in the antimicrobial agents, there has been steady rise in efforts to explore medicinal plants as natural sources of antimicrobials. A recent study has mentioned that *Calpurnia aurea* leaves have been found to show remarkable antimicrobial activity against *S. aureus, E. coli* and *Salmonella* species (Zeleke et al., 2019). However, traditionally, the leaf of this plant were used for the treatment of diarrhoea, fungal diseases and stomach-ache (Tadeg et al., 2005; Shemsu et al., 2013). The bark, leaf, stem and fruit of *Cordia africana* have been found to exhibit antimicrobial activity against different pathogenic bacteria and fungi (Emtinan et al., 2015). A study with more than 50 species of medicinal plants has shown that plants such as *Withania somnifera* (Amukkara), *Datura metel* (Attana), *Spermacoce hispida* (Hin Getakola) and *Cassia fistula* (Ehela) showed an inhibition zone of 12–13 mm diameter at against *Bacillus cereus*. Moreover, *Geophila repens*, *S. hispida, Withania somnifera* and *D. scandens* showed diameter of inhibition zone as 10-12 mm *Staphylococcus aureus* (Mohott et al., 2020). The antimicrobial and antioxidant potential of *Eugenia uniflora* (Suriname cherry) has also been explored. It has been documented that the plant extract demonstrated inhibitory activity against Methicillin Resistant *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis* and *Candida albicans*, and that the

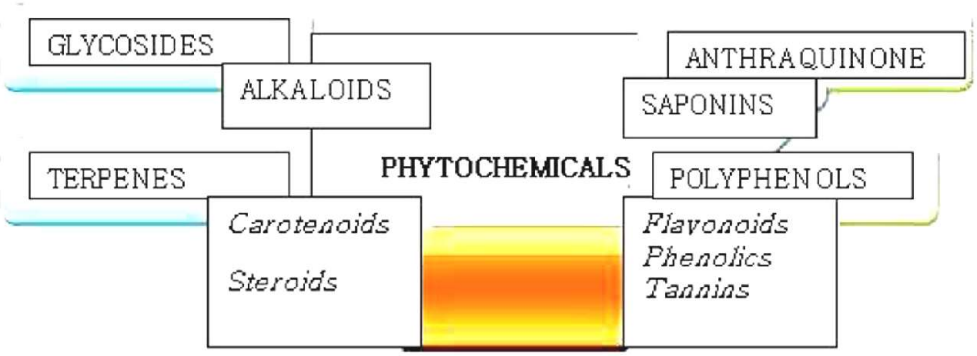

Figure 1. Some of the important Phyto- chemicals

maximum inhibition was obtained for *P. aeruginosa* (Aladesanmi et al., 2019). However, *Berberis asiatica* (Chutro), *Neopicrorhiza scrophulariiflora* (Kutki) and *Rhododendron anthopogen* (Laliguras) plant extracts were stated to have shown higher zone of inhibition for *S. aure*us and *E. coli.*(Rachana Regmi et al., 2019). In another study, methanolic extracts from the leaves of *Tinospora cordifolia* (heart-leaves moonseed), *Ziziphus mauritian*a (Indian plum), *Sida cordifolia* (country mallow), *Acacia nilotica* (gum Arabic tree), *Withania somnifer* (Indian ginseng) have been mentioned to exhibit effective antibacterial activity against *Bacillus subtilis, E. coli, Pseudomonas fluorescens, Staphalococcus aureus* and *Xanthomonas axonopodis*. *Withania somnifera* has also been documented to be the effective against *Candida albicans* (Kambizi et al., 2008). It has also been stated that organic extracts and essential oil of *Ziziphora clinopodioides* have been found to show antibacterial property against a large class of bacteria including *Acidovorax facilis, Bacillus flexus, Bacillus sphaericus, Brevibacillus brevis, Corynebacterium, ammonia genes, Enterobacter sakazakii, Moraxella catarrhalis* and *Xanthomonas* (Ozturk et al., 2007). The leaves extracts of *Mikania glomerata*, *Baccharis trimera*, *Mentha piperita* (peppermint) and *Cymbopogon citratus* (lemongrass), and *Allium sativum*, *Syzygium aromaticum* (clove) and *Zingiber officinale,* obtained with methanol as solvent were also reported to work as an antimicrobial agents to inhibit *Staphylococcus aureus* (Oliveira et al., 2007). *Rubia cordifolia* (madder) was said to have inhibitory properties against ESBL producing uropathogenic *E. coli* and also have high potential as an alternative antibacterial agent to resist the invasion by such organisms (Sawhney et al., 2012).

Medicinal Plants: Bioactive Compounds

It has been documented that the bioactive constituents of plant extracts might be utilized for the treatment of different illnesses and also can be utilized as another formulation for the novel medication disclosure in pharmaceutical businesses (Singh et al., 2017). The therapeutic capabilities of plants have been described owing to some chemically active substances that produce characteristic physiological activity on the human body (Yadav et al., 2017). Auxiliary metabolites or phytochemicals from plants have been said to possess prominent pharmacological activities like anti-allergic, anti-infection, hypoglycaemic and anti-cancerous too. These metabolites act as shield against unstable free radicals (Harini and Nithyalakshmi, 2017). There are mounting interests in using plant derived natural antimicrobial products. It has been already mentioned in the preceding paragraphs that the healing properties of the plants have been attributed to their rich phytochemical constitution.

The above cited bioactive compounds have been said to possess therapeutic value and produce a definite action on human body (Edoga et al., 2005; Mann, 1978). Moreover, various phytochemicals which belong to different chemical classes have also been found to show in vitro inhibitory effects on many microorganisms (Cowan, 1999). Phytochemicals are pharmacologically powerful compounds. Alkaloids have been found to be good analgesics and diuretics and reported to act against malarial parasites. However, terpenoids are best known for their activity against carcinoma, viruses, helminths, and malarial parasites. They are also quoted as anti inflammatory compounds. On the other hand, glycosides have been said to harbour antifungal and antibacterial properties. Phenols and flavonoids have been described for their antioxidant, anti allergic and antibacterial properties etc. Saponins were reported to have anti-inflammatory, antiviral and plant defence activities (Maurya et al., 2008; Chopra et al., 2002).

Common Indian Medicinal Plants: A selective approach

The following paragraphs selectively describe about the four commonly used plants in the Indian recipes.

Emblica officinalis: The fruit of *Emblica officinalis* generally known as amla has been documented as a highly valued Indian traditional medicine (Scartezzini et al., 2006). The fruits of *Emblica officinalis* after drying were used to treat haemorrhagic, diarrhoea, and dysentery patients in unani system of medicine (Parrotta, 2001). Amla has been said to harbour multiple benefits as aperients, astringent, cooling, diuretic, laxative, hair tonic, appetizer, and could be used against fresh wounds, jaundice, hepatitis refrigerant, and gastric trouble (Shinwari and Khan, 1998; Zabihullah et al., 2006; Abbasi et al., 2009). This plant has been studied to have anti toxin role against bacteria in respiratory diseases especially in treatment of lung infections (Chopra and Simon, 2000). The fruits have also been said to be anti-inflammatory, analgestic and antipyretic (Sharma et al., 2003).

Preclinical researches have revealed that *Emblica officinalis* (amla**)** has remedial values such as antipyretic, analgesic, antitussive, antiatherogenic, adaptogenic, cardioprotective, gastroprotective, antianemia, anti-hypercholesterolemia, wound healing, antidiarrheal, antiatherosclerotic, hepatoprotective, nephroprotective, and neuroprotective (Baliga and Dsouza, 2011). Several studies have confirmed the antibacterial activity of *Emblica officinalis* essential oil, It is said to possess inhibitory activity against *Staphylococcus aureus* and has been used as medication against *Staphylococcal* infections (Saxena and Patil, 2014; Choudhary and Grover, 2019).

Emblica officinalis has been documented to possess antibacterial activities against *E. coli* and *B. subtilis*. It has been described as antiviral agent against cold and influenza and also exhibited in vitro antifungal properties (Ahmed et al., 1998; Dutta et al., 1998; Gautam and Shukla, 2017). Amla extracts have been widely studied for several biological and pharmacological activities, and have been found to be antibacterial, antifungal, antiviral (Hutchings and Cock, 2018; Singh et al., 2019). Recently, *Phyllanthus emblica* fruits extract have been concluded to have therapeutic significance against pathogens and could be used for green synthesis of silver nanoparticles (Shah and Malik, 2019). It has been reported that the antimicrobial activity of *Embilica officinalis* owes to the presence of flavanoids, ascorbic acid, gallic acid, alkaloids and hydrolysable tannins (Varghese et al., 2013). Amla is enriched with phytochemical elements like alkaloids, tannins, and flavonoids and is protective against free radical damage. A number of bioactive compounds such as polyphenols, ellagic acid, chebulinic acid, gallic acid, chebulagic acid, apeigenin, quercetin, corilagin and leutolin have been reported in *Emblica officinalis* and has been found to be rich in vitamin C also (Patel et al., 2011; Variya et al., 2016; Yadav et al., 2017). Some of the important phyto constituents of *Emblica* were determined as hydrolysable tannins, emblicanin A, emblicanin B, punigluconin and pedunculagin (Perianayagam et al., 2005). Emblicanin A and B have been intended to be the most effective constituents with immense in vitro antioxidant activity (Ghosal et al., 1996).

Figure 2. *Emblica officinalis*

Ocimum sanctum:

The aqueous extracts of *Ocimum sanctum* have been used for treatment of different types of poisoning, stomach-ache, common colds, headaches, malaria, inflammation, and heart disease (Pattanayak et al., 2010). Studies have been carried out on tulsi plant to explore blend of activities such as antimicrobial (inhibitory to bacteria, viruses, fungi, protozoa, helminths and malarial parasites); remedial properties for diarrhoea cases, liver protection, diabetes, nervous system, anti-oxidant, anti-cataract, anti-inflammatory, cardiac functions, hypertension allergies, cancer, high cholesterol, immunomodulation, memory boosting, asthma, thyroid function anti-fertility, anti-ulcer, arthritis etc (Vasudevan et al., 1999; Mondal et

Figure 3. *Ocimum sanctum*

Table 1. Phytochemical compounds and uses of selected medicinal plants

Bioactive compounds	Plant remedial properties
Emblica officinalis (Khan et al., 2009)	
Emblicanin A & B	Antimicrobial; Remedy for liver disorder, diabetes
Ocimum sanctum (Jain et al., 2015)	
Citral, Taxol, Apigenin & Ursolic acid	Acts against bacteria, fungi Remedy for: Fever, diabetics, carcinoma, liver disorder
Aloe vera (Sahu et al., 2013)	
Campesterol,β- sisosterol, Aloin, emodin	Antiviral and antiseptic Remedy for: umours, diabetes, liver function
***Aegle* marmelos** (beal)(Venkatesan 2009; Sivaraj 2011; Rakesh et al., 2019)	
Alkaloids, steroids, terpenoids, flavonoids, phenolic compounds, cardiac glycosides	Respiratory tract, Indigestion, Fever, Asthma, dysentery & diarrhoea, jaundice Constipation, tumors & ulcers, Antibacterial

al., 2009; Mohan et al., 2011; Pattanayak et al., 2010; Mahajan et al., 2013). There is voluminous literature on experimental evidence, however lacking in human trial data to suggest that tulsi might help in the treatment of various human bacterial infections including urinary tract infections, skin and wound infections, typhoid fever, cholera, tuberculosis, gonorrhea, acne, herpes simplex, leishmaniasis, various pneumonias, and fungal infections (Ali and Dixit, 2012; Singh et al., 2005; Mandal et al., 2012; Parag et al., 2010; Farivar et al., 2006; Shokeen et al., 2005; Sawarkar et al., 2010; Yucharoen et al., 2011; Suzuki et al., 2009; Saini et al., 2009; Deo et al., 2011; Balakumar et al., 2011; Das et al., 2010; Chandra et al., 2011). *Ocimum sanctum* has documented for its role in healing wounds and that the reason for the same has been attributed to its antibacterial, antioxidant and analgesic properties (Singh et al., 2007; Shetty et al., 2008).

The oil obtained as an extract from the leaves and flowers of tulsi possess significant remedial values like expectorants, analgesics and antipyretics. Besides this, it has been suggested to be useful in reducing stress and inflammation, hypoglycaemia, asthma, hepato protection, hypotension, and act as hypolipidemic and immunomodulatory medicinal herb (Singh et al., 2010). Essential oil extracted from *Ocimum tenuiflorum* have been found to exhibit antimicrobial activity against *S. aureus* (including MRSA), *E. coli and Pseudomonas aeruginosa*. The essential oil obtained from this plant has been said to be a valuable topical antimicrobial agent for the control of skin infections caused by the said organisms (Yamani et al., 2016). The main components responsible for the antimicrobial activity of tulsi oil have been quoted as camphor, eucalyptol, and eugenol. It has been hypothesised that β-caryophyllene, though present in very low concentrations might also have contributed to the antimicrobial activity of the oil. It has also been cited that *Ocimum* could be a promising candidate for hand sanitizer, mouthwash, and water purifier (Cohen, 2014).

***Aloe vera*:**

Aloe vera has been defined as "the plant of immortality" by Egyptians. Since hundreds of years, *Aloe vera* has been used as remedy in countries like India, China, Greece, Egypt, Japan and Mexico (Marshall, 1990). A number of claims regarding therapeutic value and subsequent pharmacological actions of *Aloe vera* have been made (Townsend, 1998).

Aloe vera gel comprises of 99.3% water and the remaining 0.7% as solids with glucose and mannose being major constituents. These sugars together with the enzymes and amino acids in the gel have been said to provide skin care properties (Agarry et al., 2005). In the present era, *Aloe vera* plant has been said to be utilized for different purposes in dermatology (Surjushe et al., 2008). It has been stated that oral consumption of *Aloe vera* might be effective in reducing blood glucose in diabetic patients and in lowering blood lipid levels in hyperlipidaemia. In a study, the scientists were of the view that the topical application of A*loe vera* did not seem to prevent radiation-induced skin damage. However, it might be a useful treatment for genital herpes and psoriasis (Vogler and Ernst, 1999). It is

Figure 4. Aloe vera

documented that *Aloe vera* possessed different uses as purgative, antihelminthic, hemorrhoid cure, and uterine energizer and that it could be utilized frequently in blend with licorice root, to treat dermatitis or psoriasis (Robson et al, 1982).

It has been quoted to possess antifungal, antiviral and antibacterial activity against skin diseases, for example, skin inflammation, herpes, and scabies (Haller et al., 1991; Mantle et al., 2001). The alcoholic extracts have been found to display higher antibacterial and anti fungal activity than aqueous extract (Choi et al., 2001). Bioactive constituents in crude extracts of *Aloe vera* have also proven their antibacterial efficacy (Irshad et al., 2011). *A. vera* gel has been cited to possess maximum inhibitory effect against *Staphylococcus aureus* and *Trichophyton mentagrophytes* (Olaleye and Bello-Michael, 2005). The leaves of *Aloe vera* have been said to harbour organically active compounds, acetylated mannans, polymannans, anthraquinone C-glycosides, anthrones and anthraquinones, and different lectins.

Aegle marmelos:

Aegle marmelos (Bael) is one of the holy trees of the Hindus (Dhankhar et al., 2011). The plant has been described for treating disorders like respiratory tract infections, indigestion, fever, asthma, dysentery, diarrhoea, jaundice, constipation, tumors and ulcers.

The extracts from leaves of *A. marmelos* have been evaluated for the presence of alkaloids, cardiac glycosides, terpenoids, saponins, tannins, flavonoids, and steroids (Venkatesan 2009; Sivaraj, 2011). The fruit of *A. marmelos* is known for its high nutritional value and have been found to contain alkaloids, steroids, terpenoids, flavonoids, phenolic compounds besides other constituents like lignin, fat, oil, proteins, carbohydrates and cardiac glycosides (Rajan, 2011). The extracts of *Aegle marmelos* prepared by using methanol, ethanol or aqueous solvents have shown concentration dependant antimicrobial action against *S. aureus, E.coli, Proteus vulgaris and Lactobacillus* (Rakesh et al., 2019). In earlier research investigation, petroleum ether extract of leaves showed antimicrobial activity against multi drug resistant strains of *Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Salmonella typhi, Proteus vulgaris, Pseudomonas aeruginosa and Klebsiella pneumonia*s (Gavimath, 2008). A comparative data had shown significantly higher antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, Klebsiella pneumoniae, Proteus mirabilis, Escherichia coli, Salmonella paratyphi* A and *Salmonella paratyphi* B using methanol extract as compared to using chloroform extracts (Poonkothai, 2008).

Conclusion

There are quite efficacious medicines to control the hazardous activity of various organism but still keeping in view the possibility of emerging newer strains and development of drug resistance to the existing medications, there is constant need for consistent surveillance to screen the local environmental isolates for their response to the alternative user friendly natural resources available in the form of green vegetation. The efforts could evolve newer promising tools to eliminate the harmful organisms.

Figure 5. *Aegle marmelos*

References

Abbasi AM, Khan MA, Ahmad M, Zafar M, Jahan S, Sultana S. 2010. Ethnopharmacological application of medicinal plants to cure skin diseases and in folk cosmetics among the tribal communities of North-West Frontier Province, Pakistan. Journal of Ethnopharmacology, 128(2):322-35.

Abdelrahim SI, Almagboul AZ, Omer MEA, Elegami A. 2002. Antimicrobial activity of *Psidium guajava* L. Fitoterapia, 73(7-8):713-15.

Agarry OO, Olaleye MT, Bello-Michael CO. 2005. Comparative antimicrobial activities of *Aloe vera* gel and leaf. African Journal of Biotechnology, *4*(12):1413-14.

Ahmad I, Beg AJ. 2001. Antimicrobial and phytochemical studies on 45 Indian medicinal plants against multi-drug resistant human pathogens. Journal of Ethnopharmacology, 74:113–23.

Ahmad I, Mehmood Z, Mohammad F. 1998. Screening of some Indian medicinal plants for their antimicrobial properties. Journal of Ethnopharmacology, 62(2):183-93.

Ahmad M, Khan MA, Zafar M, Sultana S. 2007. Treatment of common ailments by plant-based remedies among the people of district ttock (Punjab) of Northern Pakistan. African Journal of Traditional, Complementary and Alternative Medicines, 4:112–20.

Ahmad SS, Husain SZ. 2008. Ethnomedicinal survey of plants from Salt Range (Kalar Kahar), Pakistan. Pakistan Journal of Botany, 40:1005–11.

Aladesanmi AJ, Oriola AO, Oguntimehin SA, Akinkunmi EO, Igbeneghu OA, Obuotor EM. 2019. Comparative

antimicrobial and antioxidant activities of four medicinal plants. Ife Journal of Science, 21(2):59-66.

Ali H, Dixit S. 2012. In vitro antimicrobial activity of flavanoids of Ocimum sanctum with synergistic effect of their combined form. Asian Pacific Journal of Tropical Disease, 2:S396-98.

Arora DS. 1998. Antimicrobial activity of tea (*Camellia sinensis*). Antibiotic and Chemotherapy, 2:4–5.

Aslam M. 2002. Aspects of Asian medicine and its practice in the West. In: Evans WC (ed) Trease and Evans Pharmacognosy, 15th ed. Elsevier, London, pp 467–91.

Balakumar S, Rajan S, Thirunalasundari T, Jeeva S. 2011. Antifungal activity of *Ocimum sanctum* Linn.(Lamiaceae) on clinically isolated dermatophytic fungi. Asian Pacific Journal of Tropical Medicine, 4(8):654-57.

Baliga MS, Dsouza JJ. 2011. Amla (*Emblica officinalis* Gaertn), a wonder berry in the treatment and prevention of cancer. European Journal of Cancer Prevention, 20(3):225–39.

Bamola N, Verma P, Negi C. 2018. A review on some traditional medicinal plants. International Journal of Life Science and Scientific Research,4(1):1550-56.

Bast F, Rani P, Meena D. 2014. Chloroplast DNA phylogeography of holy basil (*Ocimum tenuiflorum*) in Indian subcontinent. The Scientific World Journal, 3:847482. Doi;10.1155/2014/847482.

Cai L, Wu CD. 1996. Compounds from *Syzygim aromaticum* possessing growth inhibitory activity against oral pathogens. Journal of Natural Products, 59:987–90.

Chandra R, Dwivedi, Shivam K, Jha AK. 2011. Detection of antimicrobial activity of *Oscimum sanctum* (Tulsi) and *Trigonella foenum* graecum (Methi) against some selected bacterial and fungal strains. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 2(4):809-13.

Chavan PA. 2016. Evaluation of Antimicrobial activity of Various Medicinal Plants Extracts of Latur Zone against Pathogens. International Journal of Life Sciences and Scientific Research, 2(5):612-18

Choi SW, Son BW, Son YS, Park YI, Lee SK, Chung, MH. 2001. The Wound-Healing Effect of a Glycoprotein Fraction Isolated from *Aloe Vera*. British Journal of Dermatology, 145:535.

Chopra A, Doiphode V. 2002. Ayurvedic medicine: Core concept, therapeutic principles and current relevance. Medical Clinics of North America, 86:75-89.

Chopra D, Simon, D. 2000. The Chopra Centre Herbal Handbook. Rider, London.

Choudhary M, Grover K. 2019. Amla (*Emblica officinalis* L.) Oil. In Fruit Oils: Chemistry and Functionality, pp. 875-82.

Cohen M. 2014. Tulsi - *Ocimum sanctum*: A herb for all reasons. Journal of Ayurveda and Integrative Medicine, 5(4):251. doi:10.4103/0975-9476.146554

Cowan MM. 1999. Plant products as antimicrobial agents. Clinical Microbiology Reviews, 12:564–82.

Das J, Buragohain B, Srivastava RB. 2010. In vitro evaluation of *Ocimum sanctum* leaf extract against dermatophytes and opportunistic fungi. Asian Jornal of Microbiology Biotechnology and Environmental Sciences, 12:78992.

Deo SS, Inam F, Mahashabde RP. 2011. Antimicrobial activity and HPLC fingerprinting of crude ocimum extracts. E-Journal of Chemistry, 8:14307.

Dutta, BK, Rahman I, Das TK. 1998. Antifungal activity of Indian plant extracts. Mycoses, 41(11-12):535-36.

Edeoga HO, Okwu DE, Mbaebie BO. 2005. Phytochemical constituents of some Nigerian medicinal plants. African Journal of Biotechnology, 4(7):685-88.

Emtinan A, Hassan H, Muddathir S, Afra A, Salwa G. et al. 2015. Antimicrobial and phytochemical screening of *Cordia africana* in Sudan. World Journal of Pharmacy Research, 4:257-69.

Farivar TN, Fard AH, Zahedani SS, Naderi M, Moud BS. 2006. Anti tuberculosis effect of *Ocimum sanctum* extracts in in vitro and macrophage culture. Journal of Medical Sciences, 6:348-51.

Gajera HP, Patel SV, Golakiya BA. 2005. Antioxidant properties of some therapeutically active medicinal plants—an overview. Journal of Medicinal and Aromatic Plant Sciences, 27:91–100.

Gautam A, Shukla S. 2017. *Emblica officinalis* (Amla) leaf extract potentiates antibacterial activity of some antibiotics. Journal of Pharmacognosy and Phytochemistry, 6(2):233-36.

Gavimath CC, Ramachandra YL, Rai SP, Sudeep HV, Ganapathy PSS, Kavitha BT. 2008. Anibacterial activity of *Aegle marmelos* correa leaves extract. Asian Journal of Bio Science, 3(2):333-36.

Ghosal S, Tripathi VK, Choun S. 1996. Active constituents of *Emblica officinalis*: Part 1. The chemistry and antioxidant effect of two new hydrolysable tannins. Emblicanin A and B. Indian Journal of Chemistry, 35B: 941-48.

Grover JK, Yadav S, Vats V. 2002. Medicinal plants of India with anti-diabetic potential. Journal of Ethnopharmacology, 81:81–100.

Haller Jr JS. 1990. A drug for all seasons. Medical and pharmacological history of Aloe. Bulletin of New York,

Academy of Medicine, 66(6):647-59.

Harini K, Nithyalakshmi V. 2017. Phytochemical Analysis and Antioxidant Potential of *Cucumis melo* Seeds. International Journal of Life Sciences of Scientific Research, 3(1):863-67.

Heinrich M, Barnes J, Gibbons S, Williamson EM. 2004. Fundamentals of Pharmacognosy and Phytotherapy. Churchill Livingstone, Edinbrugh, pp. 245–52.

Hutchings A, Cock IE. 2018. An interactive antimicrobial activity of *Emblica officinalis* Gaertn. fruit extracts and conventional antibiotics against some bacterial triggers of autoimmune inflammatory diseases. Pharmacognosy Journal, 10(4):654-62. https://doi.org/10.5530/pj.2018.4.108.

Irshad S, Butt M, Younus H. 2011. In-vitro antibacterial activity of *Aloe barbadensis* Miller (*Aloe vera*). International Research Journal of Pharmaceuticals, 1(2):59-64.

Jain S, Mohan R, Rai R. 2015. Ocimum sanctum as an herbal medicine: A review. International Journal of Maillofacial Research, 1(1):1-12.

Kambizi L, Afolayan AJ. 2008. Extracts from *Aloe ferox* and *Withania somnifera* inhibit *Candida albicans* and *Neisseria gonorrhoea*. African Journal Biotechnology, 7(1):12-15.

Khan KH. 2009. Roles of *Emblica officinalis* in medicine-A review. Botany Research International, 2(4):218-28.

Koochek MH, Pipelzadeh MH, Mardani H. 2002. The effectiveness of *Viola odorata* in the prevention and treatment of formalin-induced lung damage in the rat. Journal of Herbs Spices and Medicinal Plants, 10:95–103.

Mahajan N, Rawal S, Verma, M, Poddar M, Alok S. 2013. A phytopharmacological overview on Ocimum species with special emphasis on *Ocimum sanctum*. Biomedicine and Preventive Nutrition, 3(2):185-92.

Mahesh B, Satish S. 2008. Antimicrobial activity of some important medicinal plant against plant and human pathogens. World Journal of Agriculture Sciences, 4:839–43.

Mandal S, Mandal MD, Pal NK. 2008. Enhancing chloramphenicol and trimethoprim in vitro activity by *Ocimum sanctum* Linn. (Lamiaceae) leaf extract against *Salmonella enterica* serovar Typhi. Asian Pacific Journal of Tropical Medicine, 5:220-24.

Mann J. 1978. Secondary Metabolism. Oxford University Press, London, pp. 154.

Mantle D, Gok MA, Lennard TW. 2001. Adverse and beneficial effects of plant extracts on skin and skin disorders. Adverse. Drug Reaction Toxicology Reviews, 20(2):89-103.

Marshall JM. 1990. *Aloe vera* gel: What is the evidence? The Pharmaceutical Journal, March 24: 360-62.

Maurya R, Singh G, Yadav PP. 2008. Antiosteoporotic agents from Natural sources. In: Atta-ur-Rahman (Ed.) Studies in Natural Products Chemistry, 35:517-45.

Mohan L, Amberkar MV, Kumari M. 2011. *Ocimum sanctum* linn. (TULSI)-an overview. International Journal of Pharmaceutical Sciences Review and Research, 7:513.

Mohotti S, Rajendran S, Muhammad T, Strömstedt AA, Adhikari A, Burman R, de Silva ED, Göransson U, Hettiarachchi CM, Gunasekera S. 2020. Screening for bioactive secondary metabolites in Sri Lankan medicinal plants by microfractionation and targeted isolation of antimicrobial flavonoids from Derris scandens. Journal of Ethnopharmacology, 246:112158.

Mondal S, Mirdha BR, Mahapatra SC. 2009. The science behind sacredness of Tulsi (*Ocimum sanctum* Linn.). Indian Journal of Physiology and Pharmacology, 53:291-306.

Oliveira DG, Prince KA, Higuchi CT, Santos ACB, Lopes LMX, Simões MJS. 2007. The anti-mycobacterial activity of some Brazilian indigenous medicinal drinks. Journal of Basic and Applied Pharmaceutical Sciences, 28:165-69.

Ozturk S, Ercisli S. 2007. Chemical constitutions and antibacterial activity of *Ziziphora clinopodioides*. Food Control, 18:535-40.

Parag S, Vijyayshree N, Rami B, Patil B. 2010. Antibacterial activity of *Ocimum sanctum* Linn. and its application in water purification. Research Journal of Chemistry Environment, 14:4650.

Parrotta AJ. 2001. Healing plants of Peninsular India. New York: CABI publishing, pp. 308.

Patel JR, Tripathi P, Sharma V, Chauhan NS, Dixit VK. 2011. *Phyllanthus amarus*: Ethnomedicinal uses, phytochemistry and pharmacology: A review. Journal of Ethnopharmacology, 138(2):286-313. https://doi.org/10.1016/j.jep.2011.09.040

Pattanayak P, Behera P, Das D, Panda SK. 2010. *Ocimum sanctum* Linn. A reservoir plant for therapeutic applications: an overview. Pharmacognosy Reviews, 4:95-105. 10.4103/0973-7847.65323

Perianayagam JB, Narayan S, Gnanasekar G, Pandurangan A, Raja S, Rajagopal K, Rajesh R, Vijayarakumar P, Vijaykumar SG. 2005. Evaluation of antidiarrheal potential of *Emblica officinalis*. Pharmaceutical Biology, 43(4):373-77.

Polambo EA, Semple SJ. 2001. Antibacterial activity of traditional Australian medicinal plants. Journal of Ethnopharmacology. 77:151–57.

Poonkothai M, Saravanan M. 2008. Antibacterial activity of

Aegle marmelos against leaf, bark and fruit extracts. Ancient Science of Life, 27(3):15.

Rakesh N, Soujanya E, Tahreen J, Srividya S, Karnakar R, Ajay B, Sharada G. 2019. A study on anti-bacterial activity of *Aegle marmelos*. World Journal of Pharmaceutical Research, 4(12):1013-21.

Rios JL, Recio MC. 2005. Medicinal plants and antimicrobial activity. Journal of Ethnopharmacology, 100(1-2):80-4.

Robson MC, Heggers JP, Hagstrom WJ. 1982. Myth, Magic, Witchcraft, or Fact? *Aloe vera* Revisited. Journal of Burn Cure and Rehabilitation, 3(3):157-63.

Rajan S, Gokila M, Jency P, Brindha P, Sujatha RK. 2011. Antioxidant and phytochemical properties of Aegle marmelos fruit pulp. International Journal of Current Pharmaceutical Research, 3(2):65-70.

Rajan S, Gokila M, Jency P, Brindha P, Sujatha RK. 2011. Antioxidant and phytochemical properties of Aegle marmelos fruit pulp. International Journal of Current Pharmaceutical Research, 3(2):65-70. Sahu PK, Giri DD, Singh R, Pandey P, Gupta S, Shrivastava AK, Kumar A, Panday KD. 2013. Therapeutic and medicinal uses of Aloe vera: A review. Pharmacology and Pharmacy, 4: 599-610.

Saikia AP, Ryakala VK, Sharma P, Goswami P, Bora U. 2006. Ethnobotany of medicinal plants used by Assamese people for various skin ailments and cosmetics. Journal of Ethnopharmocology, 106:149–57.

Saini A, Sharma S, Chhibber S. 2009. Induction of resistance to respiratory tract infection with *Klebsiella pneumoniae* in mice fed on a diet supplemented with tulsi (*Ocimum sanctum*) and clove (*Syzgium aromaticum*) oils. Journal of Microbiology Immunology and Infection, 42:10713.

Samuelsson G. 2004. Drugs of Natural Origin: a Textbook of Pharmacognosy, 5th Swedish Pharmaceutical Press, Stockholm.

Sawarkar HA, Khadabadi SS, Mankar DM, Farooqui IA, Jagtap NS. 2010. Development and biological evaluation of herbal anti-acne gel. International Journal of PharmTech Research, 2:2028-31.

Sawhney R, Berry V, Kumar A. 2012. Inhibitory activity of *Rubia cordifolia* plant extract against ESBL producing urinary *E. coli* isolates. Journal of Pharmacy Research, 5(3):1328-30.

Saxena R, Patil P. 2014. In vitro antibacterial activity of *Emblica officinalis* essential oil against *Staphylococcus aureus*. International Journal of Theoretical and Applied Sciences, 6(2):7–9.

Scartezzini P, Antognoni, F, Raggi MA, Poli F, Sabbioni C. 2006. Vitamin C content and antioxidant activity of the fruit and of the Ayurvedic preparation of *Emblica officinalis* Gaertn. Journal of Ethnopharmacology, 104(1-2):113-18.

Shah F, Hasan Z, Zaidi KU. 2016. Evaluation of phyto constituent and synergistic antibacterial activity of *Ocimum sanctum* extract against some gram-positive and gram-negative species. Bioscience Biotechnology Research Communications, 9(4):856-64.

Shah GM, Khan MA. 2006. Common medicinal folk recipes of Siran Valley, Mansehra, Pakistan. Ethnobotanical Leaflets, 10:49–62.

Shah PJ, Malik R. 2019. Study of antibacterial activity of *Phyllanthus emblica* and its role in Green Synthesis of Silver Nanoparticles. Journal of Drug Delivery and Therapeutics, 9(3):76-81.

Sharma SK, Perianayagam BJ, Joseph A, Christina AJM. 2003. Anti inflammatory activity of ethanol an aqueous extracts of *Emblica officinalis* Geartn fruits. Hamdard Medicus, 46:75-78.

Shetty S, Udupa S, Udupa L. 2008. Evaluation of antioxidant and wound healing effects of alcoholic and aqueous extract of *Ocimum sanctum* Linn in rats. Evid Based Complement Alternative Medicine, 5:95-101.

Shinwari MI, Khan MA. 1998. Multiple dimensions of ethnobotany and its present status in Pakistan. Hamdard Medicus, 42:5–10.

Shokeen P, Ray K, Bala M, Tandon V. 2005. Preliminary studies on activity of *Ocimum sanctum*, *Drynaria quercifolia*, and *Annona squamosa* against *Neisseria gonorrhoeae*. Sexually Transmitted Diseases,32:106-11

Singh N, Hoette Y, Miller R. 2010. Tulsi: The Mother Medicine of Nature. 2nd ed. Lucknow. International Institute of Herbal Medicine, p. 2847.

Singh P, Singh R, Sati N, Sati OP, Ahluwalia V. 2017. Phytochemical and Pharmacological Significance of Genus: Impatiens. International Journal of Life Sciences and Scientific Research, 3(1):868-81.

Singh S, Malhotra M, Majumdar DK. 2005. Antibacterial activity of *Ocimum sanctum* L. fixed oil. Indian Journal of Experimental Biology, 43:8357.

Singh S, Taneja M, Majumdar, DK. 2007. Biological activities of *Ocimum sanctum* L. fixed oilan overview. Indian Journal of Experimental Biology, 45:40312.

Singh SN, Moses A, David A. 2019. Antimicrobial activity of *Emblica officinalis* extracts against selected bacterial pathogens. International Journal of Basic and Applied Research, 9(1):325-30.

Sivaraj R, Balakrishnan A, Thenmozhi M, Venckatesh R. 2011. Antimicrobial activity of *Aegle marmelos, Ruta graveolens, Opuntia dellini, Euphorbia royleena* and

Euphorbia antiquorum. Journal of Pharmacy Research, 4(5):1507.

Yadav SS, Dahiya K, Showkat A, Gulia SK. 2014. Antibacterial activity of *Aegle marmelos* (l) correa. International Journal of Pharmacy and Pharmaceutical Sciences, 7(3):462-64.

Surjushe A, Vasani R, Saple DG. 2008. *Aloe vera*: a short review. Indian Journal of Dermatology, 53(4):163.

Suzuki A, Shirota O, Mori K, Sekita S, Fuchino H, Takano A, et al. 2009. Leishmanicidal active constituents from Nepalese medicinal plant Tulsi (*Ocimum sanctum* L.). Chemical and Pharmaceutical Bulletin (Tokyo), 57:24551.

Tadeg H, Mohammed E, Asres K, GebreMariam T. 2005. Antimicrobial activities of some selected traditional Ethiopian medicinal plants used in the treatment of skin disorders. Journal of Ethnopharmacology, 100:168-75.

Townsend J. 1998. *Aloe vera*. The UK Reference Guide to Complementary Medicine. London: Chartwell House Publishing.

Varghese LS, Alex N, Ninan MA, Soman S, Jacob S. 2013. Evaluation of in vitro antibacterial activity whole plant (fruits, seeds, stem, leaves and roots) of *Emblica officinalis* gaertn. International Journal of Ayurvedic and Herbal Medicine, 3(6):1420-25.

Variya BC, Bakrania AK, Patel SS. 2016. *Emblica officinalis* (Amla): A review for its phytochemistry, ethnomedicinal uses and medicinal potentials with respect to molecular mechanisms. Pharmacology Research, 111:180-200.

Vasudevan P, Kashyap S, Sharma S. 1999. Bioactive botanicals from basil (Ocimum sp.). Journal of Scientific and Industrial Research, (C)58:332-38.

Venkatesan D, Karrunakarn CM, Kumar SS, Swamy P. 2009. Identification of phytochemical constituents of *Aegle marmelos* responsible for antimicrobial activity against selected pathogenic organisms. Ethnobotanical Leaflets (11): 4.

Vogler BK, Ernst E. 1999. *Aloe vera*: a systematic review of its clinical effectiveness. British Journal of General Practice, 49(447):823-28.

World Health Organisation. 1993. Summary of WHO guidelines for the assessment of herbal medicines. Herbal Gram, 28:13–14.

Yadav SS, Singh MK, Singh PK, Kumar V. 2017. Traditional knowledge to clinical trials: A review on therapeutic actions of *Emblica officinalis*. Biomedicine and Pharmacotherapy, 93:1292-1302.

Yamani HA, Pang, EC, Mantri N, Deighton MA. 2016. Antimicrobial activity of Tulsi (*Ocimum tenuiflorum*) essential oil and their major constituents against three species of bacteria. Frontiers in Microbiology, 7:681.

Yonathan D, Yeshitila A, Tadesse M, Mathewos A. 2015. Extraction and physico-chemical characterization of *Cordia africana* Lam seed oil. Journal of Advanced Botany and Zoology, 4:8.

Yucharoen R, Anuchapreeda S, Tragoolpua Y. 2011. Anti-herpes simplex virus activity of extracts from the culinary herbs *Ocimum sanctum* L., *Ocimum basilicum* L. and *Ocimum americanum* L. African Journal of Biotechnology,10:860-66.

Zabihullah Q, Rashid A, Akhtar N. 2006. Ethnobotanical survey in Kot Manzary Baba Valley Malakand Agensy, Pakistan. Pakistan Journal of Plant Sciences, 12:115–21.

Zeleke E, Enbiyale G, Mamo G, Giday M, Luelseged A. 2019. The In Vitro Antibacterial Sensitivity Test of Selected, Medicinal Plants. Journal of Genomic Medicine Pharmacogenomics, 5(1):402-12.