Review Article

Antimicrobial agents from natural sources: An overview

Rakesh Kumar Paul[1], Dibyendu Dutta[1], Dipesh Chakraborty[2], Arabinda Nayak[1], Prabir Kumar Dutta[1], Mrinmoy Nag[1]*

[1]*Department of Pharmaceutical Science, Bengal College of Pharmaceutical Sciences & Research, Durgapur-711212, India.*

[2]*Department of Pharmaceutical Science, Dr. B.C.Roy College of Pharmacy& Allied Health Sciences,Durgapur-711212, India.*

Received: 23 march 2018 Revised: 18 Aprl 2018 Accepted: 28 April 2018

Abstract

The use of natural antimicrobial agents in surrounding area has achieved great importance in the field of pharmaceutical industry. This is due to great challenge against microbes which causes pathogenic resistance by the mishandling and misuse of antibiotics. Now a day's many synthetic and semi synthetic antibiotics are available which has lot of side effect as well as very expensive. So, alternative natural antimicrobial agents search from natural sources with minimum side effect which prompt the safety and quality of pharmaceutical products. Plant has storage of many secondary metabolites which plays crucial roles in microbial infection. Likewise plants animal's products also having antimicrobial agents like Exoskeletons, Milk, and Egg Albumin etc. A large collection of bio-molecules from marine organisms also showed a great interest to compete with pathogenic microbes. This review article represents the antibacterial activity of natural products including plants and animals which are derived from land and marine sources.

Keywords: Antimicrobial, natural, land sources, marine sources

Introduction

In many developing countries large portion of population, depends on the traditional system of medicine to treat variety of disease (McGaw et al., 2000). The World Health Organization (WHO) reported that the 80% of world population relies chiefly on traditional medicine, which involve of the medicinal plant extracts or their active constituents (Ahmad et al., 1998). The look for new antimicrobial lead is a worldwide investigation, as microorganisms are resistant to caused drugs; thus an appropriate treatment is especially required (Latha and Kannabiran, 2006). Antibiotic resistance has become a serious problem and affects almost every bacterial species. Resistance to multiple antibiotics has developed among many common pathogens, such as staphylococci, pneumococci, Pseudomonas organisms and this problem is steadily increasing worldwide (Olofsson and Cars, 2007). In worldwide around 90-95% of *Staphylococcus aureus* strains is penicillin resistance, but in Asian countries about 70-80% of the same strains are methicillin resistance, MRSA (Hemaiswarya et al., 2008). Sometimes antibiotics are associated with adverse effects on host, which include depletion of beneficial gut, mucosal microorganisms, immune suppression, hypersensitivity and allergic reaction. Some drug-resistant bacteria has complicated in the treatment of infectious diseases in immune compromised, AIDS and cancer patients (McGaw et al., 2000). One way to beat this downside of drug resistance is by getting new molecules from natural resources. Plants are known to be produces a variety of compounds and medicinal properties to protect from a wide range of microorganisms including plant pathogens and environmental organisms (Bentley, 1997; Savithramma et al., 2011; Chung et al., 2011). Therefore, alternative antimicrobials are used from botanicals sources which provide flexibility and diversity, for helping to reducing the side effects and their combination used in synergistic or adjuvant therapy for delay the development of resistance (Keith et al., 2005; Konget al., 2008; Koehn and Carter, 2005; Beghyn et al., 2008; Hunter, 2008). Now a day's

Address for Corresponding Author:
Dr. Mrinmoy Nag
Assistant professor
Bengal College of Pharmaceutical Sciences and Research
Durgapur 711232, India
E-mail: mrinmoynag83@gmail.com

DOI: https://doi.org/10.31024/apj.2019.4.2.1

several antimicrobial agents are accessible, that is expensive, has toxicity and yielded drug-resistance mutants. Therefore, it must notice price effective and pronto accessible from natural anti-microbial agents, with minimum aspect effects.

Uses of antimicrobials

Antimicrobials are utilized in human medication, food items, farming, domestic animals and family unit items.

Utilized in human medication

Plant Phyto-constituents such as alkaloids, flavonoids, sesquiterpene lactones, diterpenes, triterpenes are the major source for antimicrobial agents. These normally happening plant products prevent infection antibiotic resistance microorganisms, for example, *Bacillus cereus*, *Escherichia coli*, and *Staphylococcus aureus* (Friedman, 2006).

Utilized in food items

Antimicrobial materials are applied in food products for packaging as well as food contact surfaces. Presently multi day's antimicrobial packages have a few structures, for example, expansion of sachets having unpredictable antimicrobial specialists into bundles; covering or adsorption of antimicrobials agents connected as a polymer surfaces; immobilization of antimicrobials to polymers by particle or covalent linkages and that polymers are utilized inalienably antimicrobial. Presently multi day's nourishment borne microbial sicknesses are emerging. So creative approach is required to deal with conquer microbial defilement in nourishment by the looking after quality, freshness and security of sustenance items (Appendini and Hotchkiss, 2002).

Utilized in farming

Benomyl, chlorothalonil and captan are commonly used in plant diseases (Chen et al., 2001). In agriculture imazalil and triadimefon are used to control fungal infection of fruit and vegetables. Subsequently advancement of common antimicrobial agents from plant source may be a promising approach.

Utilized in domestic animals

Numerous antimicrobial agents, for example, tetracyclins, penicillins, macrolides and lincomycin are affirmed for development advancement of animals. Dietary upgrading feed added substances are joined into the creatures to enhance their development rates (Boxall et al., 2003). Such agriculture utilizing antimicrobial agents additionally affect the treatment of human sickness. To overcome this some natural antimicrobial agents such as Allium, Artemisia, Clematis, Echium and Euphorbia are used in food animals (Viegi et al., 2003). The *Salvadora persica* L., *Colophospermum mopane* and *Dichrostachys cinerea* L. crude extracts are used by local farmers for the treatment of many domestic animals infections (Mudzengi et al., 2017).

Utilized in family unit items

To avert microbial pollution, antimicrobials are utilized in cotton strands and an extensive variety of plastic applications, for example, phones, healing centre furniture, divider covering, flooring, rooftop, film and so forth (Arcy, 2001). The best fungicide was 8-hydroxyquinoline is utilized in business paints (Lim et al., 2008). Presently multi day's normal antimicrobial agents are utilized in family unit items, which is progressively gainful for the earth and human wellbeing.

Natural antimicrobial agents from land sources

Plants Used as Natural Antimicrobial Agents

Many natural antimicrobials agents are found in plant sources e.g. plants, plant-derived compounds and plant by-products. Plant and various plant parts used as natural antimicrobial agents are mentioned in table 1.

Table 1. Antimicrobial activity present in plants

Common name	Scientific name	Family	Parts Used	Target organisms	References
Bael tree	*Aegle marmelos*	Rutaceae	Leaf, bark &fruit	*B. subtilis, S. aureus, K. pneumoniae, P. mirabilis, E. coli, S. Paratyphi A, S. paratyphi B*	(Poonkothai and Saravanan, 2008)
Spotted medick	*Medicago arabica*	Fabaceae	Root &tops	*B. cereus , B. subtilis , S. aureus, E . faecalis*	(Avato et al., 2006)
Aloe	*Aloe barbadensis*	Asphodelaceae	Leaf	*E. coli , E. faecalis , S. aureus*	Athiban et al., 2012)
Apple	*Malus sylvestris*	Rosaceae	Leaf	*E. fecalis , S. aureus*	(Hunter and Hull, 1993)
Basil	*Ocimum basilicum*	Lamiaceae	Leaf	*P. aeruginosa, Shigella sp., L. monocytogenes, S. aureus, E. coli*	(Kaya et al., 2008)
Aveloz	*Euphorbia tirucalli*	Euphorbiaceae	Stem	*B. subtilis , E. coli, Proteus vulgaris, S. aureus*	(Gupta et al., 2013)
Allspice	*Pimenta dioica*	Myrtaceae	Leaf	*Pseudomonas fluorescens, B. megaterium*	(Boyd and Benkeblia, 2014)
Black pepper	*Piper nigrum*	Piperaceae	Berry	*B. subtilus, E. faecalis, S. xylosus, S. aureus S. epidermidis, E. coli, K. pneumoniae, S. enterica*	(Zarai et al., 2013)
Barberry	*Berberis vulgaris*	Berberidaceae	Root	*E. coli*	(Ghareeb et al., 2013)
Balsam pear	*Momordica charantia*	Cucurbitaceae	Leaf and fruit	*P. aeruginosa, E. coli, S. aureus , K. pneumoniae, S. typhi*	(Mwambet, 2009)

Table 1. Continue ......

Common name	Scientific name	Family	Parts Used	Target organisms	References
Betel pepper	*Piper betel*	Piperaceae	Leaf	*V. cholera, S. aureus, D. pneumonia, K. aerogenes*	(Shitut et al., 1999)
Coriander	*Coriandrum sativum*	Apiaceae	Leaf	*S. aureus, Bacillus sp., E. coli, S. typhi, K. pneumonia, P. mirabilis*	(Matasyoha et al., 2009)
Caraway	*Carum carvi*	Umbelliferae	Seed	*E. coli*	(Gupta et al., 2011)
Clove	*Syzygium aromaticum*	Myrtaceae	Seed	*E. coli, P. aeruginosa, S. aureus*	(Ajiboye et al., 2016)
Green tea	*Camellia sinensis*	Theaceae	Leaf	*S. mutans, L. Acidophilus, S. aureus, S. epidermidis,S. typhi, S. typhimurium, S. enteritidis, S. flexneri, S. dysenteriae, V. cholerae*	(Anita et al., 2015; Hamilton - miller, 1995)
Garlic	*Allium sativum*	Amaryllidacee	Bulb	*E. coli, S. aureus, B. subtilis*	(Viswanathan et al., 2016)
Marigold	*Calendula officinalis*	Asteraceae	Petal	*B. subtulis, S. aureus, E. coli, K. pneumoniae*	(Efstratiou et al., 2012)
Gotu kola	*Centella asiatica*	Apiaceae	Whole plant	*B cereus, Serratia sp., R mucilaginosa*	(Dhiman et al., 2016)
Goldenseal	*Hydrastis canadensis*	Ranunculaceae	Aerial part	*S. aureus*	(Ettefagh et al., 2011)
Licorice	*Glycyrrhiza glabra*	Legumes	Root	*S. mutans, S. sanguis, A. viscosus, E. faecalis, S. aureus , E. coli*	(Sedighiniaet al., 2012)
Turmeric	*Curcuma longa*	Zingiberaceae	Rhizome	*S. aureus, E. coli*	(Afrose et al., 2015)
Anantamul	*Hemidesmus indicus*	Apocynaceae	Root	*S. aureus, K. pneumonia, P. aeruginosa*	(Gayathriand Kannabiran, 2009)
Papaya	*Carica papaya*	Caricaceae	Fruit	*B. cereus, E. coli, S. faecalis S. aureus, P. vulgaris, S. flexneri*	(Dawkins et al., 2003)
Onion	*Allium cepa*	Amaryllidaceae	Bulb	*S. aureus, V. cholerae*	(Eltaweel, 2013; Hannan et al., 2010)
Jamun	*Syzgium cumini L*	Myrtaceae	Leaf	*E. faecalis, P. aeruginosa, S. flexneri, S. aureus*	(de Oliveira et al., 2007)
Amla	*Emblica officinalis*	Euphorbiaceae	Fruit	*E. coli, E. cloacae, K. pneumoniae*	(Kumar et al., 2011)
Neem	*Azadirachta indica*	Meliaceae	Leaf &bark	*V. cholera, B. subtilis, E. coli, S. Typhi, M. luteus, P. vulgeris*	(Raut et al., 2014; Koona and Budida, 2011)
Tulsi	*Ocimum sanctum*	Lamiaceae	Leaf	*S. aureus, P. aeruginosa, E. coli, S. typhimurium, S. saprophytic*	(Mishra and Mishra, 2011; Kumar et al., 2011)
Arjun	*Terminalia arjuna*	Combretaceae	Leaf&bark	*S. aureus, Acinetobacter sp., P. mirabilis, E. coli*	(Aneja et al., 2012)
Capicum	*Capicum frutescens*	Solanaceae	Fruit	*P. aeruginosa*	(Soetarno et al., 1997)
Pomegranate	*Punica granatum L.*	Punicaceae	Fruit	*B. megaterium, P. aeruginosa, S. aureus , C. xerosis, E. coli, E. faecalis, M. luteus, K. marxianus, R. rubrum*	(Duman et al., 2009)
Chaff flower	*Achyranthes aspera*	Amaranthaceae	Root	*S. aureus, E. coli, B. Subtilis, P. vulgeris*	(Beaulah et al., 2011)
Sessile joyweed	*Alternanthera sessile*	Amaranthaceae	Leaf	*S. pyogenes, S. typhi, B. subtilis, P. vulgaris*	(Johnson et al., 2010)
Cola Nut	*Cola acuminate*	Sterculiaceae	Steam	*S. aureus*	(Shama et al., 2011)
Wild Jasmine	*Clerodendrum inerme* L	Verbenaceae	Leaf	*S. aureus*	(Chahal et al., 2010)
Asthma Weed	*Euphorbia hirta*	Euphorbiaceae	Whole Plant	*S. aureus, E. coli*	(Ogueke et al., 2007)
Dahlia	*Dahlia pinnata*	Asteraceae	Leaf	*E. aerogenes, P. aeruginosa*	(Bissa et al., 2011)
False Daisy	*Eclipta prostrata* L	Asteraceae	Leaf	*S. typhi*	(Karthikumar et al., 2007)
Champa	*Plumeria alba*	Apocynaceae	Petal	*E. coli*	(Syakira and Brenda, 2010)
Rosy Milkweed Vine	*Oxystelam esculentum*	Asclepiadaceae	Leaf	*E. coli*	(Khan et al., 2008)
White Frangipani	*Plumeria ruba*	Apocynaceae	Leaf	*S. epidermidis, E. coli*	(Baghel et al., 2010)
Cherry Ashok	*Polyalthia cerascides*	Annonaceae	Steam Bark	*Corynebacterium dipthieriae*	(Treeratanapiboon et al., 2011)
Myrobalan	*Terminalia chebula*	Combretaceae	Fruit	*S. aureus, S. epidermidis, S. typhi, P. aeruginosa, B. subtillis*	(Kannan et al., 2009)
Black catnip	*Phyllanthus amarus*	Euphorbiaceae	Leaf	*S. typhi*	(Oluwafemi and Debiri, 2008)
corn mint	*Mentha arvensis*	Lamiaceae	Leaf	*B. cereus, Serratia sp.*	(Dhiman et al., 2016)
St John's wort	*Hypericum perforatum*	Hypericaceae	aerial parts	*A. baumanii, E. coli, E. faecalis, K. oxytoca, K. pneumoniae, P. aeruginosa, S. aureus*	(Egamberdieva et al., 2017)

Plant-derived Compounds

The plant-derived antimicrobial mainly found in herbs and their spices (Cueva et al., 2010; Negi, 2012). The antimicrobial activity of these compounds mainly based on their structural characteristics. Major groups plant compounds that are responsible for antimicrobial activity e.g. phenolics, phenolic acids, quinones, saponins, flavonoids, tannins, coumarins, terpenoids, and alkaloids (Ciocan and Bara, 2007; Lai and Roy, 2004).

Plant By-products

During food processing, large amount of by-products are generated. By-products of fruits and vegetables (Table 2) are potentially good sources of minerals and organic acid that have a wide range of antimicrobial properties (Chanda et al., 2010).

Antimicrobial Agents from Animal Sources

Many natural antimicrobials agents are found in animal sources mentioned in table 3.

Antimicrobial Agents from Marine Source

Many natural antimicrobials agents are found in animal sources mentioned in table 4.

Conclusion

Since, there is an increased demand for antibiotic so it is necessary to make free of synthetic chemicals as well as semi-synthetic for the well-being of the living systems. Natural products can be used for the prevention and cost effective in place of synthetic and semi-synthetic antimicrobial drugs to minimize the side effect. Therefore,

Table 2. Plant by-products used as antimicrobials

By-products	Major component	Target organisms	References
Green tea waste	Tannins	*S. aureus* , *E. coli*	(Sung et al., 2012)
Coconut husk	Phenolics and tannins	*L. monocytogenes* , *S. aureus* , *V. cholera*	(Wonghirundecha and Sumpavapol, 2012)
Potato peels	Chlorogenic, caffeic, gallic, protocatechuic acids	*E. coli* , *S. typhimurium*	(Sotillo et al., 1998)
Tomato seeds	Fatty acids, carotenoids, saponins,phenolic compounds	*S. aureus* , *S. epidermidis* , *M. luteus* , *E. faecalis* , *B. cereus*	(Taveira et al., 2010)
Apple peels	Polyphenolic compounds	*S. aureus* , *P. fluorescens*	(Agourram et al., 2013)

Table 3. Antimicrobial agents obtain from animal sources

Antimicrobial agent	Major source	Target organisms	References
Defensins	Mammalian epithelial cells of chickens, turkeys	Gram-positive and Gram -negative bacteria	(Tiwari et al., 2009)
Chitosan	Exoskeletons of Crustaceans & arthropods	*E. coli, S. aureus, Pseudomonas sp., E. coli, L. monocytogenes*	(Tiwari et al., 2009 ; Leleu et al., 2011)
Casein and whey	Milk protein	*Enterobacter sakazakii,* *E. coli, S. aureus, L. monocytogenes, S. typhimurium, B. subtilis*	(Hayes et al., 2006; Korhonen andRokka, 2010)
Lactoferrin	Milk	*E. coli, L. monocytogenes,* *Salmonella sp.* , *Pesudomonas sp.*	(Lonnerdal , 2011; Perez et al., 2012)
Ovotransferrin	Egg albumin	*Micrococcus, Bacillus spp., E. c oli,L. monocytogenes, S. aureus*	(Perez et al., 2012; Ko et al., 2008; Ko et al, 2009)
Lactoperoxidase	Raw milk, colostrum, saliva and other biological secretions	*Salmonella sp., E. coli, S. aureus, L. monocytogenes, Y.entericolitica*	(Perez et al., 2012)
Pleurocidin	Myeloid cells and mucosal tissues of many vertebrates and invertebrates	*L. monocytogenes, E. coli*	(Burrowes et al., 2004; Jung et al., 2007)
Lysozyme	Hens' eggs, mammalian milk	*C. tyrobutyricum, Bacillus sp., Micrococcus sp., L. monocytogenes*	(Perez et al. , 2012; Juneja et al., 2012)

Table 4. Antimicrobial agents from marine source

Classification	Scientific name	Family	Target organisms	References
Algae	*Laurencia papillosa*	Rhodomelaceae	*E. coli, P. aerugenosa, K. pneumoniae, & Shigella flexineri*	(Kavita et al., 2013)
Cnidarians	*Carijoa* sp.	Clavulariidae	*S. albus, S. aureus, E. coli, P. putida, Nocardia brasiliensis, & Vibrio parahaemolyticus*	(Zhao et al., 2013)
	Melitodes squamata	Melithaea	*Bacillus subtilis & M. luteus*	(Huang et al., 2012)
Sponges	*Amphimedon sp.*	Niphatidae	*S. aureus*	(Kubota et al., 2013)
	Callyspongia aerizusa	Callyspongiidae	*S. aureus, B. subtilis, and E. coli*	(Ibrahim et al., 2010)
	Suberea ianthelliformis	Aplysinellidae	*P. aeruginosa*	(Xu et al., 2012)
	Stylissa caribica	Dictyonellidae	*P. aeruginosa, K. pneumonia*	(Dahiya and Gautam, 2010)
	Clathria compressa	Microcionidae	*S. aureus, MRSA, and VRSA*	(Gupta et al., 2012)
	Petromica citrina	Desmanthidae	*S. aureus, S. epidermidis, E. faecalis, M. fortuitum,Neisseria gonorrhoeae*	(Marinho et al., 2012)
	Agelas mauritiana	Agelasidae	*MRSA and S. aureus*	(Yang et al., 2012)
Arthropods	*Scylla paramamosain*	Portunidae	*C. glutamicum, B. subtilis, M. lysodeikticus, M. luteus, E. coli, S. flexneri, V. harveyi, V. alginolyticus, V. parahaemolyticus, P. aeruginosa, P. stutzeri, P. fluorescens*	(Liu et al., 2012)
	Portunus trituberculatus	Portunidae	*V. alginolyticus, Edwardsiella tarda, P. Aeruginosa & S. aureus*	(Liu et al., 2013)
	Scylla paramamosain	Portunidae	*Aeromonas hydrophila, P. fluorescens, S. flexneri, E. coli, V. harveyi, M. leteus, S. aureus, B. subtilis, B. cereus, S. epidermidis*	(Peng et al., 2012)
Echinoderms	*Apostichopus japonicus*	Stichopodidae	*E. coli*	(La et al., 2012)
Mollusks	*Hexaplex trunculus*	Muricidae	*M. luteus, S. pneumonia, C. diphteriae, E. Faecalis, E. cloacae, B. subtilis, B. cereus, S. aureus & S. epidermidis*	(Zarai et al., 2012)
	Cenchritis muricatus	Littorinidae	*S. aureus & E. coli*	(Lopez-Abarrategui et al., 2012)
	Mytilus coruscus	Mytilidae	*E. coli & S. lutea*	(Yang et al., 2011)
	Mytilus coruscus	Mytilidae	*E. coli, V. parahaemolyticus, P. aeruginosa, P. vulgaris, V. harveyi, B. subtilis, S. aureus, S. luteus, and B. megaterium*	(Liao et al., 2013)
	Chlamys farreri	Pectinidae	*E. coli*	(Zhou et al., 2012)
Reptiles	*Caretta caretta*	Cheloniidae	*E. coli and S. typhimurium*	(Chattopadhyay et al., 2006)
Fish	*Gadus morhua*	Gadidae	*Moritella viscose, Yersinia ruckeri, V. anguillarum, Aeromonas hydrophila, Aeromonas salmonicida, P. aeruginosa, E. coli, B. megaterium, Lactobacillus sp.*	(Broekman et al., 2011)
	Rachycentron canadum	Rachycentridae	*E. coli*	(Ngai and Ng, 2007)
	Branchiostoma belcheritsingtauense	Branchiostomidae	*E. coli*	(Zhang et al., 2005)
	Cynoglossus semilaevis	Cynoglossidae	*Edwardsiella tarda, V. anguillarum, E. coli, M. luteus, S. iniae*	(Li et al., 2013)
	Sebastes schlegelii	Sebastidae	*A. salmonicida, A. hydrophila, Photobacterium damselae, V. parahaemolyticus*	(Kitani et al., 2013)
	Cynoglossus semilaevis	Cynoglossidae	*V. anguillarum*	(Lu et al., 2014)
	Oplegnathus fasciatus	Oplegnathidae	*E. coli, E. tarda, S. iniae*	(Kasthuri et al., 2013)
	Scophthalmus maximus	Scophthalmidae	*E. tarda, V. anguillarum, M. luteus, and S. aureus*	(Zhang et al., 2014; Yu et al., 2013)
	Epinephelus coioides	Serranidae	*P. stutzeri, S. aureus, MRSA*	(Qi et al., 2013; Huang et al., 2013)
	Pleuronectes americanus	Pleuronectidae	*S. aureus, E. faecium, P. acnes, E. Coli &P. aeruginosa*	(Choi and Lee, 2012)

further investigation is required to determine the optimum levels of antimicrobials that can be safely applied in living systems. Therefore, there continues to be a need to develop a more practical and effective delivery system for these antimicrobial compounds in food products. Furthermore, safety and health risks of natural antimicrobials need to be assessed before future applications in food products.

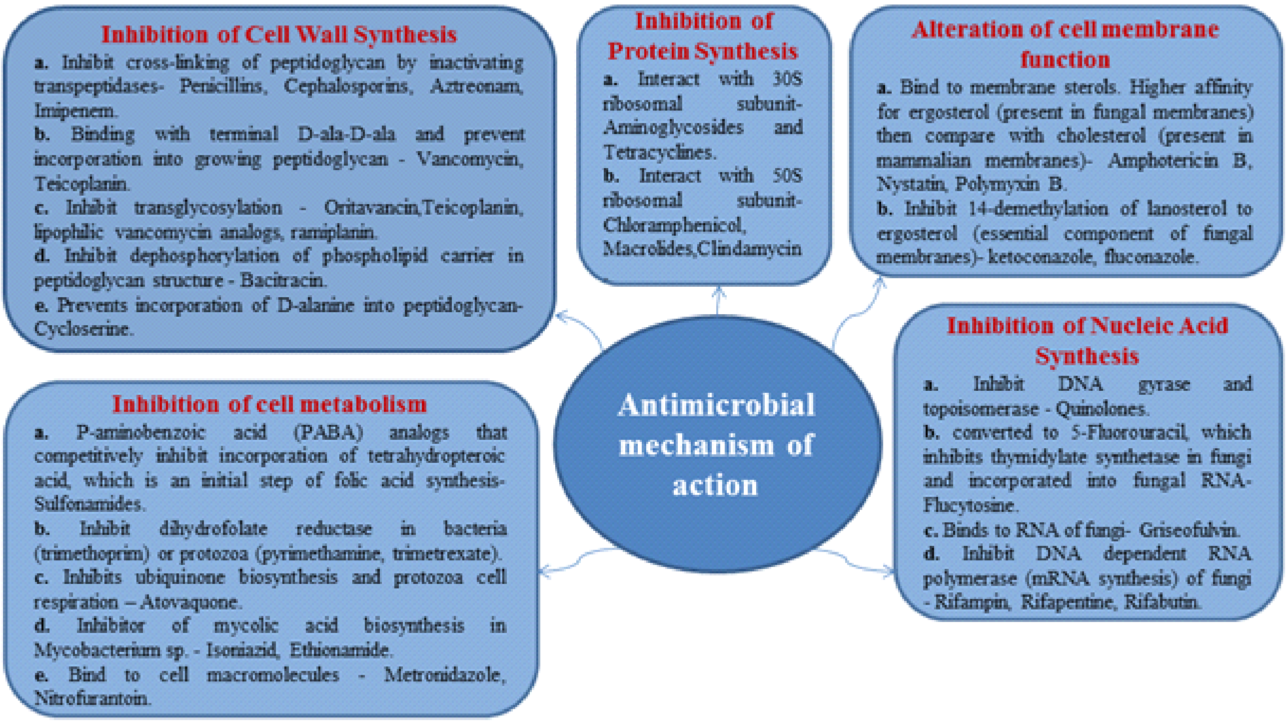

Figure 1. Mechanism of action of antimicrobial agents

Acknowledgement

The authors are grateful to Dr. Mrinmoy Nag, Department of Pharmaceutical Science, Bengal College of Pharmaceutical Sciences and Research, Durgapur for his support while conducting this work.

Conflicts of interest

The authors declare that they have no conflict of interests.

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