

Ayurvedic medicine as a solution to replace antibiotics in order to combat antibiotic resistance in bacteria

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Abstract

Shallaki (*Boswellia serratta*) and Jeeraka (*Cuminum cyminum*) extracts are commonly used in ayurveda as anti-inflammatory agents. They are used in prevention and treatment of diarrhea. They are known to possess anti-bacterial properties due to the presence of anti-biofilm properties of some of their constituent compounds such as terpenes. Ayurvedic medicine can be considered for treating bacterial infections alongside with or in place of allopathic antibiotics such as Vancomycin to overcome the growing issue of antibiotic resistance in bacteria that makes it harder to treat. Shallaki and Jeeraka show many health benefits and have minimal negative side effects therefore can be ideal to provide a low-cost and effective solution to overcome antibiotic resistance.

Keywords: Shallaki (*Boswellia serratta*); Jeeraka (*Cuminum cyminum*); Ayurveda; Boswellic acids; Phenolic compounds; Terpenes; Anti-biofilm activity, Antibiotic resistance; Allopathy

1. Introduction

Multi drug-resistant bacteria are becoming a problem in today's world largely due to incorrect and overuse of current antibiotics (in allopathy). Therefore, it has become essential to develop more antibiotics to combat bacterial infections. Ayurveda, a centuries old medical field that has been gaining popularity, involves the use of several plant extracts to cure illnesses. Ayurvedic medicine shows that extracts with antibacterial properties can be used as substitutes to allopathic antibiotics to address this grave concern of global health.

Several antibiotics like Vancomycin which are used to treat infections caused by bacteria like *Staphylococcus aureus* have started to become increasingly ineffective as the bacteria are becoming resistant. Vancomycin is used to treat methicillin-resistant *Staphylococcus* (MRSA) [1]. However, due to antibiotic resistance to Vancomycin, around 24% of the population is dying due to septicemia infection caused by methicillin-resistant *S. aureus* [2].

Considering the vast number of plant-based compounds in ayurveda, it may be possible to identify novel classes of antibacterial agents. Here, novel mechanisms of action and potent drug-like compounds for future development can be discovered. Furthermore, ayurveda and allopathy can come together to provide broader accessibility to healthcare at a lower cost, which could help millions of people.

Ayurveda is a traditional Indian medicinal system that has been practiced for over 3000 years [3]. It follows the principles of balancing the body, mind, and spirit in order to attain good health and well-being [4]. Ayurveda heavily encourages the use of natural remedies, herbal treatments, dietary guidelines, and lifestyle practices to prevent and treat various illnesses and problems. It provides a strong emphasis on personalized treatments based on individual constitution (doshas) and focuses on disease prevention [5]. However, self-medication has become a concern in

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ayurveda. Self-medication in allopathy is one of the reasons for the growth of resistant bacteria. While ayurvedic medicine is considered completely safe, this is incorrect. Improper or excessive use of certain ayurvedic extracts can lead to unwanted side-effects. Additionally, ayurvedic extracts can become poisonous if not used appropriately.

This article will discuss the antibacterial properties and mechanisms of bacterial inhibition exhibited by Shallaki and Jeeraka, which are used commonly in Ayurveda.

2. Shallaki

Shallaki, also known as Indian frankincense or *Boswellia serrata*, is a large sized branching tree species that grows in certain regions of India, in the Middle East and Northern Africa. The extracts of *B. serrata* commonly used for therapeutic purposes include plant parts such as the sap and the bark. It is generally ingested as oleo gum-resin, which is collected by tapping an incision made in the tree trunk and then removing its oil content by storing it in a specific bamboo basket. The oleo gum resins consist of 30-60% resin, 5-10% essential oils and other polysaccharides. Some of the wide number of compounds it possesses include terpenes, tetracyclic triterpenic acids and pentacyclic triterpenic acids like β -boswellic acid, acetyl- β -boswellic acid, etc. In traditional ayurvedic and unani texts, *B. serrata* is considered to be effective for treating diarrhea, ringworm, boils, cardiovascular diseases, mouth sores, bronchitis, asthma, cough, hair-loss, jaundice, syphilitic diseases, irregular menses, stimulation of liver, etc [6].

Boswellic acids like 3-hydroxy-11-keto- β -boswellic acid are reported to be the main cause of the resin's anti-bacterial properties. Also, several studies have pointed out boswellic acids' promising bio-film inhibitory activities [7].

3. Jeeraka

Jeeraka, also known as cumin or *Cuminum cyminum*, is a small herb species that is found in the Mediterranean region and Southern Asia [8]. While it is used widely in several ayurvedic decoctions, it is also used as a spice in cooking because of its flavor and aroma. Decoctions that include cumin are mainly used for problems such as diarrhea, bloating, vomiting, fever and skin diseases because it is known to have antioxidant and antimicrobial/ antibacterial properties [9]. Some of the more prominent compounds of cumin include cuminaldehyde, cymene and terpenoids such as cuminal, β -pinene, β -myrcene, ρ -cymene, γ -terpinene, linalyl acetate, cuminyl alcohol and ρ -mentha-1,4-dien-7-ol [10]. The cumin (essential) oil contains most of these compounds and is the one that shows significant antibacterial activity.

4. Mechanisms of inhibition

There are five classes of natural compounds that have antimicrobial and antibiofilm properties - lectins, alkaloids, polypeptides and polyacetylenes, terpenoids, phenols, and essential oils [11]. Ayurveda builds upon this advantage. Essential oils of *B. serrata* extracts usually contain terpenes with a pentacarbon isoprene unit [7]. Also, cumin oil has monoterpene hydrocarbon along with another antibiofilm substance cuminaldehyde. Terpenes are phytochemicals that cause damage to the bacterial membrane, suppress some virulence factors, have significant anti-QS activity and thus inhibit biofilm formation [12, 13]. Many resistant bacteria are found to have biofilms, which can make them more resistant to antimicrobials. Therefore, the effect of terpenes on biofilms are vital in anti-bacterial efforts. Additionally, the mechanisms of action of natural substances on the biofilm include membrane disruption, the ability to bind to the adhesin-cell wall complex, interactions with DNA, and protein binding. According to a study, *Boswellia* extract is effective against Gram-negative bacteria (e.g., *E. coli*), which are more resistant to antibiotics (e.g., Vancomycin) than Gram-positive cells due to relative impermeability of the outer membrane [7].

5. Other health benefits

Aside from exhibiting antibacterial effects, *B. serrata* and *C. cyminum* have been noted to cause additional health benefits that antibiotics do not show.

B. Serrata is significant in many boswellic acids, which are associated with antioxidant, anti-inflammatory, anti-proliferative properties as they have helped to show improvement against certain chronic diseases and some forms of cancer. Boswellic acid contains phytochemical compounds, which exhibit antioxidant activity. Thus, these acids are beneficial for people suffering from chronic illness such as cardiovascular diseases and cancer that have occurred owing to the overproduction of oxidants within the body. Boswellic acids such as KBA and AKBA are effective in reducing the production of cytokines and inhibiting enzymes responsible for inflammatory responses, proving as effective therapeutics [11]. For example, when Shallaki administered orally and through ointment on people suffering from

Osteoarthritis, they showed improvements in radiological findings at places like joint space. While these are some of the examples or benefits against some diseases, *B. Serratta* extracts have shown effectiveness against some other inflammatory disorders such as inflammatory bowel disease and metabolic disorders such as Atherosclerosis [14].

C. cyminum also contains compounds such as flavonoids that act as antioxidants by neutralising free radicals that lead to cell damage [15, 16]. This can help prevent ailments like cancer and coronary heart diseases. Phenolic compounds in certain jeera extracts are effective antioxidants and anti-inflammatory in nature. Jeeraka is commonly used in ayurveda mainly for digestive disorders such as diarrhea. Dietary cumin shortened food transit time by influencing digestive enzymes and bile secretion. It also helps with managing and preventing diabetes through mechanisms such as stimulating antioxidant defences, modulating signalling pathways and hormones that control glucose sensitivity [17].

6. Ayurvedic principles

The principles of ayurveda differ by a great extent when compared to allopathy. Ayurvedic medicine aims to cure all diseases and maintain the overall health of the body, focusing on both physical and mental health. However, allopathic medicine focuses on providing specific treatments that align with certain physical health issues. Ayurvedic medicine often works slowly and has more of a long-term effect as it tries to address the root cause of a disease. However, allopathic medicine aims to provide a quick cure, which could be only temporary. Also, ayurvedic treatments and medicines tend to be cheaper as many treatments involve affordable plant extracts. Ayurvedic medicine also tends to have a very lower number of side-effects compared to allopathic medicine. For example, some adverse side-effects of a commonly used antibiotic Ampicillin include seizure and hemolytic anemia [18].

7. Cell cytotoxic effects

B. serrata induces human cell cytotoxicity through different mechanisms like inhibiting signalling pathways, and enzymes. However, as shown in various studies, this is particular to cancer cell proliferation and survival as boswellic acids mainly induce tumor cell-specific apoptosis. Therefore, *B. serrata* is considered to show anti-cancer properties. Some of the mechanisms include inhibition of angiogenesis (new blood vessel formation that is vital for the growth and metastasis of a tumor); induction of apoptosis; inhibition of proliferation by interfering with the cell cycle and DNA replication; targeting signalling pathways like the PI3K/Akt pathway that is crucial for cancer cell survival and growth; and the disruption of mitochondrial function that leads to cell death [19].

Similarly, *C. cyminum* essential oil has been found to induce human cell cytotoxicity likely due to the presence of compounds like phenols, aldehydes and alcohols in the oil. Through in vitro studies utilising human cancer cell lines, a study showed ethanolic extract of cumin seeds that includes compounds like cuminaldehyde showed a cytotoxic activity of 25%, 61%, 40%, 31%, 28%, 27% against the cancer cell lines SF-295, Colon 502713, Colo-205, Hep-2, A-549, OVCAR-5, PC-5 respectively with the highest being 61% against human colon cancer cell lines. Flow cytometry analysis showed that the presence of terpinolene in cumin was able to reduce the rate of apoptosis and necrosis induced by the 24-hour aged HEWL fibrils in the PC12 cells, which are a type of cancer cell lines [20].

8. Future prospects

This review emphasizes the essential function that ayurvedic extracts, particularly jeeraka and shallaki have in inhibiting bacterial growth. However, more research is required to better understand the degree to which and how many more different plant-based extracts like these exhibit antibacterial properties, especially, in the context of the use of ayurvedic medicine to substitute traditional antibiotics. Future studies can investigate the effect of other ayurvedic medicine or individual ayurvedic medicine components on the growth of different bacteria and even of highly resistant bacteria. With much potential to transform the field of antibiotics, the future implications will be to replace ineffective antibiotics with ayurvedic medicine and potentially even integrate them with allopathic medicine to treat bacterial infections and diseases.

9. Conclusion

Ayurvedic extracts like Shallaki and Jeeraka as discussed above can act as effective substitutes to allopathic antibiotics against bacterial infections because of their antibacterial properties. Mechanisms of inhibition like disrupting the bacterial membranes and inhibiting biofilm formation are promising solutions to combat the growing problem of antibiotic resistance. Beyond this, the extracts discussed show additional health benefits such as addressing chronic illnesses because of antioxidant and anti-inflammatory properties. Although Ayurvedic principles are different from

allopathy, the lower costs and reduced number of side effects make Ayurvedic medicine a great option for affordable and quality healthcare solutions. Nonetheless, more research is needed to be conducted to identify other Ayurvedic antibacterial extracts and their degree of effectiveness.

Compliance with ethical standards

Disclosure of conflict of interest

The authors report no conflicts of interest in this work

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