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Review on *Ocimum tenuiflorum* - A potential herb for drinking water disinfection

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ABSTRACT

Safe drinking water is essential for healthy living. Microbial unsafe water is still a major concern in most developing countries. Lack of clean water for use by rural communities in developing countries is of great concern globally. Contaminated water causes water-borne diseases such as diarrhea, which often lead to deaths, children being the most vulnerable. According to a recent reports nearly about 1 in 8 lack access to clean water. More than 3.5 million people die each year from water-related disease, 84% of which are children. Natural plant extracts have been used for water purification for many centuries. Most of these extracts are derived from the seeds, leaves, pieces of bark or sap, roots and fruit extracts of trees and plants. This study review explores the antimicrobial activity and traditional uses of *Ocimum tenuiflorum* and also suggests simple, economic, safe and effective alternative method to disinfect water at consumer end.

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Introduction

Water is essential for survival. It has been stated that our existence is "intimately connected with the quality of water available to us". According to F. Batmanghelidj MD, author of "Your Body's Many Cries for Water", "25% of the human body is made up of solid matter while the remaining 75% is water." Therefore, if our bodies are not continuously supplied with water, our bodies become dehydrated and the vital organs will deteriorate until they are no longer viable for human life[1].

Water has always played a prominent role in human civilization. When people first began settling in one place and growing crops for sustenance, it was invariably near water sources like rivers, lakes, or groundwater springs. Water was needed for drinking, preparing food, bathing, cleaning, irrigating crops, and a variety of other tasks, so it was important to have ready access to this resource. The water sources used for supplying water were not always clean however, and treating drinking water to improve smell, taste, clarity, or to remove disease-causing pathogens has occurred in one form or another throughout recorded history[2, 3].

Water-related diseases put an economic burden on both the household and the nation's economy. At household levels, the economic loss includes cost of treatment and wage loss during sickness. Loss of working days affects national productivity. On the other hand, the government spends a lot of money and time on treatment of the sick and providing other supportive services.

Provision of clean and safe water in rural areas is a great challenge for the developing countries of the world since most communities rely on poor traditional sources that often provide unsafe domestic water. Because of economic and political constraints, the universal provision of piped water is not currently - feasible. This circumstance leaves millions without access to safe drinking water[4]. It is estimated that world over, about 1.6 million people die every year from diarrheal diseases (including cholera) attributable to lack of access to safe drinking water and basic sanitation and 90% of these are children under 5, mostly in developing countries. Approximately 150 million people are infected with schistosomiasis causing thousands of deaths yearly; approximately 500 million people are at risk of trachoma from which 146 million are threatened by blindness and 6 million are visually impaired. Intestinal helminthes (*A. trichuriasis* and hookworm infection) are plaguing the developing Countries due to inadequate drinking water with 133 million suffering from high intensity intestinal Helminthes infections, there are around 1.5 million cases of clinical hepatitis every year.[4]

Drinking Water in Rural India

A vast rural Indian population is dependent on the supply of untreated water, despite of spending billions of rupees for water purification. Thus the rural population is thriving on the contaminated water supply which is the root cause of their ailments. Rural India has more than 700 million people residing in about 1.42 million habitations spread over 15 diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. The non-uniformity in level of awareness, socio-economic development, education, poverty, practices, rituals and water availability add to the complexity of the task. Despite an estimated total of Rs. 1,105 billions spent on providing safe drinking water since the First Five Year Plan was launched in 1951, lack of safe and secure drinking water continues to be a major hurdle and a national economic burden.[5]

As per estimates, the average expenditure of rural households on health services amounts to 5.28 per cent of their average annual income. This percentage can vary with population in different income groups but the important message that can be derived from these facts is that our rural households are forced to spend a significant amount of their earnings on health. According to Down to Earth, rural people in India spend at least Rs.100 each year for the treatment of water/sanitation-related diseases[6].

Microorganisms in Water

Although the epidemiological relation between water and disease had been suggested as early as the 1850s, it was not until the establishment of the germ theory of disease by Pasteur in the mid-1880s that water as a carrier of disease-producing organisms was understood. In the 1880s, while London experienced the "Broad Street Well" cholera epidemic, Dr. John Snow conducted his now famous epidemiological study. Dr. Snow concluded that the well had become contaminated by a visitor, with the disease, who had arrived in the vicinity. Cholera was one of the

first diseases to be recognized as capable of being waterborne. Also, this incident was probably the first reported disease epidemic attributed to direct recycling of non-disinfected water. Now, over 100 years later, the list of potential waterborne diseases due to pathogens is considerably larger, and includes bacterial, viral, and parasitic microorganisms respectively.

A major cause for the number of disease outbreaks in potable water is contamination of the distribution system from cross connections and back siphonage with non-potable water. However, outbreaks resulting from distribution system contamination are usually quickly contained and result in relatively few illnesses compared to contamination of the source water or a breakdown in the treatment system, which typically produce many cases of illnesses per incident. When considering the number of cases, the major causes of disease outbreaks are source water contamination and treatment deficiencies.[7] For example, in 1993 a Cryptosporidiosis outbreak affected over 400,000 people in Milwaukee, Wisconsin. The outbreak was associated with deterioration in the raw water quality and a simultaneous decrease in the effectiveness of the coagulation-filtration process.[8,9] Historically, about 46 percent of the outbreaks in the public water systems are found to be related to deficiencies in source water and treatment systems with 92 percent of the causes of illness due to these two particular problems.

All natural waters support biological communities. Because some microorganisms can be responsible for public health problems, biological characteristics of the source water are one of the most important parameters in water treatment. In addition to public health problems, microbiology can also affect the physical and chemical water quality and treatment plant operation. The major pathogenic organisms responsible for water borne diseases in India are bacteria (*Escherichia coli, Shigella, Vibrio cholera*), viruses (*Hepatitis A, Polio Virus, Rota Virus*) and parasites (*Entamoeba histolytica, Giardia, Hook worm*) [10].

Chlorine disinfection of drinking water

Chlorine is one of the most widely used disinfectants. It is very applicable and very effective for the deactivation of pathogenic microorganisms. Chlorine can be easily applied, measured and controlled. It is fairly persistent and relatively cheap. Chlorine has been used for number of applications, such as the deactivation of pathogens in drinking water, swimming pool water and wastewater, for the disinfection of household areas and for textile bleaching, for more than two hundred years.

Chlorine kills pathogens such as bacteria and viruses by breaking the chemical bonds in their molecules. Disinfectants that are used for this purpose consist of chlorine compounds which can exchange atoms with other compounds, such as enzymes in bacteria and other cells. When enzymes come in contact with chlorine, one or more of the hydrogen atoms in the molecule are replaced by chlorine. This causes the entire molecule to change shape or fall apart. When enzymes do not function properly, a cell or bacterium will die[11].

Disinfectants, Uses and Health Effects

Chloramine is a water additive used to control microbes, particularly as a residual disinfectant in distribution system pipes. It is formed when ammonia is added to water containing free chlorine. Monochloramine is one form of chloramines commonly used for disinfection of municipal water systems. Other chloramines (di- and tri-) are not intentionally used to disinfect drinking water and are generally not formed during the drinking water disinfection process. Some people who use water containing chloramine in excess of the maximum residual disinfectant level could experience irritating effects to their eyes and nose, stomach discomfort or anemia[12].

The gaseous or liquid form of chlorine is a water additive used by municipal water systems to control microbes. It is relatively inexpensive and has the lowest production and operating costs and longest history for large continuous disinfection operations. Chlorine is a powerful oxidant. Some people who use water containing chlorine well in excess of the maximum residual disinfectant level could experience irritating effects to their eyes and nose. Some people who drink water containing chlorine well in excess of the maximum residual disinfectant level could experience stomach discomfort. Chlorine dioxide is a water additive used to control microbes and can be used to control tastes and odors. It rapidly disappears from stored water. Some infants, young children, and fetuses of pregnant women who drink water containing chlorine dioxide in excess of the maximum residual disinfectant level could experience nervous system effects. Some people who drink water containing chlorine dioxide well

in excess of the MRDL for many years may experience anemia.

Disinfection Byproducts and Their Health Effects

Disinfection byproducts are formed when disinfectants used in water treatment plants react with bromide and/or natural organic matter (i.e., decaying vegetation) present in the source water. Different disinfectants produce different types or amounts of disinfection byproducts. Disinfection byproducts for which regulations have been established have been identified in drinking water, including trihalomethanes, haloacetic acids, bromate, and chlorite.

Trihalomethanes (THM) are a group of four chemicals that are formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. The trihalomethanes are chloroform, bromodichloromethane, dibromochloromethane, and bromoform. People who drink water containing total trihalomethanes in excess of the MCL over many years could experience liver, kidney, or central nervous system problems and increased risk of cancer[13].

Haloacetic Acids (HAA) are a group of chemicals that are formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. The regulated haloacetic acids, known as HAA, are: monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid. Some people who drink water containing haloacetic acids in excess of the MCL over many years may have an increased risk of getting cancer[14]. Bromate is a chemical that is formed when ozone used to disinfect drinking water reacts with naturally occurring bromide found in source water. Some people who drink water containing bromate in excess of the MCL over many years may have an increased risk of getting cancer. Chlorite is a byproduct formed when chlorine dioxide is used to disinfect water. Some infants and young children who drink water containing chlorite in excess of the MCL could experience nervous system effects. Similar effects may occur in fetuses of pregnant women who drink water containing chlorite in excess of the MCL. Some people may experience anemia[15].

Medicinal Plants

It is generally believed that around 25% of the active compounds used in modern medicines were derived from plants. At the same time, hardly 5000 of the over 2, 50,000 flowering plants have been looked at scientifically for their medicinal properties.[16] Plants are one of the most important sources of medicines. Today the large number of drugs in use are derived from plants, like morphine from *Papaver somniferum*, Aswagandha from *Withania somnifera*, Ephedrine from *Ephedra vulgaris*,[17] Atropine from *Atropa belladonna*, Reserpine from *Roulphia* serpentine, vincristine and vinblastine from *Catharanthusroseus*, etoposide from *Podophyllum* species[18], quinine from *Cinchona* Species, artemesinin from *Artemisia annua* for malaria, reserpine from *Rauwolfiaserpentina* for hypertension, digitoxin from *Digitalis* for heart ailments[19], Gingkolides from *Gingko biloba* for cerebral ischemia as sedative, Forskolin from *Coleus forskoli* for granuloma[20,21,22] etc. The medicinal plants are rich in secondary metabolites (which are potential sources of drugs) and essential oils of therapeutic importance. The important advantages claimed for therapeutic uses of medicinal plants in various ailments are their safety besides being economical, effective and their easy availability. In all the cases, the discovery of these new derivatives was made possible, only due to the fact that original plants had shown activity, even if it was low and hence was it was only a lead.

Tulsi (*Ocimum tenuiflorum)*

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Lamiales
Family: Lamiaceae
Genus: Ocimum
Species: *O. tenuiflorum*
Binomial name: *Ocimum tenuiflorum*

Ocimum tenuiflorum L. (Tulsi) is an erect, much branched sub-shrub 30- 60cm tall, with simple opposite green or purple leaves that are strongly scented and airy stems. Leaves have petiole and are ovate, up to 5cm long, usually somewhat toothed. Flowers are purplish in elongate racemes in close whorls. *Ocimum tenuiflorum* is native throughout the world tropics and widespread as a cultivated plant and an escaped weed. It is cultivated for

religious and medicinal purposes and for its essential oil[23, 24, 25].

Tulsi is commonly cultivated in gardens. Two types of *Ocimum tenuiflorum* L. are met within cultivation: (i) Tulsi plants with green leaves known as Sri Tulsi & (ii) Tulsi plants with purple leaves known as Krishna Tulsi.[26] *Ocimum tenuiflorum* L. is held sacred by Hindus and is used as medicinal plants in day to day practice in Indian homes for various ailments. It is widely known across South Asia as a medicinal plant and an herbal tea, commonly used in Ayurveda, and has an important role within the Vaishnavite tradition of Hinduism, in which devotees perform worship involving tulsi plants or leaves[27].

Traditional uses

Tulsi is also known as "the elixir of life" since it promotes longevity. Different parts of plant are used in Ayurveda and Siddha Systems of Medicine for prevention and cure of many illnesses and everyday ailments like common cold, headache, cough, flu, earache, fever, colic pain, sore throat, bronchitis, asthma, hepatic diseases, malaria fever, as an antidote for snake bite and scorpion sting, flatulence, migraine headaches, fatigue, skin diseases, wound, insomnia, arthritis, digestive disorders, night blindness, diarrhea and influenza. The leaves are good for nerves and to sharpen memory. Chewing of Tulsi leaves also cures ulcers and infections of mouth[28,29].

The leaves of tulsi contain 0.7% volatile oil comprising about 71% eugenol and 20% methyl eugenol. The oil also contains carvacrol and sesquiterpine hydrocarbon caryophyllene. Fresh leaves and stem extract yielded some phenolic compounds (antioxidants) such as cirsilineol, circimaritin, isothymusin, apigenin and rosameric acid, and appreciable quantities of eugenol. Two flavonoids, viz., orientin and vicenin from aqueous leaf extract of tulsi have been isolated. Ursolic acid, apigenin, luteolin, apigenin-7-O-glucuronide, luteolin-7-O glucuronide, orientin and molludistin have also been isolated from the leaf extract. It also contains a number of sesquiterpenes and monoterpenes viz., bornyl acetate, -elemene, neral, - and -pinenes, camphene, campesterol, cholesterol, stigmasterol and-sitosterol[30, 31, 32].

The anticancer activity of *Ocimum tenuiflorum* has been proved and cited by several investigators. The alcoholic extract of leaves has a modulatory influence on carcinogen metabolizing enzymes such as cytochrome P 450, cytochrome b5, aryl hydrocarbon hydroxylase and glutathione S-transferase (GST), which are important in detoxification of carcinogens and mutagens[33, 34, 35]. The radioprotective effect of *Ocimum tenuiflorum* was firstly reported in the year 1995. Two isolated flavonoids, viz., orientin and vicenin from leaves showed better radioprotective effect as compared with synthetic radioprotectors.[36] The antioxidant properties of flavonoids and their relation to membrane protection have been observed. Antioxidant activity of the flavonoids (orientin and vicenin) in vivo was expressed in a significant reduction in the radiation induced lipid peroxidation in mouse liver. [37]The transient cerebral ischemia and long term cerebral hypoperfusion (causing cellular edema, gliosis and perivascular inflammatory infiltrate) have been prevented by *Ocimum tenuiflorum* proved its antihypertensive and cardioprotective activities:. The fixed oil administered intravenously produced hypotensive effect in anaesthetized dog, which seems to be due to its peripheral vasodilatory action. Essential fatty acids like linoleic and linolenic acids, contained in the oil produce series 1 and 3 (PGE1 and PGE3) prostglandins and inhibit the formation of series 2 prostglandins (PGE2)[38].

Methanolic extract and aqueous suspension of tulsi showed analgesic, antipyretic and anti-inflammatory effects in acute (carrageenan-induced pedal oedema) and chronic (croton oil induced granuloma and exudate formation) inflammations in rats. The antipyretic activity of *Ocimum tenuiflorum* fixed oil was evaluated by testing it against typhoid-paratyphoid A/B vaccine-induced pyrexia in rats. The oil on ip administration considerably reduced the febrile response indicating its antipyretic activity[39]. The extract of dried whole plant of *Ocimum tenuiflorum* ameliorated the amnesic effect of scopolamine (0.4 mg/kg) and aging-induced memory deficits in mice. Passive avoidance paradigm served as the exteroceptive behavioural model[40].

Oral administration of hydroethanolic extract of *Ocimum tenuiflorum* leaves @ 200 mg/kg in male Wistar albino rats gave protection against liver injury induced by paracetamol.[41]The fixed oil of *Ocimum tenuiflorum* administered intraperitoneally elicited significant antiulcer activity against aspirin, indomethacin, alcohol (ethanol 50%), histamine, reserpine, serotonin or stress-induced ulcers in rats.[42]The antiarthritic activity of *Ocimum tenuiflorum* fixed oil was evaluated against

formaldehyde-induced arthritis in rats. The fixed oil significantly reduced the diameter of inflamed paw.[43] Aqueous extracts of fresh leaves delayed the process of cataractogenesis in experimental models of cataract (galactosemic cataract in rats by 30% galactose and naphthalene cataract in rabbits by 1 g/kg naphthalene)[44].

Antimicrobial activity of *Ocimum tenuiflorum*

Being the most commonly used medicinal plant in Indian household its antibacterial activities have been studied against common pathogens. The essential oil from the leaves of Tulsi exhibited some inhibitory effect against *E. coli, B. anthracis, B. subtilis, Sal. newport, Sal pullorum, Staph. aureus, P. vulgaris* and *P. aeruginosa*[45], *Mycobacterium tuberculsosis, Arthobacter globiformis, B. megatherium, E. coli* and *Pseudomonas* [46,47,48, 49], *E. coli, Klebsiella aerogens, Proteus mirabilis, Salmonella typhimurium, Shigella dysentriae, Pseudomonas aeruginosa, Vibrio cholerae* and *Staphylococcus aureus*[50] , *Pasturella multocida, E. coli, Bacillus subtilis* and *Staphlocuccus aureus*[51] , *Salmonella typhi, Salmonella paratyphi A* and *Salmonella typhimurium* [52,53,54] and *E. coli, Klebsiella spp., Bacillus cerus, Bacillus subtilis, Staphylococcus aureus* [55].

Aqueous extract of *Ocimum tenuiflorum,* showed growth inhibition for *Klesbiella, E. coli, Proteus* and *Staphylococcus aureus*; while alcoholic extract of *Ocimum tenuiflorum,* showed growth inhibition for Vibrio *cholera*e. Ethanol extract exhibited significant antimicrobial activities against some of the clinical isolates and multi-drug resistant *Neisseria gonorrhoeae*[56, 57]. The ethanolic extracts have ability to inhibit clinical isolates of beta lactamase producing methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin–sensitive *Staphylococcus aureus* [MSSA] [58].The ethanol extract of *Ocimum tenuiflorum* was found to be active against *Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Bacillus thuringiensis, Shigella dysentriae, Klebsiella pneumonia, Salmonella typhi* at a minimum bactericidal concentration of 5 to 10 mg /mL[59].

Ayurvedic preparation containing *Ocimum tenuiflorum* L., *Allium stivum, Piper nigram* and *Curcuma longa* has been shown to possess antimalarial activity against *Plasmodium vivex* and *Plasmodium falciparum*. A decoction of the root of Tulsi plant is given as a diaphoretic in malarial fever. As far as its antimalarial effect is concerned Tulsi extracts and essential oil have also been found to possess insecticidal and larvicidal activities against mosquitoes. Tulsi also has anti-tubercular activity and inhibits in-vitro growth of *M. tuberculosis*[60].

The essential oils of *Tulsi* have been effective against both Gram positive and Gram-negative bacteria.[61,62] Antimicrobial activity of *Ocimum tenuiflorum* was found to be higher as compared to commonly available other species of *Ocimum* (*i.e. O. canum, O. gratissimum, O. basilicum*) in India more so, aqueous extract, alcoholic extract and seed oil of *Tulsi* shown antimicrobial properties against enteric pathogens[63,64] .

Essential oil of *Ocimum tenuiflorum* reported to have shown antimicrobial activity against *Propionibacterium acnes* in *in-vitro* study and minimum inhibitory concentration (MIC) value found to be 3.0% v/v[65]. Fresh leaves essential oil had shown more antibacterial properties compared to dried leaves essential oil of *Tulsi* and in case of fungus the property is just the reverse[66].

The essential oil obtained by steam distillation from air dried basil leaves showed antibacterial activity against resistant clinical isolates from the genera *Staphylococcus, Enterococcus* and *Pseudomonas*. The minimum inhibitory concentrations (MICs) were reported between 0.0030% and 0.0007% (v/v).[67] Basil, the essential oil is shown to have an inhibitory effect on *Aspergillus ochraceus* [68,69].

The Ocimum oil is also active against several species of bacteria (*Listeria monocytogenes, Escherichia coli, Shigella, Salmonella* and *Proteus*) and fungi *Trichophyton rubrum, T. mentagrophytes. Cryptococcus neoformans, Penicillum islandicum,* and *C. albicans*[70,71,72,73,74].

Simple, Low-Cost Water treatment using herbals

Once contamination is detected in a water source, there is need for treatment. In case of rural areas, modern water purification technologies might not be viable. In villages, it is important that simple technologies that are easy to use and can be operated without much technical know-how be promoted. The price factor is also important as technologies with high operational and recurring costs might not be useful. In India, one cannot neglect the use of traditional methods of water purification. The use of traditional methods, however, should not be publicized

unless its effectiveness has been proved through appropriate research.

In both the oral and written traditions, knowledge of alternative methods of water treatment is still available.[75] Principal among them are the Charaka Samhita and Sushruta samhita (300 A.D.) which are the foundations of the Ayurveda, the Indian system of natural healing. According to Shiva the Sushruta samhita lists seven modes of purifying water. The wood of Amla (*Phyllanthus emblica*) is used to clear small rain ponds in the Indian peninsula. Tulsi (*Ocimum sanctum*) is a water purifier with antibacterial and insecticidal properties. Drumstick tree (*Moringa oleifera*) is called the clarifier tree produces seeds, which are used for water purification. Seeds of honge (*Pongamia glabra*) and nuts of Nirmali tree (*Strychnos potatorum*) are used as water clarifiers. This is virtually cost less way to render contaminated water fit for human consumption[76].

Conclusion

The wealth of India is stored in the enormous natural flora which has been gifted to her, endowed with a wide diversity of agro-climatic conditions. In rural areas bacterial contamination of water could be due to poor sanitary conditions around water sources, improper drainage facilities near hand pumps and bore wells and located cattle sheds and latrine soak pits. The significant increase in bacterial contamination has been found between collection at water sources and eventual use. The tentative findings of researchers' show that Tulsi seem to exert germicidal effects. Water treated with Tulsi gives a pleasant taste as well. The effective antimicrobial activity of this plant is due to the synergistic effect of the active components present in the plant parts.

This review supports the traditional knowledge and the use of plants for water disinfection for sustainable use of such plant resources. Awareness of local community should be enhanced incorporating the traditional knowledge with scientific findings. In conclusion, the results support the usage of the medicinal plants and suggest that plant extracts possess compounds with antimicrobial properties that can be further explored for antimicrobial activity. This study review suggests simple economic, safe and effective alternative method to disinfect water at consumer end.

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See more ideas about Plants, Ocimum tenuiflorum, Healing herbs.Â Book Review: Dandelion Hunter by Rebecca Lerner - East West School of Planetary Herbology. With an overly stuffed plateful of responsibilities sandwiched between a week-long seminar of East West students and a month-long trip for which to prepare, I had no business reading a book. But when Pictures Of The Week Weird Pictures Animal Pictures Srinagar Baby Chickens Easter Chickens Palm Sunday Easter Weekend Holy Week. Ocimum tenuiflorum (synonym Ocimum sanctum), commonly known as holy basil or tulsi, is an aromatic perennial plant in the family Lamiaceae. It is native to the Indian subcontinent and widespread as a cultivated plant throughout the Southeast Asian tropics. Tulsi is cultivated for religious and traditional medicine purposes, and for its essential oil. It is widely used as a herbal tea, commonly used in Ayurveda, and has a place within the Vaishnava tradition of Hinduism, in which devotees perform Ocimum tenuiflorum Tulasi Scientific classification Kingdom: Plantae Division: Magnoliophyta Class: Magnoliopsida Order: Lamiales Family: Lamiaceae GenusÂ Ocimum tenuiflorum. Tulasi. Scientific classification.Â Tulasi has also been known for thousands of years as a prime herb in Ayurvedic treatment, for its diverse healing properties. It is mentioned by Charaka in the Charaka Samhita, the central teaching of Ayurvedic medicine, and in the Rigveda. Tulasi is considered to be an adaptogen, balancing different processes in the body, and helpful for adapting to stress. [4] Marked by its strong aroma and astringent taste, it is regarded as a kind of "elixir of life" and believed to promote longevity. Tulasi as an Ayurvedic medicine.