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Exploring the Universe of Ayurvedic Botanicals to Manage Bacterial Infections

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ABSTRACT: *Bacteria are a natural, and necessary, part of life. These microscopic, single-cell entities abound on inanimate surfaces and on parts of the body that make contact with the outer world, including the skin, the mucous membranes, and the lining of the intestinal tract. While we live in harmony with most bacteria, and indeed rely upon many bacteria for their beneficial properties, certain pathogenic bacteria do give rise to serious, often deadly, diseases. Since the advent of the antibiotic era in the early 1940s with the clinical use of penicillin, an ever-growing arsenal of antibiotics has provided an effective therapy against major bacterial pathogens. However, the development of antibiotic resistance is now a serious worldwide problem, caused primarily by the misuse and overuse of antibiotics. We must broaden our view of how to prevent and treat microbial infections to include alternatives that are not centered upon standard antibiotic therapy or we risk the possibility of eventually having no defense against these microbes. The Ayurvedic approach to the prevention and treatment of microbial infection recognizes the emergency use of modern drugs, but recommends traditional herbal combinations and extracts known to balance the individual and improve health, as well as herbs that help to combat or prevent microbial infections. The Indian plants possessing significant anti-microbial activity are Indian lilac or neem (Azadirachta indica), long pepper fruit (Piper longum), heart-leaved moonseed stem (Tinospora cordifolia) and amla fruit (Emblica officinalis), among others.*

For the latter half of this century, many experts considered bacterial infectious diseases to be under complete therapeutic control owing to the effectiveness of antibiotics. However, the scientific community grossly underestimated the remarkable ability of these organisms, through mutations and genetic transfer, to develop resistance to antibiotics. Although it has been known for some time that bacteria can develop resistance to a particular antibiotic, there was always another drug in stock that would work. Unfortunately, that is no longer the case. With each passing decade, bacteria that defy not only single but multiple antibiotics have become increasingly common.[1,2] For example, certain strains of enterococci bacteria no longer respond to vancomycin—the drug of last resort that doctors thought could beat any bacterial infection.[2,3] Resistant strains of the tuberculosis bacilli are also widespread, causing alarming outbreaks of tuberculosis in the U.S. The same is true of salmonellae, a leading cause of food borne infections, and enterococci bacteria, which cause a host of complications in hospital patients. Hospital infections are a huge problem worldwide and are responsible for 70,000 deaths a year in the U.S. alone.[4]

DEVELOPMENT OF ANTIBIOTIC RESISTANCE

A number of factors contribute to antibiotic resistance including 1) misuse and overuse of antibiotics in humans, animals, and agriculture; 2) patients' demand for and receipt of antibiotics when they don't need them; and 3) failure to finish an antibiotic prescription.[2] Researchers at the Centers for Disease Control and Prevention (CDC) have estimated that some 50 million of the 150 million outpatient prescriptions for antibiotics every year are unneeded.[1] Current costs related to treatment of antibiotic resistant infections are estimated by the CDC to be more than $4 billion annually.[5]

Antibiotics typically retard bacterial proliferation by entering the microbes and interfering with the production of components needed to form new bacterial cells.[1,2] However, the use (and misuse) of antimicrobial agents encourages the evolution of bacteria toward resistance. Four major mechanisms mediate bacterial resistance to antibiotics: 1) bacteria may produce enzymes that degrade antibiotics or that chemically modify and inactivate the drugs; 2) bacteria may alter or replace molecules that are normally bound by an

antibiotic – changes that essentially eliminate the drug's targets in bacterial cells; 3) bacteria can eliminate entry ports for the drugs by altering permeability; or 4) bacteria may manufacture pumps that export antibiotics before the medicines have a chance to find their intracellular targets.[1,2]

Bacteria can acquire resistance genes through several routes. Many inherit the genes, while others spontaneously produce a new resistance trait or strengthen an existing one through genetic mutations, which occur readily in bacteria. And frequently, bacteria will gain a defense against an antibiotic by taking up resistance genes from other bacterial cells in the vicinity.[1,2] Antibiotics can select for – promote the survival and propagation of – antibiotic-resistant strains, increasing the reservoir of resistance traits in the bacterial population as a whole.[1] When these resistant bacteria arise in treated individuals, they spread readily in the environment and to new hosts.

Reversing and curbing the resistance problem lies in restoring the original microbial balance between susceptible and resistant bacteria. Reversal of resistance requires an awareness of the broad consequences of antibiotic use – a perspective that concerns itself not only with curing bacterial disease at the moment but also with preserving microbial communities in the long run, so that bacteria susceptible to antibiotics will always be there to outcompete resistant strains.[1]

AN AYURVEDIC APPROACH TO MICROBIAL INFECTIONS

Western allopathic medicine emphasizes the use of antibiotics and other medicines and approaches to defend against "germs" or microbes believed to be the primary cause of many health conditions and diseases. Ayurveda recognizes the microbial approach to some degree, but generally does not recognize microbes as the primary cause of disease. According to the Ayurvedic approach, anyone who has developed an imbalance in their bodily elements, or "doshas," and has thereby weakened their immune system, may be subject to a microbial infection which is considered a symptom of that imbalance. Ayurveda recognizes as useful anything that will save the patient in an emergency, including antibiotics, but takes exception to the "magic bullet" approach of preventing and treating microbial infections strictly with antibiotics. Ayurveda recommends that balance be established in the individual for the prevention and treatment of microbial infection.

From the Ayurvedic perspective, an individual who is balanced and healthy has a strong immune system and, therefore, it will be difficult for microbial infection to take hold. Balance in Ayurveda is equivalent to health, which is equivalent to a strong and well-functioning immune system capable of defending against microbial infection. The Ayurvedic approach is to treat the whole person,including application of correct diet, lifestyle recommendations, and herbal supplements. When a person develops an infection, the design of an Ayurvedic herbal formula reflects the holistic approach. Based on traditional use, herbs are selected and combined for their ability to inhibit microbial overgrowth in various parts of the body and support those organ systems responsible for detoxification and immune function.

The herbs listed below are traditionally used to manage cold, flu, and infection. The chemical composition of each of the following plants tends to confirm their traditional use. Interestingly, each herb appears to possess properties that work on multiple biochemical pathways capable of influencing several organ systems simultaneously. The ancient practice of combining and concentrating several plants by decoction (extracting together in boiling water) that have a similar yet slightly different organ system focus, produces a finished product that treats the whole person along with the presenting complaint.

Indian lilac or Neem (*Azadirachta indica*)

Used traditionally in Ayurveda both topically and internally for microbial infection including those infections related to the skin such as acne, fungi, wound healing, antiseptic treatment, oral hygiene, parasite infection, fevers, and general infections.[6] Oil is useful in leprosy, scrofulas, skin diseases, ulcers, and wounds.[7] Neem oil and two of its bitter principles, nimbidin and nimbidol, have exhibited antibacterial, antifungal, and spermicidal activity.[7]

A study done on chick embryo tissue cultures and the skin of rabbits and monkeys showed that a 10% water extract of the tender leaves of the neem tree possesses antiviral properties. It inhibited the vaccinia and variola viruses, with even a 1.25% solution showing an antiviral effect.[8]

Ginger rhizome (*Zingiber officinale*)

Used traditionally for colds, other microbial infections, and the removal of mucous and toxins associated with microbial infections.[6] Most well known use is as a carminative and stimulant to the gastrointestinal tract, and as a digestive aid.

Guggulu gum (*Commiphora mukul*)

Used traditionally in oral hygiene and skin diseases.[6] Acts as a bitter and carminative, stimulating the appetite and improving digestion.[6,7] The oleoresin portion of the plant causes an increase of leucocytes in the blood and stimulates phagocytosis.[6]

Indian madder root (*Rubia cordifolia*)

Used traditionally for uterine and urinary system conditions including infection.[6] Dried root acts as an emmenagogue, astringent, and diuretic.[7]

Amla fruit (*Emblica officinalis*)
Used traditionally for fevers and for balancing.[6] The fruit extract exhibits antibacterial and antiviral properties.[7]

Myrrh gum resin (*Commiphora myrrha*)
Traditionally used in Ayurveda for oral hygiene, parasite treatment, antiseptic action, and as a natural antibiotic.[6]

Boswellia gum resin (*Boswellia serrata*)
Used traditionally for urinary disorders including infections.[6]

Heart-leaved moonseed stem (*Tinospora cordifolia*)
Used traditionally for antitoxin action and as a febrifuge.[6] Also used for urinary diseases, syphilis, skin diseases, and bronchitis.[7] One study showed that an ethanolic extract of *T. cordifolia* appeared to improve the phagocytic activity of the reticuloendothelial system in mice.[9]

Another recent study analyzed 6 pure compounds isolated from *T. cordifolia* for their immunomodulatory activity.[10] The compounds syringin and cordiol inhibited the *in vitro* immunohaemolysis of antibody-coated erythrocytes due to inhibition of the C3-convertase of the classical complement pathway. All 6 compounds exhibited significant enhancement of IgG antibodies, with cordiol having the highest immunostimulating activity. The compounds cordioside, cordiofolioside, and cordiol induced a significant increase in phagocytic activity by activation of the peritoneal macrophages.

In an animal model of cholestasis, significant depression of activity of polymorphonuclear cells (PMN) and peritoneal macrophages was observed.[11] Treating the rats with a water extract of *T. cordifolia* for 7 days significantly improved phagocytic activity of macrophages and PMN. The mortality rate following induced *E. coli* infection was reduced from 77.78% to 16.67%.

Mineral pitch (silajit)
Used traditionally as an antiseptic and for general balancing and strengthening.[6]

Long pepper fruit (*Piper longum*)
Used traditionally for colds, other microbial infections, and the removal of mucous and toxins associated with microbial infections.[6] The essential oil of the fruit shows antibacterial, antifungal, and anthelmintic activity.[7] An ethanol extract of the *Piper longum* fruit showed antiamoebic activity both in vitro and in vivo, curing 90% of rats with caecal amoebiasis.[12]

An Ayurvedic herbal medicine prepared from *Piper longum* and *Butea monosperma* and prescribed for the treatment of chronic dysentery and worm infestations was tested for anti-giardial and immunostimulatory activity in mice infected with *Giardia lamblia* trophozoites.[13] The preparation produced up to 98% recovery from the infection and induced significant activation of macrophages as evidenced by increased macrophage migration index and phagocytic activity.

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