REVIEW

13(34), March 1, 2014

ISSN 2278–5469 EISSN 2278–5450

Discovery

Medicinal plant extract for prevention of oral diseases

Kalavatia Ishaan[1], Rathore Madhu[2☼]

1.Department of Physiology, Jhalawar medical college Jhalawar Rajasthan, India; E-mail: Ishaan.kalavatia@gmail.com
2.Microbial Research Laboratory, MLS University Udaipur State Rajasthan India-313001; E-mail: inbiosci@gmail.com

☼**Corresponding author:** Microbial Research Laboratory, MLS University Udaipur State Rajasthan India-313001; E-mail: inbiosci@gmail.com

Publication History
Received: 20 January 2014
Accepted: 27 February 2014
Published: 1 March 2014

Citation
Kalavatia Ishaan, Rathore Madhu. Medicinal Plant Extract for Prevention of Oral Diseases. *Discovery*, 2014, 13(34), 29-38

ABSTRACT

Oral diseases are major health problems with dental caries and periodontal diseases among the most important preventable global infectious diseases. More than 750 species of bacteria inhabit the oral cavity which implicated in oral diseases. The development of dental caries basically involves acidogenic and aciduric gram-positive bacteria (*Streptococcus mutans*, Lactobacilli and Actinomycetes). Acidogenic oral bacteria like *Streptococcus mutans*, *Streptococcus salivarius*, *Streptococcus mitis*, *Streptococcus sanguis*and *Lactobacillus acidophilus* primarily causes dental caries/plaque that surrounds theorthodontic appliances in many patients undergoingorthodontic treatment. Bacteria have ability to survive in the environment of the tooth surface, gingival epithelium, and oral cavity. Most of the treatments in dental carries are aimed at either elimination or suppression of bacteria using antibiotics. Increased resistance of oral bacteria to antibiotics however, has developed keen interest of researcher in herbal treatment. Hence present review describes the use of plant extracts that inhibit the growth of oral pathogens, reduce the development of biofilms and dental plaque, influence the adhesion of bacteria to surfaces and reduce the symptoms of oral diseases. Active molecules or phytochemicals found in extract are responsible for antibacterial effect.

Keywords: Oral disease, dental caries, bacteria, plant extract, orthodontic treatment.

1. INTRODUCTION

Oral diseases continue to be a major health problem worldwide (Petersen et al. 2005). The important role of socio-behavioral and environmental factors in oral health and disease has been shown in a large number of socio-epidemiological surveys. In addition to poor living conditions, the major risk factors relate to unhealthy lifestyles (i.e. poor diet, nutrition and oral hygiene and use of tobacco and alcohol), and limited availability and accessibility of oral health services. Dental caries and periodontal diseases are among the most important global oral health problems, although conditions such as oral and pharyngeal cancers and oral tissue lesions are also significant health concerns (Petersen, 2003). Dental caries are caused by demineralization of the enamel of the tooth by acid produced from dietary sugars by microorganisms growing as a biofilm or plaque. Like any biofilm, dental plaque is formed by colonizing bacteria trying to attach themselves to the tooth's smooth surface.It has been speculated that plaque forms part of the defense systems of the host by helping to prevent colonization of microorganisms that may be pathogenic. Plaque is composed of up to 500 different organisms (Paster et al. 2001; Socransky and Haffajee, 2000). Despite general advances in the overall health status of the people living in industrialized countries, including oral and dental health, the prevalence of dental caries in school aged children is up to 90% and the majority of adults are also affected (Petersen. 2005).

Oral health is integral to general well-being and relates to the quality of life that extends beyond the functions of the craniofacial complex. There is considerable evidence linking poor oral health to chronic conditions, for example, there is a strong association between severe periodontal diseases and diabetes (Petersen et al.2005; Petersen. 2003; Petersen. 2005). There is also evidence linking poor oral health and systemic diseases, such as cardiovascular diseases, rheumatoid arthritis and osteoporosis (Rautemaa et al. 2007), while periodontal diseases and may also contribute to the risk of pregnancy complications, such as preterm low-birth weight (Yeo et al. 2005). Dental plaque (biofilm) formation is a naturally occurring process, resulting from bacterial interactions with the acquired salivary pellicle formed over the surface of the tooth shortly after brushing the tooth. Although the newly formed plaque lacks any pathogenic potential due to an insufficient number of microorganisms present, the persistence of dental plaque allows for multiple bacterial interactions, resulting in various pathologies such as gingivitis, caries, periodontitis, and peri-implantitis (Marsh. 2006; Sbordone and Bortolaia 2003). This can be cured by distinct mouthwashes with antiplaque agents such as chlorhexidine, fluoride, and cetylpyridinium chloride are recommended for use in conjunction with tooth brushing because rinsing with mouthwashes in addition to tooth brushing has been found to impart superior plaque control compared to tooth brushing alone (Feres et al. 2009).

These agents have bactericidal or bacteriostatic action against gram- positive microorganism than gram- negative microorganism (De Freitas et al. 2003). Over 750 species of bacteria inhabit the oral cavity (~50% of which is yet to be identified) and a number of these are implicated in oral diseases (Jenkinson and Lamont 2005). The development of dental caries involves acidogenic and aciduric Gram-positive bacteria, primarily the *Streptococcus mutans* (*Streptococcus mutans* and *S. sobrinus*), Lactobacilli and Actinomycetes, which metabolize sucrose to organic acids (mainly lactic acid) that dissolve the calcium phosphate in teeth, causing decalcification and eventual decay. Dental caries is thus a supra-gingival condition (Loesche. 2007). In contrast, periodontal diseases are subgingival conditions that have been linked to anaerobic Gram-negative bacteria such as *Porphyromonasgingivalis*, *Actinobacillus* sp., *Prevotella* sp. and *Fusobacterium*sp (Loesche. 2007; Tichy and Novak 1998). In periodontal diseases, the areas at or below the gingival crevice become infected causing a cellular inflammatory response of the gingiva and surrounding connective tissue. These inflammatory responses can manifest as gingivitis (extremely common and seen as bleeding of the gingival or gum tissues) or periodontitis (The inflammatory response results in loss of collagen attachment of the tooth to the bone and in loss of bone) (Jenkinson and Lamont, 2005).

Several studies, both *in vitro* and *in vivo*, have evaluated the efficacy of the antiplaque agents mentioned above (Pizzo et al.2008; Featherstone 2000). But, there are some adverse effects of these antiplaque agents on human health. Despite the widespread use of different sources of fluoride, dental caries continues to be the single most prevalent and costly oral infectious disease worldwide (NIH Consens Statement, 2001; Marsh, 2003, Dye et al. 2007). Virulent biofilms that are tightly adherent to oral surfaces are a primary cause of infectious diseases in the mouth, including dental caries (Bowen and Koo, 2011).

Therefore, now scientists found natural compounds which work against plaque. Historically all medicinal preparations were derived from plants, whether in the simple form of plant parts or in the more complex form of crude extracts, mixtures, etc. Today a substantial number of drugs are developed from plants (Fabricant and Farnsworth, 2001; Sharma et al. 2011) which are active against a number of diseases. The majority of these involve the isolation of the active ingredient (chemical compound) found in a particular medicinal plant and its subsequent modification. In the developed countries 25 percent of the medical drugs are based on plants and their derivatives (Principe, 1991-2005; Naveen et. al., 2011; Rathore et. al., 2011, 2012) and the use of medicinal plants is well known among the indigenous people in rural areas of many developing countries. In the past our ancestors made new discoveries of the healing power of plants through trial and error. Although some of the therapeutic propertiesattributed to plants have proven to be erroneous, medicinal plant therapy is based on the empirical findings of hundreds and thousands of years (Gurib-Fakim, 2006). Population rise, inadequate supply of drugs, prohibitive cost of treatments, side effects of several allopathic drugs and development of resistance to currently used drugs for infectious diseases have led to increased emphasis on the use of plant materials as a source of medicines for a wide variety of human ailments (Birdi et al. 2006).

In India, drugs of herbal origin have been used in traditional systems of medicines such as *Unani*and *Ayurveda* since ancient times. The *Ayurveda* system of medicine uses about 700 species, *Unani*700, *Siddha* 600, Amchi 600 and modern medicine around 30 species (Jawla et al. 2009). Plants, especially used in ayurveda can provide biologically active molecules andlead structures for the development of modified derivatives with enhanced activity and /orreduced toxicity. The small fraction of flowering plants that have so far been investigatedhave yielded about 120 therapeutic agents of known structure from about 90 species of plants (Ross and Brain, 1977).

In many of the developing countries the use of plantdrugs is increasing because modern life saving drugs are beyond the reach of three quarters of the third world's population although many such countries spend 40-50% of their total wealth on drugs and health care. As a part of the strategy to reduce the financial burden on developing countries, it is obvious that an increased use of plant drugs will be followed in the future. Several plants are known for their antimicrobial properties. Certain of them also described for inhibitory activity against oral microflora such as *Eryngiuncomosum*, *Commelinacadestis*, *Salpianthusarenarius*, *Schefleraoctophylln*,*Morus alba* and *Drymaringlandulosa*. The drugs are derived either from the whole plant or from different organs, like leaves, stem, bark, root, flower, seed, etc. Some drugs are prepared from excretory plant product such as gum, resins and latex. Even the allopathic system of medicine has adopted a number of plant-derived drugs.

2. ORAL MICROFLORA

Loesche introduced dental caries and periodontal disease as the most common chronic disease worldwide (Niclaus and L-Michel, 1986). Dental caries developed under bacterial colonies which produce acidic material and then remove the mineral part of tooth structure (Niclaus and L-Michel, 1986). More than 500 bacterial strains may be found in dental plaque (Kroes et al. 1996-1999). Some bacterial studies have revealed that most bacteria live in complex communities called biofilms. Oral microbial-plaque communities are biofilms composed of numerous genetically distinct types of bacteria that live in close juxtaposition on host surfaces. A biofilm is a well-organized community of bacteria that adheres to surfaces and is embedded in an extracellular slime layer (Coghlan, 1996). These bacteria communicate through physical interactions called coaggregation and coadhesion, as well as other physiological and metabolic interactions. Streptococci and actinomyces are the major initial colonizers of the tooth surface, and the interactions between them and their substrata help establish the early biofilm community. Formation of dental plaque takes place in a sequential manner leading to a structurally and functionally organized, species-rich microbial community (Marsh, 2004).

Oral "streptococci" presents the great part of oral microflora. They can be isolated from all parts of the mouth and upper respiratory tract of humans. Three species of *Streptococcus mutans*, *Streptococcus salivarius* and *Streptococcus sanguis*would be the great part of oral Streptococci and also Clarks was the first to isolate *S. mutans*from dental caries in 1924 but this activity confirmed at 1950 to 1960 in order to some experimental studies (Marsh and Mikel, 1990). Specific oral bacterial species have been implicated in several systemic diseases, such as bacterial endocarditis (Berbari et al. 1997), aspiration pneumonia (Scannapieco, 1999), preterm low birth weight (Buduneli et al. 2005; Offenbacher et al. 1998), and cardiovascular disease (Beck et al. 1996; Wu et al. 2000).

The lactobacilli and streptococci which included in lactic acid bacteria hence proposed as specific agents of the acid production that is primary to the dental caries process (Van Houte et al. 1994; Liljemark and Bloomquist, 1996). According to Bunting*et al*. (Bunting et al. 1989) and Jay (Jay, 1947) *Lactobacillus acidophilus* (*B. acidophilus*) is particularly a possible candidates or main causative agents of dental caries. Many studies carried out by them and thereafter by others have shown frequent association between the presence of lactobacilli and the prevalence of dental caries, suggesting such a possibility. For instance, increase level of fermentable carbohydrate in the diet led to elevated lactobacillus counts, whereas less carbohydrate resulted in lactobacillus reduction (Becks et al. 1944; Becks, 1950). Retention of fermentable dietary at dentition sites also favored elevated numbers of lactobacilli and the development of dental caries lesions (Crossner et al. 1989). These sites included the pits, fissures, and approximal areas of the teeth where caries lesions are most frequently found (Barr et al. 1957). In addition, placement of dental appliances such as orthodontic bands on dentition sites leads changes in the morphological conditions, which then lead to enhanced carbohydrate retention, more lactobacilli and other acidogens, a more acidogenic dental plaque, and, in turn, to caries elevation (Boyar et al. 1989; Scheie et al. 1984).

Most current dental therapies are focused on eradicating the entire dental plaque *via* mechanical removal or broad-spectrum antimicrobial treatments. Most of these new approaches aim to achieve the eradication of *S. mutans*by targeting its virulence factors, such as the colonization of the tooth surface *via* both sucrose dependent and independent adhesion mechanisms (Koga et al. 2002), cell-cell signaling (Lonn-Stensrud et al. 2007), or acid production. Numerous approaches include the development of anti- caries vaccines against either cell surface antigens (Abiko, 2000) or a glucosyltransferase enzyme that is responsible for glucan production (Xu et al. 2007).

The vast biodiversity of Indian forests provides several plants, whichare mentioned in Ayurveda for dental care. *Juglansregia*L., the royal species from family Juglandaceae, has been used in traditional medicines from ancient times. All parts of the plant: root, stem, bark, leaves, seeds, seed oil are medicinally important being depurative, anthelmintic, laxative, detergent, astringent and diuretic and exhibit antimicrobial activity to a greater extent (Chopra et al. 1986). Some extracts of the leaves show anticancer activity (Bown, 1995). The juice of the green husks, boiled with honey, is a good gargle for a sore mouth and inflamed throat. A piece of the green husks put into a hollow tooth, eases the pain. Decoction of the stem bark is useful in dental complaints. The species is also utilized in the treatment of tuberculosis and tuberculosis of cervical glands (Luna, 1985).

3. ACTIVE MOLECULES FOUND IN PLANT RESPONSIBLE FOR ANTIMICROBIAL ACTIVITY

Plants produce a diverse range of bioactive molecules making them a rich source of different types of medicines (Stuffness andDouros, 1982). Higher plants as sources of medicinal compounds have continued to play a dominant role in the maintenance of human health care since ancient times and also play a vital role in modern drug development in the pharmaceutical industry (Baker et al. 1995).

Plants have an almost limitless ability to synthesize aromatic substances, most of which are phenols or their oxygen-substitutedderivatives (Geissman, 1965). Most are secondary metabolites, of which atleast 12,000 have been isolated, a number estimated to be lessthan 10% of the total (Schultes, 1978). In many cases, these substancesserve as plant defense mechanisms against predation by microorganisms, insects, and herbivores. Some, such as terpenoids, give plantstheir odors; others (quinones and tannins) are responsible forplant pigment. Many compounds are responsible for plant flavor (e.g., the terpenoid capsaicin from chili peppers), and some ofthe same herbs and spices used by humans to season food yielduseful medicinal compounds. Antimicrobial activity of plant extracts is attributed to active molecules found in plants. These active molecules lead alteration in physiology and metabolic activity of pathogen and inhibit their growth. The effect of these compounds might be cidal or static. These compounds can be extracted by employing solvent series varying in polarity.

Resultant extracts contain a mixture of secondary metabolites including alkaloids, flavonoids, terpenoids, and other phenolic compounds; these molecules are associated to defense mechanisms of plants by their repellent or attractive properties, protection against biotic and abiotic stresses, and maintenance of structural integrity of plants. Triterpenoid group, such as triterpene,saponins, together with steroidal saponins, were isolated as antifungal constituents from medicinal plants. Terpenoids mainly include sesquiterpenes and sesquiterpene lactones (Abad et al. 2007). Phenolic classes with antifungal properties found in medicinal plants, namely simple phenolic compounds, flavones and related flavonoid glycosides, coumarins and derivatives, and anthraquinones. Alkaloid is a compound that is toxic or physiologically active, contains nitrogen in a heterocyclic ring with complex structure. These are formed as metabolic by products and have been reported to be responsible for the antimicrobial activity (Doughari, 2006). Berberine is an important representative of the alkaloid group and found potentially effective against trypanosomes and plasmodia. The mechanism of action of highly aromatic planar quaternary alkaloids such as berberine and harmane (Hopp et al. 1976) is attributed to their ability to intercalate with DNA (Phillipson et al. 1987).

In addition, numerous research groups have sought to elucidate the antibacterial mechanisms of action of selected flavonoids. The activity of quercetin, for example, has been at least partially attributed to inhibition of DNA gyrase. It has also been proposed that sophoraflavone G and (−)-epigallocatechingallate inhibit cytoplasmic membrane function, and that licochalcones A and C inhibit energy metabolism. Other flavonoids whose mechanisms of action have been investigated include robinetin, myricetin, apigenin, rutin, galangin, 2, 4, 2-trihydroxy-5-methylchalcone and lonchocarpol A (Tim Cushnie and Lamb, 2005). One of the categories of active compounds includes peptides such as lysozyme, vulgarinin, enzymes etc. These are also described for their antimicrobial potential (Wong and Ng, 2005; Wang et al. 2009)**.** Plant lectins are also described for their antimicrobial potential (Bourne et al. 1994). The inhibition of microorganismsby phenolic compounds may be due to iron deprivation orhydrogen bonding with vital proteins such as microbialenzymes (Scalbert, 1991).

Terpenoids are synthesized from acetate units, and as such they share their origins with fatty acids. They differ from fatty acids in that they contain extensive branching and are cyclized. The mechanism of action of terpenes is not fully understood but is speculated to involve membrane disruption by the lipophilic compounds (Cowan et al. 1999).

Tannin is a general descriptive name for a group of polymeric phenolic substances capable of tanning leather or precipitating gelatin from solution, a property known as astringency. One of their molecular actions is to complex with proteins through so-called nonspecific forces such as hydrogen bonding and hydrophobic effects, as well as by covalent bond formation (Haslam, 1996; Stern et al. 1996). Thus, their mode of antimicrobial action may be related to their ability to inactivate microbial adhesins, enzymes, cell envelope transport proteins, etc. They are also known to form complex with microbial polysaccharide.

Table 1

Plant extracts and phytochemicals with potential application against oral bacteria inhibitory concentration (g mL^{-1}); --D-,-diacetoxyglucopyranosyl-ent-kaur-16-ene; MIC values for chlorhexidine and triclosan have been added for comparative purposes, Ref.=References

Extract (solvent)	MIC[a]	Ref.	Phytochemical (Class)	MIC[a]	Ref.
Propolis (ethanol)	2.0–64.0	(Uzel et al. 2005)	Macrocarpals A,B,C (terpenes)	0.5–1.0	(Nagata et al. 2006)
Mikania laevigata (ethanol)	12.5–100.0	(Yatsuda et al. 2005)	Bakuchiol (terpene)	1.0–4.0	(Katsura et al. 2001)
Mikania glomerate (ethanol)	12.5–100.0	(Yatsuda et al. 2005)	Erycristagallin (flavonoid)	1.6–6.3	(Sato et al. 2003)
Drosera peltata (chloroform)	15.6–31.3	(Didry et al. 1998)	Beta acid	2.0	(Bhattacharya et al 2003)
Helichrysumitalicum (ethanol)	31.3–62.5	(Nostro et al. 2004)	Xanthorrhizol (terpene)	2.0–4.0	(Hwang et al. 2000)
Coptidisrhizoma (wat er)	31.0–250.0	(Hu et al. 2000)	Artocarpin (flavonoid)	3.1–12.5	(Sato et al. 1996)
Piper cubeba (aqueous ethanol)	90.0–200.0	(Silva et al.2007)	Artocarpesin (flavonoid)	3.1–12.5	(Sato et al. 1996)
-	-	-	Macelignan (flavonoid)	3.9	(Chung et al. 2006)
-	-	-	Catechol (phenolic)	6.5	(Badria and Zidan, 2004)
-	-	-	Kuwanon G (flavonoid)	8.0	(Park et al. 2003)
-	-	-	Xanthohumol (flavonoid)	12.5	(Lee et al. 2004)
-	-	-	Tetra iso-alpha acid	12.5	(Bhattacharya et al 2003)
-	-	-	Berberine (alkaloid)	13.0–20.0	(Hu et al. 2000)
-	-	-	Compound 2b (terpene)	15.6	(Liu et al. 2007)
-	-	-	Chlorhexidine c	1.0	(Hwang et al. 2004)
-	-	-	Triclosan c	0.1–20.0	(McBain et al. 2004)

4. PLANT SECONDARY METABOLITES PREVENT THE ADHESION OF ORAL MICROFLORA

Plants extracts and phytochemicals were investigated for their ability to prevent adhesion of cariogenic bacteria to surfaces. Antimicrobial activity of plant extracts can be attributed to a variety of components including mono- and poly-hydric phenols (Cowan et al. 1999). Leaves of *R. officianalis* L., *S. officianalis* L., *OriganumMajorana* L. contain a number of volatile phenolics including eugenol, isoeugenol and thymol and essential oils that have been shown to have antibacterial activity (Deans and Ritchie, 1987; Rasooli et al. 2008; Bernardes et al. 2010a; Sharma et. al., 2008, 2010). The precise composition depends upon a number of factors including country (Derwich et al. 2011), soil composition (Angioni et al. 2004) time of harvesting (Generalic et al. 2012). *R. officianalis* L. and *S. officianalis L.* also contain the diphenolscarnosol, rosmanol, rosmariquinone and rosmaridiphenol (Nakatani, 1992) and components derived from aromatic amino acids such as caffeic acid, cinnamic acid and rosmarinic acid (Okuda et al. 1992).

5. ANTI-ADHESION ACTIVITY OF PURIFIED PHYTOCHEMICALS

The effects of macrocarpals (phloroglucinol-sesquiterpene-coupled compounds) extracted from eucalyptus leaves on periodontopathic bacteria demonstrated that these compounds has inhibitory activity against majority of bacterial strains tested

(Nagata et al. 2006). *Porphyromonasgingivalis*was showed higher sensitivity with MIC value of 1μgmL^{-1} for macrocarpals A and B, and 0.5μgmL^{-1}for macrocarpal C. In addition, all three compounds were able to inhibit the expression of *P. gingivalis*proteases and the binding of cells to S-HA by 70–80% at a concentration of 10μgmL^{-1}.One more purified phytochemical, xanthorrhizol has been shown to inhibit the growth of oral pathogens. The xanthorrhizolhas also been investigated for inhibition ofbioflims of *S. mutans* (Rukayadi and Hwang, 2006). Many of the products are effective only at relatively high concentrations. Indeed, Cos *et al*. (2006) have suggested that strict criteria should be used to assess the potential application of natural products. In the context of anti-infective agents, MIC levels of <100μgmL^{-1} are indicative of useful bioactivity for natural product extracts. Numerous studies have compared active compounds to currently used antibacterial compounds used in dentistry, such as chlorhexidine and triclosan, as a way of determining relative effectiveness. The MIC of chlorhexidine is ~1μgmL^{-1} (Hwang et al. 2004) while triclosan has an MIC of 0.1–20μgmL^{-1} (McBain et al. 2004). Using the above criteria, extracts with MIC values of ≤100μgmL^{-1} and isolated phytochemicals with MIC values of ≤20μgmL^{-1} may be considered useful for the development as products for application against oral infections. These are listed in Table 1 and their specific applications in the prevention or treatment of oral infections (i.e., antibacterial or antiplaque properties) are summarized in Figure 1.

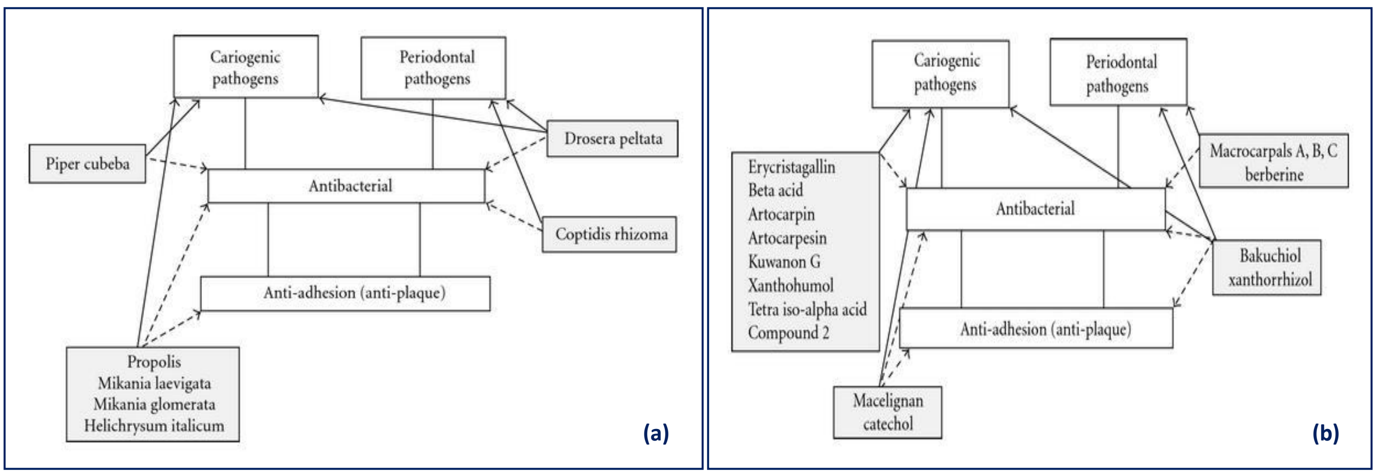

Figure 1

Potential application of plant extracts (a) and phytochemicals (b) in the prevention and treatment of oral diseases caused by cariogenic and periodontal microbial pathogens. Where known, the likely uses of extracts and phytochemicals are indicated with respect to their target pathogens (solid arrows) and biological activities (dashed arrows)

6. ESSENTIAL OILS WITH ACTIVITY AGAINST ORAL BACTERIA

The antibacterial properties of essential oils are well-known and activity against bacteria found in the oral cavity, including pathogens, has been documented (Kalemba and Kunicka, 2003). Indeed, there is evidence that commercial mouthwashes containing essential oils are useful in the long-term control of plaque and mild-to-moderate gingivitis and are preferred to those containing chlorhexidine for long-term daily use (Ciancio, 2003; Santos, 2003). A number of recent studies add to the evidence that essential oils may be suitable additives in products used for the maintenance of oral hygiene or prevention of dental disease.

The essential oil of *Melaleucaalternifolia* (Myrtaceae), known as tea tree oil (TTO), has been used medicinally for many years. TTO has antimicrobial properties and is used in the superficial treatment of skin infections. The activity of TTO against an extensive collection of oral bacterial isolates was investigated by Hammer *et al*. (Hammer et al. 2003) who determined MIC and MBC values in the range 0.003–2.0% (v/v). Further, time-kill assays showed that exposure of *S. mutans* and *Lactobacillus rhamnosus* to 0.5% (v/v) TTO resulted in >3 log reduction of viable cells within 30s. The activity of TTO against oral pathogens was supported in a study involving this and other essential oils, including manuka oil, eucalyptus oil, lavandula oil and rosmarinus oil (Takarada et al. 2004). In addition to their inhibitory and bactericidal activities, most of the oils were able to inhibit the adhesion of *S. mutans* and *P. gingivalis*.

Essential oils are also capable of enhancing the activity of chlorhexidine. When used in combination, the essential oils of cinnamon and manuka were able to significantly reduce the amount of chlorhexidine required to inhibit the growth of oral pathogens (Filoche et al. 2005). This enhanced activity was also seen against bacterial cultures grown as biofilms. Between 4- and 10-fold reductions of the amount of chlorhexidine required to inhibit biofilm bacteria was observed when used in combination with cinnamon, manukaand*Leptospermummorrisonii* oils.

The essential oils of *Artemisia lavandulaefolia* (Asteraceae), *A. capillaries*, *A. scoparia* and *A. feddei* have been shown to inhibit the growth of oral (Cha et al. 2005; Cha et al. 2005), with the greatest activity generally observed against obligate anaerobes. However, the oils also showed strong activity against other groups, including facultative anaerobes and microaerophilic bacteria. A recent study reported that the essential oil of*Cryptomeria japonica* (Taxodiaceae) exhibited strong activity against all bacteria tested, especially oral bacteria, with MIC of 0.025–0.5mgmL^{-1} (Cha et al. 2007).

While these *in vitro* results are very encouraging, the known toxicity of TTO when ingested (Hammer et al. 2006) suggests that further studies of the safety of this and other essential oils for use in the oral cavity need to be addressed. In this context, Takarada et al. (2004) showed that the essential oils used in their study had little effect on human umbilical vein endothelial cells *in vitro* when tested at a concentration of 0.2% (v/v), well within the MIC and MBC values of several oils against some of the bacteria tested.

7. PLANT EXTRACT AGAINST ORAL BACTERIA

Several studies have demonstrated the antibacterial effect of plant extracts (Morgan et al. 2001) against oral bacteria. Extracts of green tea inhibited the growth of *S. mutansin vitro* (Sakanaka et al. 1989) and prevented its attachment to tooth enamel by inhibiting glucosyltransferase activity (Sakanaka et al. 1989). These activities were probably due to the presence of catechins (Hamilton-Miller, 2001). Oolong tea extracts inhibited experimental dental caries in Specific Pathogen Free rats infected with mutans streptococci (Ooshima et al. 1998) and reduced dental plaque formation in humans (Ooshima et al. 1994). Various Chinese medicines rich in tannins (Kakiuchi et al.1986), extracts of cocoa, coffee (Kashket et al. 1985), hops (Yaegaki et al. 2008) and propanone extracts of bark (Mitsunaga and Abe, 1997) also inhibited GTA. Aqueous extracts of various African plants inhibited attachment of *S. mutans*to glass or hydroxyapatite beads (Wolinsky and Sote, 1984). Extracts of cocoa bean husk have been shown to be cariostatic (Ooshima et al. 2000). *Rosmarinusofficianalis* L. and *Salvia officianalis* L. have been widely studied for their antimicrobial activity (Moreno et al. 2006). *R. officianalis L.* extracts have been shown to inhibit growth and GTA production in *Streptococcus sobrinus* (Tsai et al. 2007).

SUMMARY OF RESEARCH

Oral health influences the general quality of life and poor oral health is linked to chronic conditions and systemic diseases. Many bacteria are known to be responsible for oral diseases. The effective way to control oral diseases are use of natural compounds like plant extract, essential oil etc. These natural compound contained active molecule which interfere with metabolic activity o pathogenic bacteria and protect from oral infections and diseases.

FUTURE ISSUES

Isolation and identification of active compound from plant extracts and development of remedies will be helpful to get rid of many oral diseases. Cytotoxicity checking of such remedies will further refine this study.

REFERENCE

1. Abad MJ, Ansuategui M and Bermejo P. Active antifungal substances from natural sources. ARKIVOC (7), 2007, 116-145
2. Abiko Y. Passive immunization against dental caries and periodontal disease: development of recombinant and human monoclonal antibodies. Crit Rev Oral Biol Med., 11(2), 2000, 140–158
3. Angioni A, Barra A, Cereti E, Barile D., Coissson, J.D., Arlorio., M et al. Chemical composition, plant genetic differences, antimicrobial and antifungal activity investigation of the essential oil of Rosmarinusofficinalis L. J Agric Food Chem., 52, 2004, 3530-3535.
4. Badria FA and Zidan OA. Natural products for dental caries prevention. Journal of Medicinal Food, 7(3), 2004, 381–384.
5. Baker JT, Barris RP, Carte B, Cordell GA, Soejarto, D D, Cragg G M et al. Natural product drug discovery: New perspective on international collaboration. J. Nat Prod., 58, 1995, 1325-1357
6. Barr JH, Diodati RR and Stephans RG. Incidence of caries at different locations on the teeth. J Dent Res., 36, 1957, 536–545
7. Beck J, Garcia R, Heiss G, Vokonas PS, and Offenbacher S. Periodontal disease and cardiovascular disease. J. Periodontol., 67, 1996, 1123–1137
8. Becks H, Jensen AL, Millarr CB. Rampant dental caries. Prevention and prognosis. J Am Dent Assoc., 31, 1944, 1189–1200
9. Becks H. Carbohydrate restriction in the prevention of dental caries using the LA count as one index. J CA Dent Assoc., 26, 1950, 53–58.
10. Berbari E F, Cockerill III FR and Steckelberg JM. Infective endocarditis due to unusual or fastidious microorganisms. Mayo Clin. Proc., 72, 1997, 532–542
11. Bernardes WA, Lucarini R, Tozatti MG, Souza M G M, Andrade Silva M L, da Silva Filho, A. A., et al. Antimicrobial activity of Rosmarinusofficinalis against oral pathogens: relevance of carnosic acid and carnosol. Chem. Biodivers. 7, 2010a, 1835-1840
12. Bhattacharya S, Virani S, Zavro M, and Haas GJ. Inhibition of Streptococcus mutans and other oral Streptococci by hop (Humuluslupulus L.) constituents. Economic Botany, 57(1), 2003, 118–125
13. Birdi T J , Brijesh S, Daswani PG, Tetali P, Rojatkar SR, Antia NH et al. Pongamiapinnata (L.) Pierre leaves: Understanding the mechanism(s) of actionin infectious diarrhea. J Zhejiang Univ Science, 7, 2006, 665-674
14. Bourne Y, Ayouba A, Rouge P and Cambillau C. Interaction of a legume lectin with two components of the bacterial cell wall. The Journal of Biological Chemistry, 269,1994, 9429-9435

15. Bowen WH and Koo H. Biology of Streptococcus mutans-derived glucosyltransferases: role in extracellular matrix formation of cariogenic biofilms. Caries res.,45, 2011, 69–86
16. Bown D. Encyclopedia of Herbs and their uses. Darling Kinderley, London ISBN O-7513-020-31, 1995
17. Boyar RM, Thylstrup A, Holmen L and Bowden GH. The microflora associated with the development of initial enamel decalcification below orthodontic bands in vivoin children living in a fluoridated-water area. J Dent Res., 68, 1989, 1734–1738
18. Buduneli N, Baylas H, Buduneli E, Turkoglu O, Kose T, and Dahlen G. Periodontal infections and pre-term low birth weight: a case-controlstudy. J. Clin. Periodontol.,32, 2005, 174–181
19. Bunting RW, Crowley M, Hard DG and Keller M. The prevention of dental caries through the limitation of growth of Bacillus acidophilus in the mouth. J Am Dent Assoc., 16, 1989, 224–230
20. Cha JD, Jeong MR, Choi HJ et al. Chemical composition and antimicrobial activity of the essential oil of Artemisia lavandulaefolia. PlantaMedica, 71(6), 2005, 575–577
21. Cha JD, Jeong MR, Jeong SI, Moon SE, Kil BS, Yun SI, et al. Chemical composition and antimicrobial activity of the essential oil of Cryptomeria japonica. Phytotherapy Research 21, 2007, 295–299.
22. Cha JD, Jeong MR, Jeong SI, Moon SE, Kim JY, Kil BS, et al. Chemical composition and antimicrobial activity of the essential oils of Artemisia scoparia and A. capillaries. PlantaMedica, 71, 2005, 186–190.
23. Chopra RN, Nayar SL and Chopra RC. Glossary of Indian Medicinal Plants (Including the Supplement) Council of Scientific and Industrial Research , New Delhi, 1986
24. Chung JY, Choo JH, Lee MH and Hwang JK. Anticariogenic activity of macelignan isolated from Myristicafragrans (nutmeg) against Streptococcus mutans. Phytomedicine 13(4), 2006, 261–266
25. Ciancio S. Improving oral health: current consideration. Journal of Clinical Periodontology, 30 (suppl. 5), 2003, 4-6.
26. Coghlan, A. Slime City. New Scientist, 15(2045), (1996), 32-36
27. Cos P, Vlietinck AJ, Berghe DV and Maes L. Anti-infective potential of natural products: how to develop a stronger in vitro 'proof-of-concept'. Journal of Ethnopharmacology, 106(3), 2006, 290–302.
28. Cowan J, Joyce J, MacPherson D and Weedon E. Developing the ability to reflect - the role of others and self. Paper presented at the 4th Northumbria Assessment Conference, 1999
29. Crossner CG, Claeson R and Johansson T. Presence of mutans streptococci and various types of lactobacilli in interdental spaces related to development of proximal carious lesions. Scand J Dent Res., 97, 1989, 307–315
30. De Freitas CS, Diniz HF, Gomes JB, Sinisterra RD, Cortes ME. Evaluation of the substantivity of chlorhexidine in association with sodium fluoride in vitro. PesquiOdontol Bras.,17(1), 2003,78-81
31. Deans SG and Ritchie G. Antibacterial properties of plant essential oils. Int J Food Microbiol., 5,1987,165-180.
32. Derwich E, Benziane Z, Chabir R and Taouil R. In vitro activity and GC/MS analysis of the erssential oil extract of leaves of Rosmarinusofficianalis grown in Morocco. Int J Pharm Pharmaceut Sci., 3, 2011, 89-95
33. Didry N, Dubreuil L, Trotin F, and Pinkas M. Antimicrobial activity of aerial parts of Droserapeltata Smith on oral bacteria. Journal of Ethnopharmacology, 60(1),1998, 91-96
34. Doughari JH. Antimicrobial activity of Tamarindusindicalinn. Trop. J. Pharm. Res., (5), 2006, 597
35. Dye BA, Tan S, Smith V, Lewis BG, Barker LK, Thornton-Evans G et al. Trends in oral health status: United States, 1988–1994 and 1999–2004. Vital Health Stat.,248, 2007,1–92
36. Fabricant DS and Farnsworth NR The value of plants used in traditional medicine for drug discovery. Environ Health Pers.,109 (Suppl 1), 2001,69-75
37. Featherstone JD. The science and practice of caries prevention. J Am Dent Assoc.,131(7), 2000, 887-899
38. Feres M, Gursky LC, Faveri M, Tsuzuki CO, Figueiredo LC. Clinical and microbiological benefits of strict supragingival plaque control as part of the active phase of periodontal therapy. J ClinPeriodontol. 36 (10), 2009, 857-867
39. Filoche SK, Soma K, and Sissons CH. Antimicrobial effects of essential oils in combination with chlorhexidinedigluconate. Oral Microbiology and Immunology, 20 (4), 2005, 221–225
40. Geissman T A. In Biogenesis of Natural Compound8, Ed. by Bernfeld, P. Oxford: Pergamon Press Ltd., 1965, 590.
41. Generalic I, Skroza D, Surjaka J, Mozinab S S, Ljubenkovc I, Katalinic A, SimateVandVisˇnjaKatalinic. Seasonal Variations of Phenolic Compounds and Biological Properties in Sage (Salvia officinalis L.). ChemBiodivers, 9, 2012, 441-457
42. Gurib-Fakim. A Review – Medicinal plants: Traditions of Yesterday and drugs of tomorrow. Mol Asp Med.,27, 2006,1- 93
43. Hamilton-Miller JMT. Anti-cariogenic properties of tea (Camellia sinensis). J Med Microbiol., 50, 2001, 299-302
44. Hammer KA, Carson CF, Riley TV, and Nielsen JB. A review of the toxicity of Melaleucaalternifolia (tea tree) oil. Food and Chemical Toxicology, 44, 2006, 616–625
45. Hammer KA, Dry L, Johnson M, Michalak EM, Carson CF and Riley TV. Susceptibility of oral bacteria to Melaleucaalternifolia (tea tree) oil in vitro. Oral Microbiology and Immunology, 18(6), 2003, 389–392
46. Haslam E. Natural polyphenols (vegetable tannins) as drugs and medicines: possible modes of action. Journal of Natural Products,59, 1996, 205-215
47. Hopp KH, Cunningham LV, Bromel MC, Schermeister L J and Wahba Khalil S K. In vitro antitrypanosomal activity of certain alkaloids against Trypanosomalewisi. Lloydia, 39, 1976, 375–377
48. Hu JP, Takahashi N, and Yamada T. Coptidisrhizoma inhibits growth and proteases of oral bacteria. Oral Diseases, 6 (5), 2000, 297–302
49. Hwang JK, Chung JY, Baek NI and Park JH. Isopanduratin a from Kaempferiapandurata as an active antibacterial agent against cariogenic Streptococcus mutans. International Journal of Antimicrobial Agents 23 (4), 2004, 377–381.
50. Hwang JK, Chung JY, Baek NI, and Park JH. Isopanduratin a from Kaempferiapandurata as an active antibacterial agent against cariogenic Streptococcus mutans. International Journal of Antimicrobial Agents, 23(4), 2004, 377–381.
51. Hwang JK, Shim JS, and Pyun YR. Antibacterial activity of xanthorrhizol from Curcuma xanthorrhiza against oral pathogens. Fitoterapia, 71(3), 2000, 321–323
52. Jawla S, Gupta AK, Singla R and Gupta V. General awareness and relative popularity of allopathic, ayurvedic and homeopathic systems Journal of Chemical and Pharmaceutical Research, 1 (1), 2009,105-112
53. Jay P. The reduction of oral Lactobacillus acidophilus counts by the periodic restriction of carbohydrates. Am J Orthod Oral Surg., 33, 1947, 162–172
54. Jenkinson HF and Lamont RJ. Oral microbial communities in sickness and in health. Trends in Microbiology. 13(12), 2005, 589-595.
55. Kakiuchi N, Hattori M, Nishizawa M, Yamagishi T, Okuda T and Namba T. Studies on dental caries prevention by traditional medicines. VIII. Inhibitory effect of various tannins on glucan synthesis by glucosyltransferase from Streptococcus mutans. Chem Pharm Bull., 34 (2), 1986, 720-725
56. Kalemba D and Kunicka A. Antibacterial and antifungal properties of essential oils. Current Medicinal Chemistry, 10 (10), 2003, 813–829.
57. Kashket S, Paolino VJ, Lewis DA and Van Houte J. In vitro inhibition of glucosyltransferase from the dental plaque bacterium Streptococusmutans by common beverages and food extracts. Arch Oral Biol., 30, 1985, 821-826
58. Katsura H, Tsukiyama RI, Suzuki A, and Kobayashi M. In vitro antimicrobial activities of bakuchiol against oral microorganism. Antimicrobial Agents and Chemotherapy, 45(11), 2001, 3009–3013

59. Koga T, Oho T, Shimazaki Y and Nakano Y. Immunization against dental caries. Vaccine, 20(16), 2002, 2027–2044
60. Kroes I, Lepp PW and Reiman DA. Bacterial diversity within the human subgingivalcrevice. ProcNatlAcadSci., 96(25), 1996-1999, 14547-14552
61. Lee SS, Zhang W, and Li Y. The antimicrobial potential of 14 natural herbal dentifrices: results of an in vitro diffusion method study. Journal of the American Dental Association, 135(8), 2004, 1133–1141
62. Liljemark WF and Bloomquist C. Human oral microbial ecology and dental caries and periodontal diseases. Crit Rev Oral Biol Med., 7, 1996, 180–198
63. Liu XT, Shi Y, Yu B et al. Antibacterial diterpenoids from Sagittariapygmaea. PlantaMedica, 73 (1), 2007, 84–90.
64. Loesche W. Dental caries and periodontitis: contrasting two infections that have medical Implications. Infectious Disease Clinics of North America. 21 (2), 2007, 471– 502
65. Lonn-Stensrud J, Petersen FC, Benneche T and Scheie AA. Synthetic bromated furanone inhibits autoinducer- 2-mediated communication and biofilm formation in oral Streptococci. Oral MicrobiolImmunol., 22(5), 2007, 340–346
66. Luna Chamouleau, Chamouleau Argueta and Cano. Phytotherapy Research, 1994, 1990, 1985, 2008, 22(4), (3)13, 557-559
67. MadhuRathore, Kanika Sharma and Naveen Sharma. Antimicrobial Potential of Botanicals and Disease control. The Natural Products Journal,Vol. 1, 2011,105-115
68. Marsh PD. Are dental diseases examples of ecological catastrophes.Microbiology, 149, 2003, 279–294
69. Marsh PD. Dental plaque as a biofilm and microbial community-Implications for health and disease. BMC Oral Health 6 (Suppl 1), 2006, S14
70. Marsh PD. Dental plaque as a microbial biofilm. Caries Re., 38, 2004, 204-211
71. Marsh PH and Mikel M. Oral Microbiology, translation of Malekzadeh F, Mal ekzadeh SH. Rouzbahani Co.,1990, 23-50.
72. McBain AJ, Ledder RG, Sreenivasan P and Gilbert P. Selection for high-level resistance by chronic triclosan exposure is not universal. Journal of Antimicrobial Chemotherapy, 53(5), 2004, 772–777.
73. McBain AJ, Ledder RG, Sreenivasan P, and Gilbert P. Selection for high-level resistance by chronic triclosan exposure are not universal. Journal of Antimicrobial Chemotherapy, 53(5), 2004, 772–777
74. Mitsunaga T and Abe I. Inhibitory effects of bark proanthocyanidins on the activities of glucosyltransferases of Streptococcus sobrinus, J Wood Chem Technol., 17, 1997, 327–340
75. Moreno S, Scheyer T, Romano CS and Vojnov AA. Antioxidant and antimicrobial activities of R. officianalis L. extracts linked to their polyphenol composition. Free Rad Res., 40 (2), 2006, 223–231
76. Morgan TD, Beezer AE, Mitchell JC and Bunch AW. A microcalorimetric comparison of the anti-Streptococcus mutans efficiency of plant extracts and antimicrobial agents in oral hygiene formulations. J ApplMicrobiol., 90, 2001,53-58
77. Nagata H, Inagaki Y, Yamamoto Y, Maeda K, Kataoka K, Osawa K, et al., Inhibitory effects of macrocarpals on the biological activity of Porphyromonasgingivalis and other periodontopathic bacteria. Oral Microbiology and Immunology, 21, 2006, 159–163
78. Nakatani N. Natural antioxidents as spices. In Phenolic compounds in food and their effects on health II eds Huang, M-T., Ho, C-T. and Lee, C.Y. ACS Symposium Series 507, Washington DC, American Chemical Society, 1992, 73-86
79. National Institutes of Health Diagnosis and management of dental caries throughout life NIH Consens Statement,18, 2001, 1–30
80. Naveen Sharma, MadhuRathore and Kanika Sharma. Role of Natural Metabolites in Plant Disease Management. Elixir Bio Tech.,41, 2011, 5637-5647
81. Niclaus P and L-Michel CB. Chlorhexidinedigluconate-An agent for chemical plaque control and prevention of gingival inflammation J. Periodontal Res., Suppl.,1986,74-89
82. Nostro A, Cannatelli MA, Crisafi G, Musolino AD, Procopio F and Alonzo V. Modifications of hydrophobicity, in vitro adherence and cellular aggregation of Streptococcus mutans by Helichrysumitalicum extract. Letters in Applied Microbiology, 38(5), 2004,423–427
83. Offenbacher S, Jared HL, O'Reilly PG, Wells SR, Salvi GE, Lawrence HP et al. Potential pathogenicmechanisms of periodontitis associated pregnancy complications. Ann. Periodontol, 3, 1998, 233–250
84. Okuda T, Toshida T and Hatano T. Pharmacologically active tannins isolated from medical plants. In Plant Polyphenols: Synthesis, Properties, Significance eds Hemingway, R.W.andLaks, P. E. New York and London, Plenum Press. 1992, 539-569
85. Ooshima T, Minami T, Aono W, Tamura Y and Hamada S. Reduction of dental plaque deposition in humans by Oolong tea extracts. Caries Res., 28,1994, 146- 149
86. Ooshima T, Minami T, Matsumoto M S, Fujiwara T, Sobue S and Hamada S. Comparison of the cariostatic effects between regimes to administer Oolong tea polyphenols in SPF rats. Caries Res., 32, 1998, 75-80
87. Ooshima T, Osaka Y, Sasaki H, Osawa K, Yasuda H, Matsumura M, et al. Caries inhibitory activity of cacoa bean husk extract in in vitro and animal experiments. Arch Oral Biol., 45, 2000, 639-645
88. Park KM, You JS, Lee HY, Baek NI and Hwang JK. Kuwanon G. An antibacterial agent from the root bark of Morusalba against oral pathogens. Journal of Ethnopharmacology, 84(2-3), 2003, 181–185
89. Paster BJ, Boches SK, Galvin JL et al. Bacterial diversity in human subgingival plaque. J Bacteriol. (183), 2001, 3770-3783
90. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, and Ndiaye C. The Global burden of oral diseases and risks to oral health. Bulletin of the World Health Organization, 83(9), 2005, 661–669
91. Petersen PE. The burden of oral disease: challenges to improving oral health in the 21st century. Bulletin of the World Health Organization, 83 (1), 2005, 3
92. Petersen PE. The World Oral Health Report continuous improvement of oral health in the 21st century—the approach of the WHO Global Oral Health Programme. Community Dentistry and Oral Epidemiology, 31(3), 2003, 24
93. Phillipson J D and O'Neill M J. New leads to the treatment of protozoal infections based on natural product molecules. Acta Pharm Nord., 1, 1987, 131–144
94. Pizzo G, La Cara M, Licata ME, Pizzo I, D'Angelo M. The effects of an essential oil and an amine fluoride/stannous fluoride mouthrinse on supragingival plaque regrowth. J Periodontol., 79 (7), 2008, 1177-1183
95. Principe P. Monetising the pharmacological benefits of plants. US Environmental protection Agency, Washington, D.C.,2005-1991
96. Rasooli I, Shayegh S, Taghizadeh M, Darvish S and Astaneh A. Phytotherapeutic prevention of dental biofilm formation. Phytother Res.,22, 2008,1162–1167
97. RathoreMadhu, Sharma Naveen and Sharma Kanika. Plant based drugs against tuberculosis infections. Novel Science International Journal of Medical Science, 1(5): 2012, 148-154
98. Rautemaa R, Lauhio A, Cullinan MP, and Seymour GJ. Oral infections and systemic disease-an emerging problem in medicine. Clinical Microbiology and Infection, 13(11), 2007, 1041–1047
99. Ross MSR and Brain KR. An Introduction to Phytopharmacy. Pitman Medical Kent, 1977, 84
100. Rukayadi Y and Hwang JK. In vitro activity of xanthorrhizol against Streptococcus mutans biofilms. Letters in Applied Microbiology, 42 (4), 2006, 400–404
101. Sakanaka S, Kim M, Taniguchi M and Yamamoto T. Antibacterial substances in japanese green tea extract against Streptococcus mutans, a cariogenic bacterium. AgricBiol Chem., 53 (9), 1989, 2307-2311

102. Santos A. Evidence-based control of plaque and gingivitis. Journal of Clinical Periodontology, 30 (suppl. 5), 2003,13–16.
103. Sato M, Fujiwara S, Tsuchiya H et al. Flavones with antibacterial activity against cariogenic bacteria. Journal of Ethnopharmacology, 54(2-3), 1996,171–176
104. Sato M, Tanaka H, Fujiwara S et al. Antibacterial property of isoflavonoids isolated from Erythrinavariegata against cariogenic oral bacteria. Phytomedicine, 10(5), 2003, 427–433
105. Sbordone L and Bortolaia C. Oral microbial biofilms and plaque-related diseases: Microbial communities and their role in the shift from oral health to disease. Clin Oral Investig. 7(4), 2003, 181-188
106. Scalbert A. Antimicrobial properties of tannin. Phytochem., 30, 1991) 3875-3883
107. Scannapieco F A. Role of oral bacteria in respiratory infection. J. Periodontol.70, 1999, 793–802
108. Scheie AA, Arneberg P and Krogstad O. Effect of orthodontic treatment on prevalence of Streptococcus mutans in plaque and saliva. Scand J Dent Res., 92, 1984, 211–217
109. Schultes R E. The kingdom of plants. In: Thomson W A R, editor. Medicines from the Earth. New York, N.Y: McGraw-Hill Book Co., 1978, 208
110. Sharma N. and Sharma K. Antifungal activity of Origanummajorana against Deteuromy- cetesfungi. Asian Journal of Experimental Science, 24 (1), 2010, 101-105
111. Sharma N., Kumari J.,Rathore M., Sharma A., Sharma K. Antifungal activity of some Medicinal Herb Extracts against fungi imperfectii. Journal of Pure and Applied Microbiology, 2(2), 2008, 563-567
112. Sharma, N., Rathore, M., De. Eric Clarq and Sharma, K. Study of Antiviral Potential and Cytotoxicity of Plant Extract and Essential oil from Origanummajorana.J. Innovative Medicine and Biology(CIJIMB), N1Jen.,2011,p. 74
113. Silva MLDA, Coímbra HS, Pereira AC et al. Evaluation of Piper cubeba extract, cubebin and its semi-synthetic derivatives against oral pathogens. Phytotherapy Research 21(5), 2007, 420–422
114. Socransky SS and Haffajee AD. Periodontal microbial ecology. Periodontol. (38), 2000, 135-187
115. Stern DI, Common MS and Barbier E B. Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development. World Development, 24, 1996, 1151-1160.
116. Stuffness M and Douros J. Current status of the NCL plant and animal product program, J. Nat Prod., 45, 1982, 1-14
117. Takarada K, Kimizuka R, Takahashi N, Honma K, Okuda K, and Kato T. A comparison of the antibacterial efficacies of essential oils against oral pathogens. Oral Microbiology and Immunology, 19 (1), 2004, 61–64
118. Tichy J and Novak J. Extraction, assay, and analysis of antimicrobials from plants with activity against dental pathogens (Streptococcus sp.). Journal of Alternative and Complementary Medicine, 4 (1), 1998, 39-45
119. Tim Cushnie TP and Lamb AJ Antimicrobial activity of flavonoids. Int J Antimicro Ag; 26, 2005, 343-356.
120. Tsai PJ, Tsai TH and Ho SC In vitro inhibitory effects of rosemary extracts on growth and glucosyltransferase activity of Streptococcus sobrinus. Food Chem., 105, 2007, 311–316
121. Uzel A, Sorkun K, Önçağ O, Çoğulu D, Gençay O, and Salih B. Chemical compositions and antimicrobial activities of four different Anatolian propolis samples. Microbiological Research, 160(2), 2005,189–195.
122. Van Houte J, Lopman J and Kent R. The predominant cultivable flora of sound and carious human root surfaces. J Dent Res., 73, 1994, 1727–1734
123. Wang F, Li F, Chai ZG and Sun M. Anti-biofilm Effect of Dental Adhesive with Cationic Monomer, Journal of Dental Research, 88,2009,372-376
124. Wolinsky L and Sote EO. Isolation of natural plaque-inhibiting substances from 'Nigerian chewing sticks'. Caries Res., 18,1984, 216-225
125. Wong J H and Ng T B.Vulgarinin, a broad-spectrum antifungal peptide from haricot beans (Phaseolus vulgaris). Int. J. Biochem. Cell Biol.37, 2005, 1626
126. Wu T, Trevisan M, Genco RJ, Dorn JP, Falkner KL and Sempos CT. Periodontal disease and risk of cerebrovascular disease: thefirst national health and nutrition examination survey and its follow-up study. Arch. Intern. Med.,160, 2000, 2749–2755
127. Xu QA, Yu F, Fan MW, Bian Z, Chen Z, Peng B et al. Protective efficacy of a targeted anti-caries DNA plasmid against cariogenic bacteria infections. Vaccine, 25(7),2007, 1191–1195
128. Yaegaki K, Tanaka T, Sato T, Murata T, Imai T, Tagashira M et al. Hop polyphenols suppress production of water-insoluble glucan by Streptococcus mutans and dental plaque growth in vivo. J Clin Dent.,19 (2), 2008,74-78
129. Yatsuda R, Rosalen PL, Cury JA et al. Effects of Mikania genus plants on growth and cell adherence of mutansStreptococci. Journal of Ethnopharmacology, 97(2), 2005, 183–189,
130. Yeo BK, Lim LP, Paquette DW and Williams RC. Periodontal disease—the emergence of a risk for systemic conditions: pre-term low birth weight. Annals of the Academy of Medicine Singapore, 34(1), 2005, 111–116
131. Yoshino K, Nakamura Y, Ikeya H, Sei T, Inoue A, Sano M, et al. Antimicrobial activity of tea extracts on cariogenic bacterium (Streptococcus mutans). J Food HygSoc Jap., 37 (2), 1995,104-108