Biomedical & Pharmacology Journal, June 2018. Vol. **11**(2), p. 1073-1082

Herbendodontics – Phytotherapy In Endodontics: A Review

S. Vishnuvardhini, Andamuthu Sivakumar, Vaiyapuri Ravi, A.S. Prasad and J.S. Sivakumar

Department of Conservative Dentistry and Endodontics,
Vivekanandha Dental College for Women, India.
*Corresponding author E-mail: s.vishnuvardhini@gmail.com

http://dx.doi.org/10.13005/bpj/1468

(Received: 10 April 2018; accepted: 04 June 2018)

Plants have been used for health disorders and to prevent diseases including epidemics since times immemorial. Many plants are used as Phytomedicines in dentistry because they possess varying degree of biological and antibacterial effects. In endodontics, plants and their extract can be used as irrigant and intracanal medicament to prevent the potential side effects caused by conventional chemical agents. Such herbal preparations are derived from the roots, leaves, seeds, stems and flowers of medicinal plants. This paper emphasize on the advantages of different herbal plants and their products when used as phytotherapy in endodontics.

Keywords*:* Endodontics, Root canal system, Microorganisms, Herbs, Phytotherapy, irrigants, intracanal medicaments, E. faecalis.

The potential role of microorganisms in the initiation and progression of endodontic infections has long been established. So, the main objective of endodontic treatment is either prevention or repair of periapical pathosis caused by these microorganisms[1,2] In order to achieve complete elimination of infection and to promote helaing,"chemo-mechanical preparation" of the tooth is carried out by mechanical instrumentation of the root canal space with simultaneous use of chemical agents[3]

Nowadays there has been an increasing trend to seek herbal alternatives for endodontic treatment. This way of use of herbals for curing various diseases is known as "Phytotherapy or Phytomedicine or Ethnopharmacology". In recent years, there has been an extreme growth in the field of herbal medicine due to their beneficial properties, ease of availability and less side effects[4]

The root canal anatomy is complex and the challenging part of endodontic treatment is to disinfect this complex system most effectively. For this purpose, irrigants and intracanal medicaments are used in endodontics which primarily reduces the microorganisms inside the root canal system. The most commonly used irrigants in endodontics are sodium hypochlorite (NaOCl), ethylene-diamine-tetra-acetic acid (EDTA) solution and chlorhexidine (CHX) which can cause harmful side effects. Intracanal medicaments such as calcium hydroxide causes collagen breakdown and leads to weakening of radicular dentin. Triple antibiotic paste containing minocycline, metronidazole and ciprofloxacin have potential side effects of tooth discoloration and also cause demineralisation of dentin[5-7]

In the search for novel irrigants and intracanal medicaments with good biocompatibility

and antimicrobial activity, researchers have explored a number of potential agents of natural origin. India has rich source of medicinal plants that are widely distributed throughout the country[1] In ancient times, they believed that right herb in the right combination keeps the body system in harmony. Herbs contains different components such as essential oils, flavonoids, tanins and alcohols through which it attains varying degree of medicinal values[4]

Plants, animals & minerals are all sources of phytotherapeutic agents. Many herbs have potential use in endodontics which can be used with minimal incidences of complications.

Herbal Alternatives used as Irrigants in Endodontics

***Azadiarachta indica* – Neem**

It is also called as "Indian neem / Margosa tree / Indian lilac". This medicinal tree common in India, is considered holy. US National Academy of Sciences entitled neem as "a tree for solving global problems" as it produces numerous biological activities[8]

Tetranortriterpenes extracted from neem are nimbin, nimbidinin, nimbolide and nimbidinic acid. The crude extracts from their leaves, bark, flowers, roots and seeds have various pharmacologic actions. It possess a significant antibacterial action against many gram positive and gram negative microorganisms such as *Streptococcus mutans*, *M.tuberculosis, Streptomycin resistant strains, M.pyogenes, Vibrio cholera* & *Klebsiella pneumonia.*[9]

From the studies done by Bohra *et al*, it reveals us that the aqueous and ethanolic extract of neem leaf has potential action against *E. faecalis*. It is as effective as NaOCl. [10] So, neem can be used as a potential alternative to sodium hypochlorite against endodontic microflora.

***Melaleuca alternifolia* – Tea tree oil**

This tree is native to wet lowland locations of Australia. Its height is usually 10-25 feet and has a papery white bark, dark green needle-like leaves and colourful blossoms. It possess great antibacterial and antifungal properties due to the presence of its major active component terpinen-4-ol (30%-40%). It has also mild tissue solvent action which can be used for dissolving necrotic pulp tissue[11]

In an in vitro study done by Sadr Lahijani, it is demonstrated that tea tree oil is as effective as NaOCl and less toxic than NaOCl[12]

***Curcuma longa* – Turmeric**

Turmeric belongs to Zingiberaceae family which is a perennial plant with small stem, large oblong leaves and bears ovate brownish yellow rhizomes. This popular Indian herb is used since ancient times as food preservatives, colouring material and in traditional medicine for treating sprains and swelling caused by injury. Turmeric contains polyphenols like curcuminoids [curcumin (diferuloylmethane), dimethoxycurcumin & bisdimethoxycurcumin] and various volatile oils like tumerone, atlantone & zingiberone[13] In this curcumin is the main yellow pigment which is responsible for antimicrobial, anti-inflammatory, antioxidant, anticarcinogenic, anti mutagenic, antifungal and anti –coagulant activities.

The antimicrobial action of turmeric is due to the reason that curcumin destroys the assembly of a protein-filamenting temperature-sensitive mutant Z (FTSZ) profilaments and enhances the GTPase activity of FTSZ which are all deterimental to bacteria[14] As an irriganting solution, turmeric prevents the formation of biofilms. This is because it eliminates the extracellular polymeric substance matrix which serves as the source of nutrient or substrate for further cell growth of bacteria[15]

Many in vitro studies have proved the beneficial effects of curcumin when used as aqueous solutions against gram positive bacterias like *E. faecalis*, *Streptococcus intermedius* and other gram negative bacteria like *E. coli.* Prasanna Neelakantan et el done an in vitro study to compare the antimicrobial activity of curcumin and NaOCl against *E. faecalis* which showed that curcumin has similar antimicrobial action as NaOCl[16] In 2013, Hemanshi Kumar *et al* designed an in vitro study in which they found that curcumin extract showed larger zones of microbial inhibition against the *E.faecalis* anaerobes. Hence, it can be used as an endodontic irrigant especially in retreatment cases[17]

***Morinda citrifolia* – Noni fruit**

Noni also known as Indian Mulberry, nono or nonu, BaJiTian, cheese fruit and Nhau in various countries across the world. They are indigenous in tropical countries. It is discovered by Polynesians and it has been used as one of the traditional folk medicinal plants over 2000 years[18]

A variety of compounds have been identified from Noni fruit such as Acubin, L-asperuloside, atizarin and also some anthraquinone compounds which are responsible for its antimicrobial activity against infectious bacterial strains like *Pseudomonas aeruginosa, Proteus morgaii and Shigella*[19] Besides this, it also exhibits anti tumor, anti-inflammatory, analgesic, anthelmintic and immune-enhancing properties[20]

In 2008, Murray *et al* conducted a study to evaluate the efficacy of Morinda citrifolia juice (MCJ) as an irrigating solution. The results of the study showed that MCJ was same as NaOCl in conjuction with EDTA, in removing smear layer from the instrumented root canal walls[21] It was the first juice to be indicated as a possible alternative to NaOCl as an endodontic irrigant as it is biocompatible & antioxidant in nature.

Triphala

It is an ayurvedic combination of dried and powdered fruits of three herbal plants namely *Terminalia bellerica* (Bibhitaki), *Terminalia chebula* (Halituki) and *Emblica officinalis* (Amalaki). Triphala consists of tannins, quinones, flavonoids, gallic acid and vitamin C. Bacterioststic and bactericidal properties of triphala are mainly because of tannic acid. It can be used as chelating agent due to the presence of citric acid in its fruits. Dimethyl sulfoxide was used as a solvent for triphala.

Emblica officinalis has got antimicrobial and cytotoxic effects whereas ethanolic extract of *Terminalia chebula* has broad spectrum activity against different bacterias like *Salmonella typhi, Staphylococcus epidermidis & Bacccilus subtilis*. *Terminalia bellerica* was found to be highly potential when compared to other two fruits. It also has more potency against *E. faecalis*[22] In a study conducted by Prabhakar *et al* in 2010, revealed that triphala was effective against root canal biofilms and are similar to NaOCl & doxycycline based irrigating agents. This is because its free radical scavenging action makes it an efficient tool to prevent formation of biofilm[23]

***Syzigium aromaticum* – Clove**

Essential oils of clove are eugenol, isoeugenol and vanillin which exhibits antioxidant, antibacterial and anodyne effects. Clove oil has sedative action on pulpal inflammation[24]

Gupta *et al* made an SEM study to evaluate the effectiveness of three different plant extracts namely *Syzigium aromaticum* (clove), *Ocimum sanctum* (tulsi) and *Cinnamum zeylanicum* (cinnamon) when used as an endodontic irrigant. The study results revealed that among the experimental groups tested, Syzigium aromaticum along with EDTA was the most effective in removing smear layer[25]

***Acacia nilotica* – Babool**

Babool also called as Gum Arabic tree

S.no	Phytomedicines Used In Endodontics	Active Ingredients
1.	*Azadiarachta indica* – Neem	Nimbin, nimbidinin, nimbolide and nimbidinic acid
2.	*Melaleuca alternifolia* – Tea tree oil	Terpinen-4-ol
3.	*Curcuma longa* – Turmeric	Curcuminoids, tumerone, atlantone & zingiberone
4.	*Morinda citrifolia* – Noni fruit:	Acubin, L-asperuloside, atizarin & anthraquinone
5.	Triphala	Tannins, quinones, flavonoids, gallic acid and vitamin C.
6.	*Syzigium aromaticum* - Clove	Eugenol, isoeugenol and vanillin.
7.	Acacia nilotica - Babool	Tannins, phenolic compounds, essential oils & flavonoids
8.	*Allium sativa* - Garlic	Allicin
9.	Zingiber officinale – Ginger	Zingerone, gingerol & 6-shagoal
10.	Propolis – Honey bee wax	Flavonoids and cinnamic acid derivatives
11.	*Aloe barbadenis* – Aloe vera	Aloin and aloe-emodin
12.	*Agaricus bisporus* - Mushroom	Plectasin, confuentin, grifolin and neogrifolin
13.	*Arctium lappa*	Sesquiterpene lactones and inulin
14.	*Glycyrrhiza glabra* - Liquorice	Triterpenoid compound - Glycyrrhizin
15.	Rhus plants	Tannins & gallic acids
16.	*Vaccinium macrocarpon* - Cranberry	Flavonoids, phenolic acids, anthocyanins and condensed tannins
17.	*Psidium guajava* - Guava	Guajaverin
18.	*Riccinus communis* - Castor	Ricinoleic acid

is common species found in Indian and African sub-continent. It consists of tannins, phenolic compounds, essential oils & flavonoids which are all responsible for its antimicrobial antioxidant, antifungal, antiviral and antibiotic functions.

Rosina Khan *et al* revealed that this tree possess effective antimicrobial action against *Streptococcus mutans* and *E. faecalis*[26] Dhanya Kumar *et al* in 2011 investigated the antibacterial activity of four plant extracts namely clove, cinnamon, liquorice and babool and stated that babool is most effective in erradicating E. faecalis organisms when used at 50% concentration[27]

***Allium sativa* – Garlic**

The bulbs of garlic or Amaryllidaceae has been used medicinally as antimicrobial & antihyperlipidemic agent since ancient times. It has also numerous other effects such as detoxification, antioxidant, anticarcinogenic, anticoagulant, antihypertensive, antibacterial, antifungal, antiviral and anti-inflammatory[28]

The active ingredient of garlic is allicin which makes garlic a popular antimicrobial agent and produces immunological functions. Allicin has detrimental action on the cell wall and cell membrane of the bacterias. It was found that the ethanolic extract of garlic are effective against *Stahylococcus aureus* and it exhibits both bacteriostatic & bactericidal activity[29] Also it was shown that the aqueous solution of garlic has antibacterial effect against 17-multidrug-resistant bacterial isolates. So this can be utilised as an herbal alternative to NaOCl[30]

In 2014, a study was done by Basma A. Alrazhi *et al* to evaluate the antibacterial activity of garlic and ginger as irrigant. In that garlic extract reported to inhibit the formation of biofilms by *Streptococcus epidermidis* and exhibited antibacterial efficacy against *E. faecalis*[31]

***Zingiber officinale* – Ginger**

The rhizomes of Zingiberaceae are commonly used ingredient in large number of foods & beverages across the world. They was found to have anti-inflammatory, analgesic, antipyretic, antimicrobial and hypoglycemic actions[32] Zingerone, gingerol & 6-shagoal were the major components determined in ginger. Ethanol & n-hexane extracts of ginger exhibits antibacterial activities against aerobic bacterias associated with periodontitis[33, 34] Moreover it was found that the ethanolic extract was effective against *Candida albicans and E. faecalis*.

The efficacy of ethanolic extract of ginger was compared with chlorhexidine and garlic extract in a study, in that ginger exhibited highest antibacterial efficacy against *E. faecalis*[31] From the reported literature, ginger produced markable antimicrobial effect against gram negative bacterias like *Porphyromonas gingivalis, Porphyromonas endodontalis* and *Prevotella intermedia.* This is because that gingerol present in ginger inhibited the growth of these organisms[35]

Jeeryin

This is a Chinese herbal plant which were popular for its antimicrobial properties. It is effective against anerobes when used as irrigating solution along with ultrasonic activation. The 30% jieeryin solution has similar effect as that of NaOCl in root canal irrigation[36]

Hybanthus enneaspermus

It is popularly called as Ratanpurus that belongs to Violaceae family, is herb or under shrub seen in tropical and sub-tropical areas. It has anti-inflammatory and anti-oxidant properties[37-41]

In a study done by Kalepu Vamsi *et al* in 2014, to evaluate the antibacterial activity of *Hybanthus enneaspermus* & CHX against *E. faecalis,* the study results showed that 50% aqueous form of *Hybanthus enneaspermus* inhibits the most resistant anaerobe *E. faecalis* and its effect is as comparable with that of CHX[42]

Herbal Alternatives used as Intracanal Medicaments in Endodontics

***Propolis* – Honey bee wax**

Propolis is a natural antibiotic resinous material obtained by honey bees (*Apis mellifera L.*) from different plant species like trees of poplars & conifers and mix with wax and other substances. It exhibits varying degree of antioxidant, antiviral, anti-inflammatory , antibacterial, antifungal, antitumor, immunomodulating, pharmacological properties such as healing, cytostatic & are cariostatic. The main biologically active components present in this antitoxic natural substance are flavonoids and cinnamic acid derivatives[43, 44]

In a study done with propolis, it inhibited the activity of hyaluronidase and has significant anti-inflammatory action as they contain caffeic acid and phenethylester (CAPE)[45] Ethanolic

preparation of propolis enhances bone regeneration and induces hard tissue bridge formation in vital pulp therapy procedures. It also contains viscidone which further makes it used as an irrigating solution. It can also be used as a transport medium for avulsed teeth as it maintains the viability of periodontal ligament cells. Propolis can be effectively used along with calcium hydroxide as dressing for elimination endodontic pathogens especially against *E.faecalis*[46, 47]

***Aloe barbadenis* – Aloe vera**

Aloe vera contains clear gel surrounded by the green part of leaf. The two active components of aloe vera are aloin and aloe-emodin. Its antibacterial action is due to protein synthesis in the bacterial cells and it is rich in vitamins, minerals, enzymes, sugars, lignin, saponins, salicyclic acids and aminoacids[48]

It is effective against *S. pyogenes* and *E. faecalis* due to the presence of anthrax quinine which inhibits the formation of these two organisms. In an in vitro study done by Kurian B *et al* in 2016 showed MIC (Minimal Inhibitory Concentration) of Aloe vera was superior to calcium hydroxide in eliminating *E. faecalis* and its antibacterial activity increased with time period. [49] Compared to other natural extracts, Aloe vera has broad spectrum antibacterial activity against various oral pathogens.

***Agaricus bisporus* – Mushroom**

It has both low and high molecular weight (LMW, HMW) active compounds. Because of these compounds, it possess medicinal properties like immune modulatory, anti-inflammatory, anti-viral, anti-oxidant and antimicrobial properties. The low molecular weight components present in mushroom are plectasin, confuentin, grifolin and neogrifolin which imparts capacity to penetrate deep into dentinal tubules[50]

The gel form of mushroom is used as intracanal medicament. This is prepared by sun drying, grinding and boiling it with distilled water which then followed by adding hydroxyl ethyl cellulose as thickening agent in 2:1 ratio and injected into the canal with a syringe. Also it has been revealed that the gel form of the extract increases the contact time which enhances its performance. It has highest efficacy against gram negative bacterias[49]

***Arctium lappa* - Burdock**

This plant has been obtained from Japan and grown mostly in Brazil. They has many therapeutic applications. It possess antibacterial, antifungal, antiplatelet, antioxidant, diuretic, anxiolytic and HIV inhibitory effect. *Artium lappa* contains sterols, tannins, sulphur containing polyacetylene, volatile fatty oils & polysaccharides. The active constituent of Burdock are sesquiterpene lactones and carbohydrate inulin[51]

The antimicrobial properties of *Arctium lappa* was studied. From that it was concluded that the constituents of *Arctium lappa* showed a great effect against the most organisms such as *E. faecalis, Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis* & *Candida albicans.* This antimicrobial potential of the *Arctium lappa* makes it use as root canal medicament[52]

***Glycyrrhiza glabra* – Liquorice**

They are frequently used Kampo medicines. It exhibits anti-inflammatory, anti-viral & anti-carcinogenic effects. It consists of a triterpenoid compound namely Glycyrrhizin that that imparts sweet taste to the liquorice root[53, 54] Because of this Glycyrrhizin, it possess antimicrobial effect especially against *E. faecalis*[55, 56]

Liquorice also inhibits most of the cariogenic bacterias like *Streptococcus mutans*[57] Its biocompatibility is compared to that of calcium hydroxide due to the presence of pentacyclic triterpenoid structure. But it has slightly acidic pH whereas calcium hydroxide having strong alkaline pH of 12[58]

Rhus plants

Rhus plants are enriched with tannins & gallic acids. Tannins exhibited antibacterial & antifungal properties. Gallic acid aids in healing periradicular inflammation. It also helps in opening up of obliterated dentinal tubules[36]

Nissin

It's a naturally occurring antimicrobial peptide obtained from *Streptococcus lactis* sub species. It exerts antimicrobial activity against a huge range of bacterial spores. It was also shown that it is potential in erradicatiion of *E.faecalis* and superior to calcium hydroxide[59]

Mahendra M *et al* in 2016 done a study to assess the efficacy of Nissin, neem, propolis,

calcium hydroxide & PRP when used as intracanal medicament *against E. faecalis*. The results showed that Nissin produced better results than other tested agents[60]

***Citrus limonum* - Lemon solution**

Lemon solution has pH of 2.21 with lower acidity. It is effective in clearing the smear layer thereby acting as a chelating agent. Fresh lemon solution has antibacterial property making it an ideal root canal medicament without any side effects.

Abuziad & Eissa *et al* done a study, in which fresh lemon solution was shown to have wide antibacterial efficiency against *E. faecalis* and hence can be used as an intracanal medicament[61]

***Vaccinium macrocarpon* – Cranberry**

In ancient times, cranberry was used to treat stomach aches, scurvey and other liver diseases[62] They has numerous biologically active ingredients such as flavonoids, phenols, anthocyanins and condensed tannins.

They have antibacterial, antimicrobial and antiadhesive properties, thereby prevents inhibition of many pathogens and biofilms. The compounds present in cranberry prevents acid formation & reduces the incidence of dental caries. As cranberry juice is naturally very acidic, it may cause erosion of the teeth if used too often which can lead to pain & sensitivity in the teeth[63]

Papaine

Papaine is a proteolytic cysteine enzyme that comes from the latex of the leaves & fruits of the green adult papaya. It exhibits significant bacteriostatic and bactericidal effects.

In the study by Anug Bhardwaj *et al*, antimicrobial efficacy of natural extracts of *M.citrifolia*, papine, *A.vera gel*, 2% CHX and calcium hydroxide against *E.faecalis* were compared. In that Papaine produced significant results as compared to that of CHX than other tested agents[64]

***Eucalyptus globulus* – Eucalyptus**

It is an essential oil obtained from the leaf of Eucalyptus tree. It has anti-inflammatory and antibacterial activities which can be used as a vehicle for intracanal medicaments[65] Studies have reported that Eucalyptus oil in pure concentration were effective on *Pseudomonas aeroginosa* and *Escherichia coli.* Considering the antimicrobial potential of eucalyptus essential oil against resistant microorganisms, it is expected that its association with calcium hydroxide contributes to the control of endodontic infections[66, 67]

***Psidium guajava* - Guava**

The leaves of guava are rich in guajaverin that inhibits S.mutans & Staphylococcus aureus formation that lead to plaque. They also contain phenolic compounds, vitamins, sesquiterpene alcohols, lineol, tannins, tripentenes & flavonoids. These all ingredients make them to exert anti-inflammatory, antimicrobial, antioxidant & antimutagenic properties. The ethanolic extract of it has higher antimicrobial activity[68]

***Riccinus communis* - Castor**

It is rich in castor acid or ricinoleic acid. It can be used as intracanal medicament as well as an irrigant too[69] In an in vitro study conducted by Marcio Carneiro Valera *et al* it was found that castor was able to destroy *Candida albicans* and also significantly reduces the amount of *E. faecalis*[70] In other study done by Lucas da Fonseca Roberti Garcia *et al*, it was observed that calcium hydroxide and Castor oil paste had better activity than calcium hydroxide and propylene glycol paste against microorganisms commonly found in endodontic infections[71]

Carvacol

Carvacrol is extracted from Origanum vulgare. The prime use of carvacrol is inhibition of *E. coli & Pseudomonas aeruginosa.* The main action of Carvacrol is disruption of bacterial cell membrane. It also aids in healing of periapical tissues as they stimulates the fibres of the pulp[72, 73]

It is commercially marketed by various companies like Sigma Aldrich, Biocore, MP Biochemicals, Life chemicals & Glentham Life Sciences Ltd.

CONCLUSION

Herbal formulations are advantageous in many ways. They are safe, easily available, increased shelf life, economic and mainly there is lack of microbial resistance so far. They are most effective if used with proper knowledge. Many studies have concluded that herbal extracts produced promising results when used as endodontic irrigant and intracanal medicament.

REFERENCES

1. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ†free and conventional laboratory rats. *Oral Surg Oral Med Oral Pathol*; **20**: 340†9 (1965).
2. Sundqvist G. Bacteriological studies of necrotic dental pulps. Umea University of Odontol Dissertation, No. 7. Sweden: University of Umea; (1976).
3. Siqueira JF Jr., Rôças IN, Riche FN, Provenzano JC. Clinical outcome of the endodontic treatment of teeth with apical periodontitis using an antimicrobial protocol. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod;* **106**: 757†62 (2008).
4. Sumit mohan, Anuraag Gurtu, Anuag Singhal. Vineet Vinayak. Naturopathy and Endodontics – "A Synergistic approach" *Journal of Dental Sciences & Oral Rehabilitation,* (2012).
5. Kamat S, Rajeev K, Saraf P. Role of herbs in endodontics: An update. *Endodontology;* **23**: 96-100 (2011).
6. Patil DR. Cultural History from the Vayupurana. 1st ed. New Delhi: Motilal Banarsidass Publishers; 1973. p. 230.
7. Groppo FC, Bergamaschi Cde C, Cogo K, Franz†Montan M, Motta RH, de Andrade ED. Use of phytotherapy in dentistry. *Phytother Res;* **22**: 993†8 (2008).
8. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay U. Biological activities and medicinal properties of neem [*Azadirachtaindica*]. *Curr Sci;* **82**: 1336†45 (2002).
9. Subapriya R, Nagini S. Medicinal properties of neem leaves: A review. *Curr Med Chem Anticancer Agents;* **5**: 149†6 (2005).
10. Bohora A, Hegde V, Kokate S. Comparison of the antibacterial efficiency of neem leaf extract and 2% sodium hypochlorite against *E. Faecalis*, *C. Albicans* and mixed culture – An *in vitro* study. *Endodontology;* **22**:8†12 (2010).
11. Parle M, Bansal N. Herbal medicines: Are they safe? *Nat Prod Radiance;* **5**: 6†14 (2006).
12. Sadr Lahijani MS, Raoof Kateb HR, Heady R, Yazdani D. The effect of german chamomile (*Marticaria recutita* L.) extract and tea tree (*Melaleuca alternifolia* L.) oil used as irrigants on removal of smear layer: A scanning electron microscopy study. *Int Endod J;* **39**:190†5 (2006).
13. Chattopadhyay I, Biswas K, Bandyopadhyay U, Banerjee RK. Turmeric and curcumin: Biological actions and medicinal applications. *Curr Sci*; **87**: 44†53 (2004).
14. Rai D, Singh JK, Roy N, Panda D. Curcumin inhibits FTSZ assembly: An attractive mechanism for its antibacterial activity. *Biochem J;* 410:147†55 (2008).
15. Kishen A, George S, Kumar R. *Enterococcus faecalis*†mediated biomineralized biofilm formation on root canal dentine *in vitro*. *J Biomed Mater Res A;* **77**: 406†15 (2006).
16. Neelakantan P, Subbarao C, Subbarao CV. Analysis of antibacterial activity of Curcumin against *Enterococcus fecalis*. *Int J Curr Res Rev;* **3**: 37†42 (2011).
17. Hemanshi Kumar. An in vitro evaluation of the antimicrobial efficacy of Curcuma longa, Tachyspermum ammi, chlorhexidine gluconate, and calcium hydroxide on Enterococcus faecalis, *Journal of Conservative Dentistry,* **16**(2), 144-147 (2013).
18. Morton JF. The ocean-going Noni, or Indian mulberry [Morinda citrifolia, Rubiaceae] and some of its 'colorful' relatives. *Economic Botany;* **46**: 241-56 (1992).
19. Levand O, Larson HO. Some chemical constituents of Morinda citrifolia. *Planta Med;* **36**: 186-7 (1979).
20. Kandaswamy D, Venkateshbabu N, Gogulnath D, Kindo AJ. Dentinal tubule disinfection with 2% chlorhexidine gel, propolis, *Morinda citrifolia* juice, 2% povidone iodine, and calcium hydroxide. *Int Endod J;* **43**: 419†23 (2010).
21. Murray PE, Farber RM, Namerow KN, Kuttler S, Garcia†Godoy F. Evaluation of *Morinda citrifolia* as an endodontic irrigant. *J Endod;* **34**:66†70 (2008).
22. Pulok KM, Sujay R, Sauvik B, Kumar DP, Kanti BT, Utpalendu J, *et al*. Clinical study of 'Triphala': A well-known phytomedicine from India. *Int J Pharm Technol;* **5**:51-4 (2006).
23. Prabhakar J, Senthilkumar M, Priya MS, Mahalakshmi K, Sehgal PK, Sukumaran VG. Evaluation of antimicrobial efficacy of herbal alternatives [Triphala and green tea polyphenols], MTAD, and 5% sodium hypochlorite against Enterococcus faecalis biofilm formed on tooth substrate: An in vitro study. *J Endod;* **36**:83 – 86 (2010).
24. Moon SE, Kim HY, Cha JD. Synergistic effect between clove oil and its major compounds and antibiotics against oral bacteria. *Arch Oral Biol*; **56**: 907-16 (2011).
25. Gupta A, Duhan J, Sangwan P, Hans S, Goyal V. The effectiveness of three different plant extracts used as irrigant in removal of smear layer: A scanning electron microscopic study. *J Oral Health Comm Dent*; **9**(1), 16-22 (2015).
26. Rosina Khan, Barira Islam, Mohd Akram, Shazi Shakil, Anis Ahmad, S.Manazir Ali. Antimicrobial activity of five herbal extracts against multi drug resistant (MDR) strains of

bacteria and fungus of clinical origin, *Molecules,* **14**: 586-597 (2009).

27. Dhanya Kumar N. M., Preena Sidhu. The antimicrobial activity of azardirachta indica, glycyrrhiza glabra, cinnamum zeylanicum, syzygium aromaticum, accacia nilotica on streptococcus mutans and Enterococcus faecalis - An in vitro study. *Endodontology,* **23**(1): 18-25 (2011).
28. Rees LP, Minney SF, Plummer NT, Slater JH, Skyrme DA. A quantitative assessment of the antimicrobial activity of garlic (*Allium sativum*). *World J Microbiol Biotech;* **9**: 303-307 (1993).
29. Palaksha MN, Mansoor A, Sanjoy D. Antibacterial activity of garlic extracts on streptomycin-resistant *Staphylococcus aureus* and *Escherichia coli* solely in with synergism streptomycin. *J Nat Sci Biol Med*; **1**: 12-15 (2010).
30. Durairaj S, Srinivasan S, Lakshmana P. *In vitro* Antibacterial Activity and Stability of Garlic Extract at Different PH and Temperature. *Elec J Biol*; **5**: 5-10 (2009).
31. Basma A. Alrazhi, Alaa H. Diab, Somaia A. Essa, Geraldine M. Ahmed and Shahira M. Ezzat. Antibacterial activity of the ethanolic extracts of allium sativum l. Bulbs and zingiber officinale roscoe rhizomes as irrigating solutions. *World Journal of Pharmacy and Pharmaceutical Sciences,* **3**(6): (324—337) (2014).
32. Mascolo N, Jain R, Jain SC, Capasso F. Ethnopharmacologic investigation of Ginger (*Zingiber officinale*). *J Ethnopharmacol;* **27**: 129-140 (1989).
33. Atai Z, Atapour M, Mohseni M. Inhibitory Effect of Ginger Extract on *Candida albicans*. *Am J Appl Sci.;* **6**: 1067-1069 (2009).
34. Gulve MN, Gulve ND. Comparison of Antimicrobial Efficacy of Ginger Extract and 2% Sodium Hypochlorite against *Enterococcus faecalis* using agar diffusion method. *J Ind Dent Assoc;* **4**: 347-349 (2010).
35. Park M, Bae J, Lee DS. Antibacterial Activity of [10] Gingerol and [12]-Gingerol isolated from Ginger Rhizome against Periodontal Bacteria. *Phytother Res*; **22**: 1446–1449 (2008).
36. Traditional Chinese medicine used in root canal disinfection research. Pharmacy papers (Online article). http:/ eng.hi138.com/?b106.
37. Sahoo S, Kar DM, Mohapatra S, Rout SP, Dash SK. "Antibacterial activity of Hybanthus enneaspermus against selected urinary tract pathogens" *Indian J Pharm Sci*, **68**: 653-5 (2006).
38. Boominathan R, Parimaladevi B, Mandal SC and Ghoshal SK. "Anti-inflammatory evaluation of Ionidium suffruticosam Ging. in rats," *J. Ethnopharmacol*, **91**(2-3), 367-70: (2004).
39. Boominathan R, Parimaladevi B and Mandal SC. "Evaluation of antitussive potential of Ionidium suffruticosam Ging. (Violaceae) extract in albino mice," *Phytotherapy Res.*, **17**: 838-9: (2003).
40. Weniger B, Lagnika L, Vonthron-Senecheau C, Adjabimey D, Gbenou J, Moudachirou M, Brun R, Anton R and Sanni A. "Evaluation of ethnobotanically selected Benin medicinal plants for their in vitro antiplasmodial activity," *J. Ethnopharmacol.*, **90**(2-3), 279: (2004).
41. Hemlatha S, Wahi AK, Singh PN and Chansouria JPN. "Anticonvulsant and free radical scavenging activity of Hybanthus enneaspermus: A preliminary screening,"*Indian J. Traditional Knowledge*, **2**(4): 383-8: (2003).
42. Kalepu Vamsi, and Pradeep Kumar Bholla. "Antibacterial Activity of Hybanthus Enneaspermus against Enterococcus Faecalis - A Root Canal Organism." *International Journal of Dental Sciences and Research*, **2**(6C): 14-16 (2014).
43. Hu F, Hepburn HR, Li Y, Chen M, Radloff SE, Daya S, *et al*. Effects of ethanol and water extracts of propolis (bee glue) on acute inflammatory animal models. *J Ethnopharmacol;* **100**:276†83 (2005).
44. Kosalec I, Pepeljnjak S, Bakmaz M, Vladimir†Knezevi S. Flavonoid analysis and antimicrobial activity of commercially available propolis products. *Acta Pharm;* **55**:423†30 (2005).
45. Scheller S, Ilewicz L, Luciak M, Skrobidurska D, Stojko A, Matuga W, *et al*. Biological properties and clinical application of propolis. IX. Experimental observation on the influence of ethanol extract of propolis (EEP) on dental pulp regeneration. *Arzneimittelforschung;* **28**:289†91 (1978).
46. Banskota AH, Tezuka Y, Kadota S. Recent progress in pharmacological research of propolis. *Phytother Res;* **15**:561†71 (2001).
47. Oncag O, Cogulu D, Uzel A, Sorkun K. Efficacy of propolis as an intracanal medicament against *Enterococcus faecalis*. *Gen Dent*; **54**:319†22 (2006).
48. Wynn RL. *Aloe vera* gel: Update for dentistry. *Gen Dent;* **53**:6†9 (2005).
49. Kurian B, Swapna DV, Nadig RR, Ranjini MA, Rashmi K, Bolar SR. Efficacy of calcium hydroxide, mushroom, and Aloe vera as an intracanal medicament against *Enterococcus faecalis*: An *in vitro* study. *Endodontology;* **28**:137-42 (2016).
50. Alves MJ, Ferreira IC, Dias J, Teixeira V, Martins A, Pintado M. A review on antimicrobial activity of mushroom (*Basidiomycetes*) extracts and

isolated compounds. *Planta Med;* **78**:1707 18 (2012).
51. Pereira JV, Bergamo DC, Pereira JO, Franca Sde C, Pietro RC, Silva- Sousa YT. Antimicrobial activity of Arctium lappa constituents against microorganisms commonly found in endodontic infections. *Braz Dent J*., **16**(3): 192-196 (2005).
52. Gentil M, Pereira JV, Sousa YT, Pietro R, Neto MD, Vansan LP *et al*. In vitro evaluation of the antibacterial activity of *Arctium lappa* as a phytotherapeutic agent used in intracanal dressings. *Phytother Res;* **20**:184 6 (2006).
53. Olukoga A, Donaldson D. Historical perspectives on health. The history of liquorice: The plant, its extract, cultivation, commercialisation and etymology. *J R Soc Promot Health;* **118**:300 4 (1998).
54. Shibata S. A drug over the millennia: Pharmacognosy, chemistry, and pharmacology of licorice. *Yakugaku Zasshi;* **120**:849 62 (2000).
55. Haraguchi H, Tanimoto K, Tamura X, Mizutani K, Kinoshita T. Mode of antibacterial action of retrochalcones from Glycyrrhiza inflata. *Phytochemistry;* : 125–9 (1998).
56. Bodet C, La VD, Gafner S, Bergeron C, Grenier D. A Liquorice extract reduces lipopolysaccharideinduced proinflammatory cytokine secretion by macrophages and whole blood. *J Periodontol*; **79**: 1752–61 (2008).
57. Segal R, Pisanty S, Wormser R, Azaz E, Sela MN. Anticariogenic activity of licorice and Glycyrrhizine I: Inhibition of *in vitro* plaque formation by *Streptococcus mutans*. *J Pharm Sci;* **74**:79 81 (1985).
58. Badr AE, Omar N, Badria FA. A laboratory evaluation of the antibacterial and cytotoxic effect of liquorice when used as root canal medicament. *Int Endod J*; **44**:51 8 (2011).
59. Hemadri M *et al*. Nisin Vs Calcium Hydroxide – Antimicrobial Efficacy on Enterococcus Feacalis – An In-vitro Study. *International Journal of Contemporary dentistry;* **2**(3); (2011).
60. Mahendra M, Agrawal N, Munaga S, Tyagi S. Antimicrobial activity of different biological extracts as intracanal medicament against *Enterococcus faecalis*: An *in vitro* study. *Endodontology*; **28**:166-70 (2016).
61. Abuzied ST, Eissa SA. Comparative Study on Antibacterial Activities of two Natural Plants Versus Three Different Intracanal Medicaments. Available from: http://www.kau.edu.sa/Files/165/Researches/19240_ Comparative%20Study%20On.pdf.
62. Seal M, Rishi R, Satish G, Divya KT, Talukdar P, Maniyar R. Herbal panacea: The need for today in dentistry. *J Int Soc Prev Community Dent* ; **6**: 105 9 (2016).
63. Bodet C, Grenier D, Chandad F, Ofek I, Steinberg D, Weiss EI. Potential oral health benefits of cranberry. *Crit Rev Food Sci Nutr.;* **48**(7): 672-680 (2008).
64. Anuj Bhardwaj, Suma Ballal, and Natanasabapathy Velmurugan. Comparative evaluation of the antimicrobial activity of natural extracts of Morinda citrifolia, papain and aloe vera (all in gel formulation), 2% chlorhexidine gel and calcium hydroxide, against Enterococcus faecalis: An in vitro study. *Journal of Conservative Dentistry,* **15**(3): 293, (2012).
65. Yuri Wanderley Cavalcanti, Leopoldina De Fátima Dantas De Almeida, Mariana Machado Teixeira De Moraes Costa, Wilton Wilney Nascimento Padilha. Antimicrobial activity and pH evaluation of Calcium hydroxide associated with natural products. *Braz Dent Sci.* **13**(8): 49-54, (2010).
66. Cimanga K, Kambu K, Tona l, Apers s, De bruyne T, Hermans N *et al*. Correlation between chemical composition and antibacterial activity of essential oils of some aromatic medicinal plants growing in the democratic republic of congo. *J ethnopharmacol,* **79**(2): 213-20 (2002).
67. Prabuseenivasan S, Jayakumar M; Ignacimuthu S. In vitro antibacterial activity of some plant essential oils. *Bmc complement Altern med,* **39**(6): 486-94, (2006).
68. Sanches NR, Cortez DA, Schiavini MS, Nakamura CV, Filho BP. An evaluation of antibacterial activities of *Psidium guajava*. *Braz Arch Biol Technol* 2005; **48**:429 30.
69. Lucas Da Fonseca Roberti Garcia, Gabriela Lemos De Almeida, Fernanda De C. P. Pires-De-Souza, Simonides Consani. Antimicrobial activity of a calcium hydroxide and Ricinus communis oil paste against microorganisms commonly found in endodontic infections. *Rev Odonto Ciênc*, **24**(4): 406-409, (2009).
70. Marcia Carneiro Valera, Lilian Eiko Maekawa, Luciane Dias de Oliveira, Antonio Olavo Cardoso Jorge, Érika Shygei, and Cláudio Antonio Talge Carvalho. In vitro antimicrobial activity of auxillary chemical substances and natural extracts on Candida albicans and Enterococcus faecalis in root canals. *J Appl Oral Sci,* **21**(2): 118–123, (2013).
71. Lucas da Fonseca Roberti Garcia, Gabriela Lemos de Almeida, Fernanda de C. P. Pires-de-Souza, Simonides Consani. Antimicrobial activity of a calcium hydroxide and Ricinus communis oil paste against microorganisms commonly found in endodontic infections. *Rev. odonto ciênc*, **24**(4): 406-409, (2009).

72. De Vincenzi M, Stammati A, De Vincenzi A, Silano M. "Constituents of aromatic plants: Carvacrol". *Fitoterapia* 2004; **75**: 801-4.

73. Seghatoleslami S, Samadi N, Salehnia A, Azimi S. Antibacterial activity of endemic Satureja Khuzistanica Jamzad essential oil against oral pathogens. *Iran Endod J*; 4:5 9 (2009).