

**ROLE OF BOTANICALS AS ANTIMICROBIAL AGENTS IN MANAGEMENT OF DENTAL INFECTIONS – A REVIEW.****DHINAHAR.S ¹ AND LAKSHMI.T *²**

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ABSTRACT

Streptococcus mutans is the most common cariogenic bacteria associated with dental caries. It is believed to be the chief etiologic agent in human dental caries. On the other hand *Enterococcus faecalis*, a gram positive cocci is associated with primary endodontic infections and persistent infections, asymptomatic chronic periradicular lesions and is responsible for the failure of root canal treatment cases. In recent years the use of and search for drugs and dietary supplements derived from botanicals have been accelerated in dental practice. Ethnopharmacologists, botanists, microbiologists, and natural-products chemists are combing the Earth for botanicals and "leads" which could be developed for treatment of infectious diseases. Traditional healers have long used botanicals to prevent or cure infectious diseases. Botanicals are rich in a wide variety of secondary metabolites, such as tannins, terpenoids, alkaloids, & flavonoids, which have been found in vitro to have antimicrobial properties. Hence this review attempts to summarize the current status of botanicals like *Acacia Catechu*, *Allium sativum*, *Azadirachta indica*, *Syzygium Aromaticum* and *Tea tree oil* as potential anti microbial agents used in the management of Dental infections caused by *Streptococcus mutans* and *Enterococcus faecalis*.



KEY WORDS

Streptococcus mutans , *Enterococcus faecalis* ,Dental infections, Botanicals ,Remedy.

INTRODUCTION

Oral diseases impact our quality of life and may lead to systemic and threatening diseases. The relationship between the high incidence of oral diseases and microorganisms is well known. Because of the increased bacterial resistance to antibiotics, toxic and harmful effects of few common antibacterial agents, there is a continuous need for alternative therapies which are affordable, not toxic and effective, such as Botanicals^{1,2} Alternative medicine is commonly included in therapeutic and diagnostic disciplines outside the conventional health system³. In developing countries, access to dental healthcare is restricted and expensive and thus it is limited to emergency dental care procedures⁴. Dental caries is one of the most common infections of all oral diseases. It is proved that cariogenic microorganisms, especially *S. mutans* plays an essential role in the pathogenesis of dental caries. It is involved in the initiation of almost all carious lesions in enamel⁵. The main cause of dental caries was attributed to oral biofilm, also known as dental plaque, a film of microorganisms sticking to the tooth surface⁶. *Streptococcus mutans* has the ability to metabolize dietary sucrose and synthesize glucan by cell surface and extracellular glucosyl transferase. This glucan is an insoluble sticky or slimy gel relatively inert and resistant to bacterial hydrolytic enzymes which causes plaque to adhere tenaciously to tooth surfaces⁷. *Streptococcus mutans* and other organisms in the plaque produce organic acids such as lactic acid that gradually destroy the enamel to form a cavity⁸.

E. faecalis, a gram positive cocci is associated with various periradicular diseases including primary endodontic infections, persistent infections and asymptomatic chronic periradicular lesions. *E. Faecalis* is responsible for failed root canal treatment cases and is

resistant to calcium hydroxide due to its proton pump⁹.

E faecalis can also survive by genetic polymorphism and its ability to bind to dentin, invade dentinal tubules, and survive starvation. The most effective method to eradicate *E faecalis* is the use of sodium hypochlorite and 2% chlorhexidine⁹.

Sodium hypochlorite is extremely toxic to periapical tissues if injected beyond apex¹⁰. Presence of inflammatory exudate and killed micro organisms can inhibit the action of chlorhexidine in root canals¹¹. Studies have shown that the combination of NaOCl and chlorhexidine can form para-chloroaniline , a product which is potentially carcinogenic and occludes dentinal tubules¹². Various botanicals have been reported to inhibit the growth of several oral microorganisms particularly *Streptococcus mutans* and thus prevent caries. The need for affordable, effective, and non toxic alternatives has led to the search for compounds from natural sources such as plants¹³, which may overcome the high incidence of oral diseases .A few recent studies have focused on the antimicrobial activity against selected oral pathogens from natural sources. Chemical agents such as fluoride and chlorhexidine, which have been used to prevent dental caries for several decades, were associated with some side effects such as staining of teeth and fluorosis. Thus, there is no perfect antimicrobial agent to prevent dental caries until now. The use of natural products has been one of the most successful strategies for the discovery of new drugs¹⁴. Natural products have been used for thousands of years in folk medicine and they are believed to be the new source of antimicrobial agents¹⁵. Hence our review updates the efficacy of botanicals like *Acacia Catechu* ,*Allium sativum*, *Azadirachta indica*, *Syzygium Aromaticum* and

Melaleuca alternifolia, which possess potent antimicrobial properties and are used against the *Streptococcus mutans* and *Enterococcus faecalis* for the management of dental infections.

ETHNO PHARMACOLOGY:

ACACIA CATECHU WILLD :

Acacia catechu Willd. (Family: Fabaceae and subfamily: Mimosoideae.) is widely used in Ayurveda for many diseases and mainly for skin diseases¹⁶ Most of the people in Kerala use boiled Khadira water (karingali water) for drinking purpose. There are a number of ayurvedic taila (oil) formulations which contain Khadira as one of the active ingredients¹⁷. *Acacia catechu* is highly valuable for its powerful astringent and antioxidant activities. It is commonly known as Katha which is an indispensable ingredient of Pan that is beetle leaf preparation chewed in India. It is useful in dental, oral, throat infections and as an astringent for reducing oozing from chronic ulcers and wounds. The concentrated aqueous

extract known as Khair gum or cutch is an astringent, that has cooling and digestive benefits. It is beneficial in cough and diarrhea, applied externally to ulcer, boils and skin eruptions and is used extensively in Ayurvedic formulations¹⁸. The extracts of *Acacia catechu* exhibits various pharmacological effects like antipyretic, anti-inflammatory, antidiarrhoeal, hypoglycaemic, hepatoprotective, antioxidant and antimicrobial activities^{19, 20-25}. Main chemical constituents of *Acacia catechu willd* are catechin, (-) epicatechin, epigallocatechin, epicatechin gallate, epigallocatechin gallate, rocatechin, phloroglucin, protocatechuic acid, quercetin, poriferasterol glucosides, poriferasterol acylglucosides, lupenone, lupeol, procyanidin AC, kaempferol, dihydrokaempferol, taxifolin, (+)-afzelchin gum and mineral^{19,26-31}. The chief phytoconstituents of the heartwood are catechin and epicatechin. Catechins have significant antioxidant and antimicrobial effects³². It is considered to be the best antioxidant. *Acacia catechu* is useful as a topical agent for sore gums and mouth ulcers.



Figure 1
Acacia catechu willd.

ANTI MICROBIAL ACTIVITY OF ACACIA CATECHU WILLD

Acacia catechu heartwood extract is found to be an effective antibacterial agent. A study conducted in ethanolic and aqueous heartwood extract of acacia catechu, proved its efficacy as a potent anti bacterial agent. Taxifolin present in heartwood of *Acacia*

catechu is found to be responsible for its Anti bacterial effect.³³

Similar study was conducted to evaluate the potency of *Acacia catechu* heartwood extract on dental caries causing microbes and organism associated with endodontic infections like *streptococcus mutans*, *streptococcus*



salivarius, *Lactobacillus acidophilus* and *enterococcus faecalis* using disc diffusion method, MIC and MBC.³⁴

Dental caries is a microbial disease that results in destruction of mineralised tissues in the teeth. *Streptococcus mutans* and *Lactobacillus acidophilus* are potent initiators for Dental caries worldwide. Hence our study shows that *Acacia catechu* heartwood extract is highly active on oral pathogens and can be applied in Dental practice in the field of periodontics to treat dental caries, gingivitis, mouth sores and Endodontics to treat *Enterococcus faecalis* which is found in infected root canal possibly causing failure in root canal treatment³⁵.

Pawar *et al* in his study explained a dentifrice / herbal tooth powder which was comprised *Acacia catechu*, Menthol and camphor in the proportion 91%, 2.7% and 6.3% respectively. The powder of *Acacia catechu* was used to remove tartar, plaque, stain and in cleansing and polishing tooth surface without producing any abrasion whereas menthol and camphor were used as flavouring agents. A clinical study on this herbal dentifrice, reported 87-95%, 70-72% and 80-95% reductions in plaque, gingivitis and dental calculus respectively, in about 15 days of treatment³⁶.

Katha, which is used as a chewing ingredient, is a resin part of *Acacia catechu* (L.f.) Willd. (Leguminosae). The Antimicrobial screening and phytochemical analysis were performed to prove the antibacterial property and the presence of active phytochemicals in extracts of *Acacia catechu*. The agar diffusion method was selected to check the antimicrobial activity. A phytochemical analysis was done using a HPTLC instrument. Antimicrobial testing demonstrated excellent results with the petroleum ether extract against *Pseudomonas aeruginosa* (10 µg/mL), followed by the aqueous extract against *Bacillus subtilis* (20 µg/mL) and the chloroform extract against *Staphylococcus aureus* (30 µg/mL). Two major

phytochemical constituents, epicatechin and quercetin, were identified by HPTLC as active ingredients in the extract.³⁷

Gulzar *et al* also has conducted a similar study on Preliminary phytochemical and antimicrobial activity of the crude extract obtained from the leaves of *Acacia catechu* (AC.). The presence of carbohydrates, steroids, alkaloids, glycosides, tannins, saponins, flavones and phenolic compounds was indicated by the tests conducted. Antimicrobial activity of petroleum ether, ethanolic and ethanol: water (1:1) extracts of leaves of *Acacia catechu* was evaluated against some pathogenic fungi and gram positive and negative bacteria. Ethanolic extract was found to possess the broadest and potent antimicrobial activity.³⁸

Hence, with all these literature review *Acacia catechu willd* is proved to be a potent Antimicrobial agent against Dental infections like Dental caries caused primarily by *Streptococcus mutans*.

ALLIUM SATIVUM:

Allium sativum, commonly known as garlic, is a species in the onion genus, *Allium*. It has been used throughout its history for both culinary and medicinal purposes. The garlic plant's bulb is the most commonly used part. Garlic cloves are used for consumption or for medicinal purposes. *In vitro* studies indicate that garlic has been found to have antibacterial, antiviral, and antifungal activity. *Allium sativum* has been found to reduce platelet aggregation³⁹ and hyperlipidemia.⁴⁰ It is also an anti-diabetic agent.⁴¹

When crushed, *Allium sativum* yields allicin, an antibiotic⁴² and antifungal compound (phytoncide). It has been claimed that it can be used as a home remedy to help speed recovery from sore throat or other minor ailments because of its antibiotic properties. It also contains the sulfur-containing compounds alliin, ajoene, diallylsulfide, dithiin, S-allylcysteine, and enzymes, B vitamins, proteins, minerals,

saponins, flavonoids, and Maillard reaction products, which are not sulfur-containing compounds. Furthermore, a phytoalexin (allixin) was found, a nonsulfur compound with a γ -pyrone skeleton structure with antioxidant, antimicrobial effects,⁴³ antitumor promoting effects, inhibition of aflatoxin B2 DNA binding,⁴⁴ and neurotrophic effects.

Garlic possess diaphoretic, expectorant, antispasmodic, antiseptic, bacteriostatic, antiviral, antihelminthic and hypotensive effects; it is commonly used to treat chronic bronchitis, recurrent upper respiratory tract infections and

influenza.⁴⁵ In Europe and India, garlic remedies are used to treat coughs, colds, hay fever and asthma. Many modern herbalists and folk healers still rely on garlic oil ear drops to heal the pain of a child's ear infection.

The German Commission E recommends garlic as a supportive dietary measure to lower elevated blood lipids and as a preventive measure for age-dependent vascular changes; it does not note any contraindications.⁴⁶



Fig 2
Allium sativum

ANTI MICROBIAL ACTIVITY OF ALLIUM SATIVUM

The main active component of garlic is allicin. It is antibacterial and has immune regulatory functions. Allicin destroys cell wall and cell membrane of root canal bacteria⁴⁷.

This is used as irrigant alternative to NaOCl. Garlic extract inhibits the growth of oral pathogens like *streptococcus mutans* and *porphyromonas gingivalis* hence used for management of dental infections like periodontitis⁴⁸.

Despite of its antibacterial function, garlic extract also increases biofilm formation by *S.mutans* to orthodontic wire, likely through upregulation of glucosyltransferase expression. Garlic extract also plays an important role in increased bacterial attachment to orthodontic wires.⁴⁹

Aqueous extracts of garlic (*Allium sativum*) and onion (*Allium cepa*) were tested for activity against Gram-positive organisms, Gram-negative organisms and fungi. A significant growth inhibition is shown by most of the organisms. A quantitative assessment of the activity was carried out by determining the minimum bacteriostatic and bactericidal concentrations of the extracts against Gram-positive and Gram-negative organisms. Garlic extract showed greater activity as compared to the extract of onion. The activity of the garlic extract on the mouth flora of volunteers was then investigated. A mouth wash containing 10% garlic in quarter Ringer solution produced a drastic reduction in the number of oral bacteria.⁵⁰

AZADIRACHTA INDICA:

Azadirachta Indica commonly known as Neem is an evergreen tree, cultivated in several parts of the Indian subcontinent. Every part of the tree is used as traditional medicine for household remedy against various human ailments, from ancient period⁵¹⁻⁵⁶. Neem has been extensively used in ayurveda, unani and homoeopathic medicine and has become a cynosure of modern medicine. Nimbidin, a major crude bitter principle extracted from the oil of seed kernels of *A. indica* demonstrated several biological activities. Few tetranortriterpenes, including nimbin, nimbinin, nimbidinin, nimbolide and nimbidic acid have been isolated^{57,58}. Nimbidin and sodium nimbidate possess significant anti-inflammatory activity against carrageen induced acute paw oedema in rats and formalin-induced arthritis^{59,60}. Antipyretic activity has also been reported and confirmed in nimbidin⁶¹. Oral administration of nimbidin demonstrated significant Anti hypoglycaemic effect in fasting rabbits⁶²

A significant anti ulcer effect was observed with nimbidin in preventing acetylsalicylic acid, indomethacin, stress or serotonin-induced gastric lesions as well as histamine induced duodenal ulcers.^{63,64} Gedunin, isolated from neem seed oil, has been reported to possess both antifungal⁶⁵ and anti malarial⁶⁶ activities.

Studies indicates that Neem leaf extract possess anti arrhythmic⁶⁷, anti arthritic⁶⁸, anti viral,⁶⁹ anti oxidant⁷⁰ Hepato protective activity⁷¹ anti diabetic activity⁷² anti ulcer activity⁷³, anti malarial⁷⁴ and antifungal⁷⁵, anti carcinogenic activity.⁷⁶

Neem leaves, seeds and bark possess a wide spectrum of antibacterial action against Gram-negative and Gram-positive microorganisms, including *M. tuberculosis* and streptomycinresistant strains⁷⁷. *In vitro*, it inhibits *Vibrio cholerae*, *Klebsiella pneumoniae*, *M. tuberculosis* and *M. pyogenes*⁷⁸. Antimicrobial effects of neem extract have been demonstrated against *Streptococcus mutans* and *S. faecalis*⁷⁹. Studies show that Neem leaf extract is used to treat dental plaque and gingivitis⁸⁰.



Fig 3
Azadirachta indica

ANTI MICROBIAL ACTIVITY OF AZADIRACHTA INDICA:

Prashanth *et al* conducted a study to evaluate the antimicrobial effects of the chewing sticks of Neem and mango against the micro organisms like *Streptococcus mutans*

, *Streptococcus salivarius*, *Streptococcus mitis*, *Streptococcus sanguis* which are involved in the development of dental caries. An additional objective of his study was to identify an inexpensive, simple, and effective method of preventing and controlling dental caries. The



sticks were sun dried, ground into a coarse powder, and weighed into 5 gm, 10 gm, and 50 gm amounts. These were added to 100 ml of deionized distilled water. After soaking for 48 h at 4 degrees C, the water was filtered. The filtrate was inoculated onto blood agar plates containing individual species of micro organisms and incubated at 37 degrees C for 48 h. In conclusion, Mango extract, at 50% concentration, showed maximum zone of inhibition on *Streptococcus mitis*. Neem extract produced the maximum zone of inhibition on *Streptococcus mutans* at 50% concentration. Even at 5% concentration, neem extract showed some inhibition of growth for all the four species of organisms. Hence combination of neem and mango chewing sticks may provide the maximum benefit to mankind to prevent dental caries.⁸¹

Venka A *et al* conducted a study related to the antibacterial effect of Neem mouthwash against salivary levels of *streptococcus mutans* and *Lactobacillus Acidophilus*. It has been tested over a period of 2 months. Also its effect in reversing incipient carious lesions was assessed. He found that *streptococcus mutans* was inhibited by Neem mouthwashes, with or without alcohol as well as chlorhexidine; *lactobacillus* growth was inhibited by chlorhexidine alone. The initial data appears to prove its effect in inhibiting *S. mutans* and reversing incipient carious lesions, longer term clinical trials are essential⁸².

Neem has been proved to be effective against *E-faecalis* and *candida albicans*. Its antioxidant and antimicrobial properties makes it a potential agent for root canal irrigation as an alternative to sodium hypochlorite⁸³.

SYZYGIUM AROMATICUM:

Syzygium aromaticum commonly known as Clove which belongs to the family Myrtaceae. Cloves are native to Indonesia and used as a spice in cuisines all over the world. Cloves are used in Indian Ayurvedic medicine, Chinese medicine, and western herbalism and dentistry, where the essential oil is used as an anodyne for dental emergencies. Cloves are

used as a carminative, to increase hydrochloric acid in the stomach and to improve peristalsis. Cloves are also said to be a natural anthelmintic.⁸⁴ The essential oil is used in aromatherapy when stimulation and warming are needed, especially for digestive problems. Topical application over the stomach or abdomen are said to warm the digestive tract. Clove oil, applied to a cavity in a decayed tooth, also relieves toothache.⁸⁵ It also helps to decrease infection in the teeth due to its antiseptic properties. Eugenol comprises 72-90% of the essential oil extracted from cloves, and is the compound most responsible for the cloves' aroma. Other important essential oil constituents of clove oil include acetyl eugenol, beta-caryophyllene and vanillin; crategolic acid; tannins, gallotannic acid, methyl salicylate; the flavonoids eugenin, kaempferol, rhamnetin, and eugenitin; triterpenoids like oleanolic acid, stigmasterol and campesterol; and several sesquiterpenes.⁸⁶

Clove is an evergreen tree, which produces a flower bud that has numerous medicinal properties. It is often referred as clove bud. Clove bud has a shaft and a head and hence it has the Latin name *clavus* meaning nail. Clove was extensively used in the ancient Indian and Chinese civilizations and it spread to other parts of the world, including Clove is rich in minerals such as calcium, hydrochloric acid, iron, phosphorus, sodium, potassium, and vitamin A and vitamin C.⁸⁷

Oil of cloves, also known as clove oil, is an essential oil from the clove plant, *Syzygium aromaticum*. CAS number: 8000-34-8. It is a natural analgaesic and antiseptic used primarily in dentistry for its main ingredient eugenol. It can also be purchased in pharmacies over the counter, as a home remedy for dental pain relief, mainly toothache; it is also often found in the aromatherapy section of health food stores. The oil produced by cloves can be used in many things from flavouring medicine to remedies for bronchitis, the common cold, cough, fever, and sore throat infections. Oil of cloves is known best for its anaesthetic properties. It is widely reported to be effective,

and prior to the availability of anaesthetic drugs, was used by some dentists.

Clove oil is often used to relieve pain caused by dry socket, a possible complication of tooth extraction. When applied to stop a toothache, a cotton swab - applied directly to the infection site - or a very small piece of oil-soaked tissue paper is placed directly on or in

the tooth, to allow for the oil to absorb into the affected area.⁸⁸ Clove oil has antimicrobial and antifungal uses. It can be used for acne, warts, scars and parasites. Laboratory research published in 2009 demonstrated that it exhibits significant activity against *Propionibacterium acnes*, the major skin bacterium causing acne.⁸⁹



Fig 4
Syzygium aromaticum

ANTI MICROBIAL ACTIVITY OF SYZYGIUM AROMATICUM:

Cloves reduce infection and relieve pain. Clove oil is commonly used for the relief of toothache. In dentistry, clove oil is applied in an undiluted form using a plug of cottonwool soaked in the oil and applied to the cavity of the tooth.⁹⁰

Cai *et al.* reported preferential activity of crude methanolic extract of clove against Gram-negative anaerobic oral pathogens which cause periodontal diseases.⁹¹ This study included isolation of eight active constituents. The antibacterial effects of these isolated compounds were studied. The authors reported kaempferol and myricetin to have significant growth inhibitory effect against periodontal pathogens.

Dulin *et al.* explained the use of a natural plant herb, herbal extract or essential oils like eucalyptus oil and clove oil either alone or in combination with an anti-microbial compound, a fluoride ion-providing compound, analgesic,

enzyme etc. The composition was formulated in the form of a liquid or a gel which moistened a single-use disposable sterile cotton roll to be received in a buccal vestibule. The system was therapeutically effective in treatment of periodontal diseases on topical administration.⁹²

The antimicrobial activity of clove and clove bud oil were investigated by agar well diffusion method against five dental caries causing microorganisms namely *Streptococcus mutans*, *Staphylococcus aureus*, *Lactobacillus acidophilus* (bacteria), *Candida albicans* and *Saccharomyces cerevisiae* (yeast). The results indicated that clove and clove oil have a potent antimicrobial activity against the tested dental caries causing microorganisms. The highest antimicrobial activity of clove was found against *Saccharomyces cerevisiae* (25.32mm) in methanolic extract and an MIC of 50mg/ml and that of clove oil was found against *Streptococcus mutans* (34.32mm) with a MIC value of 3.125mg/ml. This study has shown the

importance of clove and clove oil and indicated that clove and clove bud oil can be used as an antimicrobial agent to cure dental caries.⁹³

Choi ung kyu conducted a study to find the optimum extraction condition of Gold-Thread for antibacterial activity against *Streptococcus mutans* using The evolutionary operation factorial design technique. Higher antibacterial activity was achieved in a higher extraction temperature ($R^2=-0.79$) and in a longer extraction time ($R^2=-0.71$). Antibacterial activity was not affected by differentiation of the ethanol concentration in the extraction solvent ($R^2=-0.12$). The maximum growth inhibitory activity of clove against *S. mutans* determined by the EVOP factorial technique was obtained at 80°C extraction temperature, 26 h extraction time, and 50% ethanol concentration⁹⁴.

Koteswara Rao *et al* investigated ten essential oils like Colve oil, mustard oil, Cinnamon oil, Rosemary oil, Eucalyptus, lavender, cinnamon, Tea tree oil, menthol, lemon oil that showed significant growth inhibitory effect against oral microbes like *Streptococcus mutans*, *Streptococcus salivarius*, *Streptococcus mitis*, *Lactobacillus fermentum*, *Lactobacillus acidophilus*, *Streptococcus gordonii*, *Streptococcus anginosus*, *Staphylococcus aureus*. In conclusion of his study, cinnamon oil, clove oil

and Tea tree oil showed significant Antimicrobial activity than other Essential oils. Mustard oil showed absence of growth inhibitory activity when compared to other Nine Essential oils⁹⁵

MELALEUCA ALTERNIFOLIA:

Tea tree oil is extracted from the tree *Melaleuca alternifolia* that grows in Australia, and has been shown to have many beneficial medicinal uses as an antiseptic, antifungal and antibacterial agent⁹⁶. Studies indicate that *Melaleuca alternifolia* is extracted from the leaves and twigs by steam distillation and the yield is about 1.8% and that the main chemical component to have antimicrobial activity in tea tree oil is attributed to terpinen-4-ol⁹⁸. Many products have been tried as mouth rinse but few are found to be effective. Those products that are effective in plaque control have side effects and hence the search for naturally derived mouth rinse with lesser side effects has been initiated. One of the natural products which show promising results is Tea tree oil. Tea tree oil is an antiseptic used to fight against the germs. It has also been used to treat cuts, minor burns, athlete's foot, and insect bites. Studies reveals that it can treat bacterial and fungal skin infections, wound infections, gum infections, acne, head lice, eczema, vaginal yeast infections, pneumonia, and other respiratory illnesses⁹⁷⁻¹⁰¹



Fig 5
Melaleuca alternifolia



ANTI MICROBIAL ACTIVITY OF MELALEUCA ALTERNIFOLIA:

Grosso FC *et al* conducted a study based upon the comparison of the Anti microbial activity of garlic, Tea tree oil, and chlorhexidine against oral micro organisms. His study revealed that garlic and chlorhexidine showed good anti microbial activity against *Streptococcus mutans* than other oral micro organisms, whereas, TTO showed significant antimicrobial effect against *Streptococcus mutans* and other oral micro organisms¹⁰². In conclusion Tea tree oil and Garlic are reported to be effective and can be used as an alternative to chlorhexidine since garlic and TTO when given in two subsequent weeks produced untoward effects like burning sensation, bad breath, unpleasant taste and nausea.

Mary Fitzpatrick tested TTO abilities to control the growth of five bacteria *Bacillus subtilis*, *Escherichia coli*, *Micrococcus roseus*, *Sarcina luteus*, *Serratia marcescens*. She also compared the antimicrobial effectiveness of fresh garlic (*Allium sativum*), an industrial cleaner and deodorizer Quad 10, and mouthwash Listerine a brand made by McNeil-PPC, Inc., contiguously with tea tree oil¹⁰³. A bacterial lawn technique on agar plates for each tested bacterium was carried out. In conclusion of his study it was reported that tea tree oil had the best antibacterial action of the strains tested due to the clear zone of inhibition measured.

Hammer *et al* carried out a study to determine the antibacterial action of Tea tree oil. A total of 162 bacterial isolates from the genera *Actinomyces*, *Branhamella*, *Capnocytophaga*, *Clostridium*, *Eikenella*, *Fusobacterium*, *Haemophilus*, *Lactobacillus*, *Neisseria*, *Peptostreptococcus*, *Porphyromonas*, *Prevotella*, *Stomatococcus*, *Streptococcus* and *Veillonella* were tested for their susceptibility to tea tree oil¹⁰⁴. All isolates were inhibited and killed by concentrations of Tea tree oil 2%, and in fact most were inhibited and/or killed at concentrations below this. Isolates with the lowest MICs and MBCs were

from the genera *Prevotella*, *Porphyromonas* and *Veillonella* and isolates with the highest MICs and MBCs were from the genera *Streptococcus*, *Fusobacterium* and *Lactobacillus*. *Streptococcus mutans* has been strongly associated with the development of dental caries. This suggests that if tea tree oil is used in a mouthwash formulation it may be effective in reducing the numbers of *S. mutans*, *L. rhamnosus* or other bacteria within the mouth. The data from his study suggest that tea tree oil may be of use in oral hygiene products. Tea tree oil is also used as root canal irrigant, but less effective compared to EDTA and NaOCl¹⁰⁵.

CONCLUSION

Dental caries is a chronic disease of multifactor etiology and pathogens. The early stage of dental caries is characterized by a destruction of superficial dental structures caused by acids which are by-products of carbohydrate metabolism by *Streptococcus mutans*. Dental caries is one of the public health concerns for several reasons. Teeth affected with dental caries are sources of infection, which can cause an inflammation of dental pulp, periodontium and gums. If left untreated, this disease gradually leads to teeth loss, which causes chewing difficulties and aesthetic problems.¹⁰⁶ Since the 19th century, when sucrose became a daily used sweetener by many people worldwide, the increasing prevalence of dental caries had also been noticed¹⁰⁷. Despite a low mortality rate associated with dental diseases they have a considerable effect on the self esteem, eating ability, nutrition and health both in childhood and older age. Dental decay also leads to tooth loss which reduces the ability to eat a varied diet.^{108,109} Tooth loss has also been associated with loss of enjoyment of food and confidence to socialize. It is therefore clear that dental diseases have detrimental effect on quality of life both in childhood and older age.¹¹⁰ Hence with all the above literature compilation it is proved that Dental caries that is primarily



caused by *Streptococcus mutans*, *Enterococcus faecalis* which causes root canal failure can be treated with botanicals like *Acacia catechu*, *Allium sativum*, *Azadirachta indica*, *Syzygium aromaticum*, *Tea tree oil (Melaleuca alternifolia)* that possess potent antimicrobial activity. Further studies are yet to be conducted in *Acacia catechu* Bark and Leaf extract against oral microbes for the management of dental infections.

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