Review Article

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Stretching new Boundaries of Endodontics with Phytotherapy: A review of literature

Abstract::

Root canal treatment has been used as an ultimate boon for various clinical situations, bypassing unnecessary extractions and preserving precious dentoalveolar structures. Although, persistence of microorganisms due to complex anatomy of root structure makes the process complex and challenging. Hence, complete and thorough debridement of the root canal by various endodontic irrigants becomes a prime necessity. In recent times, herbal alternatives are gaining popularity as a means to overcome various limitations of the conventional chemical irrigants. For the ease of the readers, review of various studies, focusing on few herbal irrigantsis summarised in tabular form for quick review &understanding. The tabular form is discussed under the heads viz. material/herbs with active constituent & its mechanism of action, investigators, aim and results/conclusion. We, as dentists of this new era are quite hopeful for these herbal materials to undergo further rigorous research in order to engrave their revolutionary marking in endodontic treatments and so more.

Key-words: Endodontic irrigants, Herbal irrigants, Herbal extracts, Antimicrobial, Antibacterial, Azadirachtaindica, Aloevera, Morinda, Tulsi

Introduction:

Root canal treatment aims to treat the pulpal pathosis by eliminating microorganisms and necrotic pulp through biomechanical debridement, and provide an adequate root filling in order to seal the canals and prevent reinfection.

However, the persistence of microorganisms owing to the complex anatomy of the root canals can lead to failure of the treatment. And here lies the importance of the chemomechanical debridement of the root canals in complete disinfection and to prevent re-infection of the canal.

Thus, we can say that the success of root canal treatment is primarily encircled upon removal of the microorganisms through chemo-mechanical preparation. The action of intracanal medicaments is enhanced by the preparation of canal and it further permits better adaptation of filling materials. At present, sodium hypochlorite (NaOCl) appears to be the most effective because it fulfills most of the requirements for an ideal endodontic irrigant. However, unpleasant taste and odor, cytotoxic effect, resorption, inability to remove smear layer and inability to eradicate microbes totally from the infected canals are the main disadvantages of this popular irrigant.[1]

As the search for novel irrigants and intracanal medicaments with good biocompatibility and antimicrobial activity continued, a number of potential agents of natural origin were discovered.[2] The advantages of herbal alternatives are easy accessibility, least expensive, increase in shelf life, low in toxicity and their lack of microbial resistance so far reported.[1] Many herbs have potential use in endodontics which can be used with minimal incidences of complications.[2]

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In this article, various herbal irrigants are reviewed as an alternative option to the conventional chemical irrigants along with their advantageous and disadvantageous aspects which are much needed before applying them in our daily clinical practice.

The Ideal Requirements of Root Canal Irrigants:

It appears evident that root canal irrigants ideally should [3]

(i) Have a broad antimicrobial spectrum and high efficacy against anaerobic and facultative microorganisms organized in biofilms,
(ii) Dissolve necrotic pulp tissue remnants,
(iii) Inactivate endotoxin,
(iv) Prevent the formation of a smear layer during instrumentation or dissolve the latter once it has formed,
(v) Be systemically nontoxic,
(vi) Be non-caustic to periodontal tissues,
(vii) Be little potential to cause an anaphylactic reaction.

A wide variety of herbal alternatives are available in the market today which are as competent as the conventional chemical endodontic irrigants. This present article collects many of the few relevant studies which support the former statement comparing their numerous advantages and efficacies.

For the ease of the readers, review of various studies, focusing on few herbal irrigants is summarized in tabular form for quick review & understanding. The tabular form is discussed under the heads viz. material/herbs with active constituent & its mechanism of action(s), investigators, aim& results/conclusion.

Table No. 1- Discussion about various Herbal Irrigants used in Dentistry

S. NO	MATERIALS / HERBS	AUTHORS/ INVESTIGATOR	AIM	RESULT/ CONCLUSION
1.	**Aloevera** (Aloe barbadensis) • **Active constituents -** Anthraquinones • **MOA-**Inhibiting protein synthesis in bacterial cells	**1. Vinothkumar et al (2013)[4]**	To evaluate the antimicrobial efficacy of various herbal extractsnamelyCurcuma longa (CL), Azadirachtaindica(AI), Aloe barbadensis(AV), Myristicafragrans(MF) and Terminaliachebula(TC) as endodontic irrigant against E. faecalisand C. albicansusing real-time quantitative polymerase chain reaction (qPCR).	Aloevera was least efficient in reducing E. faecalis and C. albicans when compared to A. indica, C. longa, M.frangrans, T.chebula using real-time quantitative polymerase chain reaction (qPCR).
		2.Karkare et al (2015)[5]	To compare the antimicrobial activity of saturated and diluted (1:1) hydroalcoholic extract of Aloe vera, garlic, and 5% NaOCl against E. faecalisusing the commonly used agar diffusion method.	Aloeverahas highest zone of inhibition against E. faecalis when compared to garlic, and 5% NaOCl.
		3. Babaji et al (2016)[6]	To evaluate the antimicrobial effect of herbal root canal irrigants (Morindacitrifolia, Azadirachtaindicaextract, Aloevera) with sodium hypochlorite (NaOCl).	Aloeverahas least antibacterial inhibitory zone against E. faecalis in comparison to NaOCl, M. citrifolia and A. indica extract using agar well diffusion method.
		4. Seth et al (2016)[7]	To check the antimicrobial efficacy tea tree oil, aloe vera extract, 3% sodium hypochlorite (NaOCl), normal saline (control) & pure cultures of E. faecalis, C. albicans& a mixed culture (1:1) using agar diffusion method.	Aloevera has highest zone of inhibition against E. faecalis than tea tree and NaOCl. No antibacterial efficacy seen against C. albicans and mixed culture.
		5. Noushad et al (2018)[8]	To compare the antimicrobial efficacy of different natural extracts such as guava leaf extract, Aloe vera extract, papaya leaf extract, and cashew apple extract against E. faecalis and C. albicans.	Aloeverahas least zone of inhibition with E. faecalis& no zone of inhibition with C. albicans when compared to cashew apple extract, papaya leaf extract, and guava leaf extract.
2.	**Babool** (Acacia nilotica) • **Active constituents -** Tannins • **MOA-** Inhibit oxidative	**1. Jain et al (2019)[9]**	To compare antibacterial activity against E.faecalis and smear layer removal efficacy of Punicagranatum, Acacia nilotica and Emblicaofficinalis distilled water extracts.	Babool has lowest zone of inhibition with E. faecalis when compared with Punicagranatum and Emblicaofficinalis& has no smear layer removal property.
		2. Gupta et al(2020)[10]	To evaluate and compare the antibacterial efficacy of Thymus vulgaris, Salvadorapersica, Acacia	Babool has higher zone of inhibition with E. faecalis when compared to

	phosphorylation by mitochondria and inhibit electron transport system in mitochondria.		nilotica, Calendula arvensis and 5% sodium hypochlorite against E. faecalis.	Salvadorapersicabut lesser zone of inhibition than 5% NaOCl, 10% C. arvensis, 20% T. vulgaris.
3.	**Clove** (Syzygiumaromaticum) • **Active constituents -** Acetyl eugenol, betacaryophylle, vanillin, crategolic acid, tannins • **MOA-**Completely destroy the integrity and reduce the quality of biofilm, disrupt the bacterial membrane, cause cytoplasm leakage, and form vesicles on the surface of cytoplasmic membrane.	**1. Madhavan et al (2015)**[11]	To demonstrate whether clove oil enhances the antibacterial effect of intracanal medicament.	Cloveenhanced antibacterial effect when combined with the other intracanal medicaments like triple antibiotic paste & Calcium hydroxide against E. faecalis.
		2. Gupta-Wadhwa et al (2016)[12]	To evaluate the intracanal bacterial reduction promoted by chemomechanical preparation using three different herbal extracts named Ocimum sanctum, Cinnamomumzeylanicum, Syzygiumaromaticum against E. faecalis.	Clovehas higher reduction of E. faecalis than O. sanctum but lower reduction than NaOCl and similar efficacy with C.zeylanicum.
4.	**Garlic** (Allium sativum) • **Active constituents -** Allicin • **MOA-** Destroys cell wall and cell membrane of bacteria.	**1. Karkare et al (2015)**[5]	To compare the antimicrobial activity of saturated and diluted (1:1) hydroalcoholicextract of Aloe vera, garlic, and 5% NaOClagainst E. faecalisusing the commonly used agar diffusion method.	Garlichas Lowest zone of inhibition with E. faecalis when compared to Aloe vera extract and5% NaOCl.
		2. Roy et al (2017)[13]	To compare the antifungal efficacy of Garlic extract (Allicin) with two most commonly used root canal irrigating solution (3% NaOCl) Sodium hypochlorite and (2% CHX) Chlorhexidinegluconate.	Garlic exhibits lowest antifungal efficacy against C. albicans when compared to 2% Chlor-hexidine 3% Sodium hypochlorite and higher than saline.
		3. Elheeny (2019)[14]	To assess the clinical and radiographic assessment of Allium sativum extract as an intracanalirrigant for pulpectomy of primary molars.	Clinical and radiographic success rate of Garlic extract as an irrigant for pulpectomy of primary molar root canals was found mildly lower than NaOCl.
5.	**Grapeseeds** (Vitisvinifera) • **Active constituents -** Proantho-cyanidin (PA) • **MOA-** Serves as a natural dentin collagencross linking to preserve mechanical properties of dentin.	**1. Ghonmode et al (2013)**[15]	To evaluate antimicrobial efficacy of Neem leaf extracts, grape seed extracts, 3% Sodium hypochlorite, absolute ethanol against E. faecalis in agar diffusion method.	GrapeseedsproduceLowest zones of inhibition against E. faecalis when compared to neem leaf extracts and 3% NaOCl.
		2. Cecchineet al (2015)[16]	To evaluate the effect of GSE, NaOCl, CHX and QMix as an antimicrobial agents against E. faecalis and their influence on flexural and ultimate tensile strength of root canal dentine.	Grapeseeds has highest antimicrobial efficacy against E. faecalis when compared to 2.5% NaOCl, 2% CHX, Qmix and distilled water and Preserved mechanical properties of dentine.
		3. Margono et al (2017)[17]	To analyze the ability of GSE as root canal irrigant in cleaning smear layer of the apical third area.	Most efficient of cleaning the smear layer on the apical third area when compared to distilled water (aquadest).
		4. Daviz et al (2020)[18]	To compare relative effectiveness of sodium hypochlorite 5.25% (NaOCl), 2% chlorhexidine gel and 6.5 % grape seed extract (GSE) against E. faecalis using instrument Reciproc R25 in root canal preparation.	Grapeseeds has lowest elimination capacity of E. faecalis from the root canals when compared to NaOCl, EDTA, and CHX.

6.	**Neem** (Azadirachtaindica) • **Active constituents** - Tetranortriterpenoids • **MOA-** Tetranortriterpenoidsuncouples mitochondrial oxidativephosphorrylation; thus, inhibiting the respiratory chain.	**1. Nayak et al (2011)**[19]	To determine the inhibitory effect of Azadirachtaindica(aqueous and alcoholic extract of neem) on Streptococcus mutans, E. faecalis and C. albicans.	Aqueous and alcoholic extracts ofNeemshowed significant antibacterial activity against S. mutans as well as E. faecalis and significant antifungal activity against C. albicans. There was no statistical difference between the efficacies of alcoholic over aqueous neem extract.
		2. Ghonmode et al (2013)[15]	To evaluate antimicrobial efficacy of Neem leaf extracts, grape seed extracts, 3% Sodium hypochlorite, absolute ethanol against E. faecalis in agar diffusion method.	Neemhas highest zones of inhibition against E. faecalis when compared to grape seed extracts and 3% NaOCl.
		3. Tyagi et al (2013)[20]	To explore newer herbal (Propolis, Morindacitrifoliaand Azadirachtaindica) irrigants, which acts as potential antimicrobial agents in the inhibition of C. albicans in comparison to sodium hypochlorite.	Neemhas higher antimicrobial efficacy against C. albicans when compared to M. citrifolia but lesser efficacy than NaOCl.
		4.Vinothkumar et al (2013)[4]	To evaluate the antimicrobial efficacy of various herbal extracts namely Curcuma longa (CL), Azadirachtaindica(AI), Aloe barbadensis(AV), Myristicafragrans(MF) and Terminaliachebula(TC) as endodontic irrigant against E. faecalisand C. albicansusing real-time quantitative polymerase chain reaction (qPCR).	Neemhas highest efficiency in reducing E. faecalis and C. albicans when compa-red to Curcuma longa, Myristicafrangrans, Terminaliachebula, and Aloebarbadensis.
		5. Rosaline et al (2013)[21]	To assess the antibacterial efficacy of three different herbal irrigants (Neem, Green Tea,MorindaCitrifolia) against E. faecalis.	Neemhas maximum reduction in adherence of E. faecalis to dentin when compared to NaOCl, Green Tea,MorindaCitrifolia and saline.
		6. Dutta et al (2014)[22]	To evaluate the antimicrobial properties of this neem extract as an irrigant during root canal treatment and compared it with NaOCl and chlorhexidineirrigants. Combinations of the leaf extract with standard irrigants were also evaluated.	The irrigant combinations (Ethanolicneem leaf extract + NaOCl and Ethanolicneem leaf extract + CHX) had better antimicrobial properties than individual irrigants.
		7. Podar et al (2015)[23]	To evaluate and compare the antimicrobial efficacy of 6% Morindacitrifolia, Azadirachtaindica, and 3% sodium hypochlorite (NaOCl) as root canal irrigants.	Neemexhibits lowest reduction in CFU of aerobic and anaerobic bacteria than Morindacitrifoliaand NaOCl.
		8. Babaji et al (2016)[6]	To evaluate the antimicrobial effect of herbal root canal irrigants(Morindacitrifolia, Azadirachtaindicaextract, Aloevera) with sodium hypochlorite (NaOCl).	Neem produces a higher inhibitory zone against E. faecalis in comparion to Aloe vera extract but lower inhibitory zone when compared to NaOCl and M. citrifolia.
		9. Daga et al (2017)[24]	To compare the antimicrobial efficacy of herbal irrigantsneem, miswak, propolis with sodium hypochlorite using conventional needle irrigation and EndoVac irrigation system against E. faecalis.	Antibacterial efficacy of Neem against E. faecalis was found lower than NaOCl and Propolis and higher than Miswak against E. faecalis.
7.	**Green tea** (Camellia sinensis) • **Active constituents** - Catechins, CatechinPallatesand Proanthocyanidins • **MOA-** Inhibition of bacterial enzyme gyrase by binding to Adenosine triphosphate B sub unit.	**1. Prabhakar et al (2010)**[25]	To evaluate the antimicrobial efficacy of Triphala, green tea polyphenols (GTP), MTAD, and 5% sodium hypochlorite against E. faecalis biofilm formed on tooth substrate.	Green tea produces least growth inhibition of E. faecalis when compared to NaOCl, MTAD and Triphala.
		2. Pujar et al (2011)[26]	To evaluate antimicrobial efficacy of Triphala, Green tea polyphenols (GTP) and 3% of sodium hypochlorite against E. faecalisbiofilm formed on tooth substrate	Green tea exhibits least zone of inhibition against E. faecalis than NaOCl and triphala.
		3. Rosaline et al (2013)[21]	To assess the antibacterial efficacy of three different herbal irrigants (Neem, GT, MC) against E. faecalis.	Green tea produces higher reduction in adherence of E. faecalis to dentin MorindaCitrifolia and saline but lower reduction than A. indica and NaOCl.

		4. Sebatni et al (2017)[27]	To evaluate the smear layer removal efficacy of various herbal extracts, namely, green tea extract, orange oil, and neem leaf extract using the scanning electron microscopic analysis.	Green tea shows least amount of smear layer removal efficacy when compared to Neem leaf extract, Orange peel extracts and NaOCl.
		5. Divia et al (2018)[28]	To evaluate the antimicrobialefficacy of Morindacitrifolia(MC), green tea polyphenols and Triphala was compared with 5% NaOClagainst E.faecalis.	Green tea produces a higher reduction of E. faecalis colonies when compared to Triphala and morinda.
8.	**Orange** (Citrus sinensis) • **Active constituents** - Polymethoxylated flavonoids, terpenoids, limonene, linalool, aliphatic hydrocarbon alcohols, octanal • **MOA-** Due to their hydrophobicity, it puncture the cell membrane which causes strong interaction with lipid components. This in turn ruptures cell structure and in turn cause leakage of component within bacteria.	**1. Bolhari et al (2012)**[29]	To determine the effects of citrus aurantifolia (CA) extract on smear layer removal in different parts of root canals.	Completed C.aurantifolia extract of orange removed more smear layer in coronal and middle parts compared with the alcoholic extract but not higher than EDTA. However, there was no significant difference in removal of smear layer the apical part with Completed C.aurantifoliaextract and EDTA.
		2. Sebatni et al (2017)[27]	To evaluate the smear layer removal efficacy of various herbal extracts, namely, green tea extract, orange oil, and neem leaf extract using the scanning electron microscopic analysis.	The amount of smear layer removal efficacy by orange was higher when compared to NaoCl and Green tea extract but lower than Neem leaf extract.
		3.Ranjitha et al (2020)[30]	To evaluate the smear layer removal efficacy of three herbal extracts used as endodontic irrigants in the apical third of the root canal.	Orange exhibits higher amount of smear layer removal efficacy in the apical third of the root canal than neem and NaOCl but lower than tulsi.
9.	**Nutmeg** (Myristica fragrans) • **Active constituents** - Myristic acid • **MOA-** Involve in membrane disruption by the lipophilic compounds	**1.Vinothkumar et al (2013)**[4]	To evaluate the antimicrobial efficacy of various herbal extractsnamelyCurcuma longa (CL), Azadirachtaindica(AI), Aloe barbadensis(AV), Myristicafragrans(MF) and Terminaliachebula(TC) as endodontic irrigant against E. faecalisand C. albicansusing real-time quantitative polymerase chain reaction (qPCR).	Nutmeg exhibits higher efficiency in reducing E. faecalis and C. albicans within the root canals when compared to T. chebula and A. barbadensis but lower efficiency than Azadarictaindica, Curcuma longa.
		2. Mali et al (2020)[31]	To evaluate and compare the effectiveness of Myristicafragrans-Nutmeg, Terminaliachebula-Myrobolan, Ocimum sanctum-Tulsi, and 2.5% sodium hypochlorite (NaOCl) on the removal of the smear layer by the scanning electron microscope (SEM).	Nutmeg produces least amount of smear layer removal efficacy than tulsi, myrobolan, NaOCl.
10.	**Morinda/Noni** (Morindacitrifolia) • **Active constituents** - Acubin, L-Asperuloside, Alizarin, Anthraquinones and Xeronine • **MOA-** It has ability to modify the molecular structure of specific inactive proteins by regulating proper folding to active enzyme.	**1. Murray et al (2008)**[32]	To compare the in vitro effectiveness of Morindacitrifolia juice (MCJ) with sodium hypochlorite (NaOCl) and chlorhexidinegluconate (CHX) to remove the smear layer from the canal walls of endodontically instrumented teeth.	Morinda has minimum inhibitory concentration of MCJ on E. faecalis growth and moderate removal of smear layer.
		2. Rosaline et al (2013)[21]	To assess the antibacterial efficacy of three different herbal irrigants (Neem, GT, MC) against E. faecalis	Morinda has higher reduction in adherence of E. faecalis to dentin than saline but lower reduction than A. indica, NaOCl and green tea extract.
		3. Tyagi et al (2013)[20]	To explore newer herbal irrigants, which acts as potential antimicrobial agents in the inhibition of C. albicans in comparison to sodium hypochlorite.	Morinda has least antimicrobial activity against C. albicans when compared to A. indica and NaOCl.
		4. Podar et al (2015)[23]	To evaluate and compare the antimicrobial efficacy of 6% Morindacitrifolia, Azadirachtaindica, and 3% sodium hypochlorite (NaOCl) as root canal irrigants.	Morinda has highest reduction CFU of aerobic and anaerobic bacteria than neem and NaOCl.

		5. Babaji et al (2016)[6]	To evaluate the antimicrobial effect of herbal root canal irrigants (Morindacitrifolia, Azadirachtaindicaextract, Aloevera) with sodium hypochlorite (NaOCl).	Morinda has highest inhibitory zone against E. faecalis in comparison to A. indica and Aloe vera extract but lesser activity than NaOCl.
		6. Chaudhary et al (2018)[33]	To evaluate the efficacy of commercial preparations of Morindacitrifolia juice (MCJ) and Triphala juice against E. faecalis and C. albicans.	Morinda has lower decrease in microbial counts of both E. faecalis and C. albicans in different time interval Triphala,NaOCl, CHX.
		7. Divia et al (2018)[28]	To evaluate the antimicrobial efficacy of Morindacitrifolia(MC), green tea polyphenols and Triphala was compared with 5% NaOCl against E. faecalis.	Morinda has least antibacterial efficacy with E. faecalis when compared to NaOCl, green tea and triphala.
		8. Singh et al (2019)[34]	To evaluate the antimicrobial effectiveness of Propolis, Morindacitrifolia juice, Sodium hypochlorite and Chlorhexidine on Enterococcusfeacalis (E. feacalis) and C. albicans (C. albicans), as endodontic irrigants.	Morinda has highest zone of inhibition with *E. faecalis* andleast zone of inhibition with*C. albicans* when compared withNaOCl, CHX.
11.	**Tea tree** (Melaleuca alternifolia) • **Active constituents** - Ellagic , Gallic acid and Tannic acid • **MOA-** Inhibits the cell division or damage to the cell walls of the bacterium	**1. Kamath et al (2013)**[35]	To compared the antibacterial efficacy of tea tree oil with 3% sodium hypochlorite and 2% chlorhexidine as a root canal irrigant, against E. faecalis.	Tea tree has higher zone of inhibition against E. faecalis than NaOCl but lower than CHX.
		2. Thosar et al (2013)[36]	To find out the minimum inhibitory concentration (MIC) of five essential oils against oral pathogens and to find out the minimum bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) of five essential oils against oral pathogens.	Tea tree has higher minimum inhibitory, minimum bactericidal concentration and minimum fungicidal concentration thyme and Lavender and lower than Eugenol and papermint against Staphylococcus aureus, Enterococcus fecalis, Escherichia coli and C. albicans.
		3. Seth et al (2016)[7]	To check the antimicrobial efficacy tea tree oil (2% volume), aloe vera extract (1:5), 3% sodium hypo-chlorite (NaOCl), normal saline (control) & pure cultures of E. Faecalis, C.Albicans & a mixed culture (1:1) using agar diffusion method.	Tea tree has highest zone of inhibition against C. albicans than Aloe vera&NaOCl.It has lower zone of inhibition against E. faecalis than Aloevera&NaOCl. It has higher zone of inhibition against Mixed culture than Aloe vera but lower than NaOCl.
12.	**Triphala** • **Active constituents** - Ellagic , Gallic acid and Tannic acid • **MOA-** Inhibits the cell division or damage to the cell walls of the bacterium	**1. Prabhakar et al (2010)**[25]	To evaluate the antimicrobial efficacy of Triphala, green tea polyphenols (GTP), MTAD, and 5% sodium hypo-chlorite against E. faecalis biofilm formed on tooth substrate.	Higher antibacterial activity against E. faecalis biofilm formed on tooth substrate when compared to green tea extract but lesser activity than NaOCl and MTAD.
		2. Pujar et al (2011)[26]	To evaluate antimicrobial efficacy of Triphala, Green tea polyphenols (GTP) and 3% of sodium hypochlorite against E. faecalisbiofilm formed on tooth substrate.	Higher zone of inhibition against E. faecalis than green tea polyphenols but less than NaOCl.
		3. Shakouie et al (2014)[37]	To compare the antimicrobial activity of Triphala (a plant derived solution) with 0.5, 1, 2.5 and 5% concentrations ofNaOCl, against E. faecalis.	Highest zone of inhibition against E. faecalis when compared to 0.5% and 1% NaOCl, however, there were no significant differences in the antimicrobial properties of Triphala and 2.5% and 5% NaOCl solutions

		6. Chaudhary et al (2018)[33]	To evaluate the efficacy of commercial preparations of Morindacitrifolia juice (MCJ) and Triphala juice against E. faecalis and C. albicans.	Moderate decrease in microbial counts of both E. faecalis and C. albicansin different time interval.
		7. Divia et al (2018)[28]	To evaluate the antimicrobial efficacy of Morindacitrifolia, Green tea polyphenols and Triphala was compared with 5% NaOClagainst E. faecalis.	Highest antibacterial efficacy with E. faecalis when compared with green tea extractandmorindacitrifolia.
		8. Satti et al (2019)[38]	To evaluate the antimicrobial efficacy of Triphala and liquorice against E. faecalis.	Highest antimicrobial Efficacy against E. faecalis when compared to NaOCl and liquorice.
13.	**Turmeric** (Curcuma longa) • **Active constituents** - Flavonoid curcumin (diferuloylmethane), Tumerone, Atlantone and Zingiberone • **MOA-** Binding of the photosensitizers to the outer membrane causingphoto sensitization of a microbial cell	**1. Praveenkumar et al (2013)**[39]	To investigate the antibacterial potential of curcumin, against standard strains of common endodontic bacteria e.g. Streptococcus mutansActinomycesviscosus, Lactobacillus casei, Porphyromonasgingivalis, Prevotellaintermedia, E. faecalis by blood agar medium.	Turmeric has significant antibacterial activity against Streptocuccusmutans, Lactobacilluscasei, Actinomycesviscosus, Porphyromonasgingivalis, Prevotellaintermedia but except E. faecalis.
		2.Neelkanthan et al (2013)[40]	To evaluate the antimicrobial efficacy of curcumin against E. faecalis biofilm formed on tooth substrate in vitro. Sodium hypochlorite (NaOCl) and chlorhexidine (CHX) served as standards for comparison.	Turmeric showed higher antibacterial activity against E.faecalis biofilm formed on the tooth substrate than CHX but less than Sodium hypochlorite (3%).
		3. Vinothkumar et al (2013)[4]	To evaluate the antimicrobial efficacy of various herbal extractsnamelyCurcuma longa (CL), Azadirachtaindica(AI), Aloe barbadensis(AV), Myristicafragrans(MF) and Terminaliachebula(TC) as endodontic irrigant against E. faecalisand C. albicansusing real-time quantitative polymerase chain reaction (qPCR).	Turmeric washigher efficient in reducing E. faecalis and C. albicans when compared to Myristicafrangrans, Terminaliachebula, Aloe barbadensis but lower efficient than Azadarictaindica.
		4. Saxena et al (2015)[41]	To evaluate and compare the antimicrobial activity of five herbal extracts, i.e., Propolis, AI, Triphala, C. longa, and MC with that of 2.5% sodium hypochlorite against E. faecalis.	Turmeric exhibit least zone of inhibition against E. faecalis than NaOCl, A. indica, Triphala.
		5. Chaitantya et al (2016)[42]	To compare the antimicrobial properties of different herbal derivatives like turmeric and morindacitrifolia and chemical irrigants i.e., NaOCl against E. faecalis.	Turmeric hasminimum zone of inhibition observed against E. faecalis when compared to NaOCl and morinda.
14.	**Tulsi** (Ocimum sanctum) • **Active constituents** - Tannins, Aerosol acid, Oleanolic acid, β caryophyllene and germacrene • **MOA-** Possess hydrophobicity, which enables them to break	**1. Bhardwaj et al (2017)**[43]	This study aimed to evaluate and compare the antibacterial efficacy of Neem, Tulsi, Guduchi extracts, and chlorhexidine against E. faecalis, when used as intracanal medicaments.	Tulsi showed higher reduction in CFU against E. faecalis than Guduchi but lower than CHX, Neem.
		2. Subbiya et al (2013)[44]	To evaluate and compare the antibacterial efficacy of Mangifera indicaL. kernel (mango kernel) and Ocimum sanctumL. leaves (tulsi) extracts with conventional irrigants (5% sodium hypochlorite (NaOCl) and 2% chlorhexidine) against E. faecalisdentinal biofilm.	Tulsi showed lower zone of inhibition, MIC and MBC against E. faecalis than Mangifera indica L. kernel, NaOCl and Chlorhexidine.

	• **MOA-** Possess hydrophobicity, which enables them to break down the lipids of bacterial cell membrane and mitochondria, disturbing the structures and rendering them more permeable as a result of which leakage of ions and other cell contents can occur.	**3. Prabhakar et al (2015)**[45]	To evaluate and compare the antibacterial efficacy of Ocimum sanctum L. leaves (TULSI) extract with Saline solution against dentinal bacterial biofilms.	Significant reduction in the number of colonies formed after irrigating the root canals with Tulsi extract when compared with Saline.
		4. Mali et al (2020)[31]	To evaluate and compare the effectiveness of Myristicafragrans–Nutmeg,Terminaliachebula–Myrobolan, Ocimum sanctum-tulsi, and 2.5% sodium hypochlorite (NaOCl) on the removal of the smear layer by the scanning electron microscope (SEM).	Tulsi has highest efficacy in removal of smear layar than Myrobalan, Nutmeg and NaOCl.
		5. Gupta-Wadhwa et al (2016)[12]	To evaluate the intracanal bacterial reduction promoted by chemomechanical preparation using three different herbal extracts named Ocimum sanctum, Cinnamomumzeylanicum, Syzygiumaromaticum, against E. faecalis.	Tulsi has least reduction in CFU against E. faecalis than NaOCl, Cinnamomumzeylanicum and Syzygiumaromaticum.
		6. Ranjitha et al (2020)[30]	To evaluate the smear layer removal efficacy of three herbal extracts (Neem, Orange peel and Tulasi extracts) used as endodontic irrigants in the apical third of the root canal.	Tulsi hashighest amount of smear layer removal efficacy in the apical third of the root canal than neem, NaOCl, orange peel.

Conclusion:

To overcome the shortcomings of conventional chemical irrigants, herbal alternatives have now been extensively researched for their antimicrobial efficacy and smear layer removing actions along with their effect on the root canal dentin. They can be used due to their minimal side effects, easy availability, cost effectiveness, low toxicity, increased shelf life and their lack of microbial resistance. This article reviews the potential herbal irrigants that could substitute the conventional chemical endodontic irrigants in pediatric clinical practice. This information could help provide the clinicians a road map to use safer alternatives to chemical irrigants in dental patients and also a baseline to conduct further trials using similar or a combination of herbal irrigants in a larger sample size and with long-term follow-ups.

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