ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Systematic Review for Phytotherapy in *Streptococcus Mutans*

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Abstract

Streptococcus mutans is one of the bacteria that are a major cause of tooth decay. Streptococcus mutans plays a special role in plaque formation and tooth decay. *S. mutans*, which is a gram-positive cocci and encapsulated bacterium, produces acid and is considered as an extracellular glucan polymer. Medicinal plants are of special value and importance in securing health status at the society level in terms of both treatment and prevention of human diseases and are as old as human history. The present review study reports on medicinal plants that are used as antibacterials against *S. mutans*. In this study, the search process was done using keywords, such as bacteria, Streptococcus mutans, and medicinal plants. Databases such as ISI Web of Science, PubMed, Scopus, Google Scholar and Science Direct were searched and the relevant articles were used for reviewing purposes. Based on the results, there are 48 medicinal plants with anti-*S. mutans* effects.

Keywords: Anti-Bacterial, *Streptococcus mutans*, Medicinal plants

INTRODUCTION

Streptococcus mutans and *Streptococcus sangui* are two of the bacteria considered as major cause of tooth decay [1-5]. Some species such as Streptococcus mutans streptococci play special role in plaque formation and tooth decay [6]. *Streptococcus mutans*, which is a gram-positive cocci and encapsulated bacterium, produces acid and is considered as an extracellular glucan polymer [7]. When mutans population reaches 50% of the total population of bacteria, it then can cause tooth decay [7]. Streptococcus mutans binds to the teeth by creating homo-polymers glucan from sucrose via glucosyltransferase [8].

Medicinal plants are of special value and importance in securing health status at the society level in terms of both treatment and prevention [9-17] of human diseases. These are parts of natural resources (18-22) and are as old as human history [23-25] and have been one of the most important sources of human food and medicine over generations [26-35]. From a historical viewpoint, plants have an important role in community development and extensive researches have been conducted to find herbal medicinal products and natural materials throughout history [23, 36-48]. Due to safety of use in comparison to conventional drugs, and antibiotic resistance, people prefer to use them and researchers conduct a lot of researches on them [49-58]. The present review study reports the medicinal plants that are used as antibacterial against *Streptococcus mutans*.

METHODS

In this study, the search process was done using keywords, such as bacteria, Streptococcus mutans, and medicinal plants. Databases such as ISI Web of Science, PubMed, Scopus, Google Scholar and Science Direct were searched and the relevant articles were used for reviewing purposes.

RESULTS

Based on the results, 48 medicinal plants are used as antimicrobials against *Streptococcus mutans*. Medicinal herbs with anti-*streptococcus mutans* effects along with their additional information are shown in Table 1.

Table1. Antimicrobial medicinal herbs against *Streptococcus mutans* along with their Farsi name, scientific name, family name

Scientific Name	Part of plant	Family Name	Origin of plant	Country of study	Bacteria	Result	Ref.
Psidium guajava	leaf	Myrtaceae	India	India	human dental Streptooccus mutans	Diameter of inhibition zone induced by ethyl acetate extract (5 and 2.5 mg/discs) of the plant was 20 mm and 18 mm, respectively. Minimum inhibitory concentration of less than 0.076 (MIC <0.076 mg / mL) was reported.	[59]
Terminalia chebula	fruit	Combretaceae	India	India	human dentalStreptococcus mutans	Diameter of inhibition zone induced by ethyl acetate extract (5 and 2.5 mg/discs) of the plant was 16 mm and 14 mm, respectively. Minimum inhibitory concentration of less than 0.076 (MIC <0.076 mg / mL) was reported.	[59]
Mimus opselengi	stick	Sapotaceae	India	India	human dentalStreptococcus mutans	Diameter of inhibition zone induced by ethyl acetate extract (5 and 2.5 mg/discs) of the plant was 16 mm and 14 mm, respectively.	[59]
Achyranthes aspera	Root	amaranthaceae	India	India	human dentalStreptococcus mutans	Diameter of inhibition zone induced by ethyl acetate extract (5 and 2.5 mg/discs) of the plant was 18 mm and 12 mm, respectively.	[59]
Polygonumcuspidatum	root	Polygonaceae	Korea	Republic of Korea	S. mutans KCTC 3298	The antibacterial effect of methanol extract of the plant was proved at MIC = 0.5-4 mg / ml and MBC 2 to 4 times higher than the MIC.	[60]
CINNAMOMUM CASSIA	bark	Lauraceae	Pakistan	Pakistan	Streptococcus mutans	The inhibition zone diameter of the plant was respectively 29, 27.15, 18, 19, 32, 19, 27 and 15 for the corresponding bacteria.	[61]
Mikanialaevigata	aerial parts	Asteraceae	Brazil	Brazil	culture collection and clinical isolates of Streptococcus mutans	Hexane extract of the plant with MIC between 12.5 and 400µg / ml and MBC between 25 and 400µg / ml proved to inhibit the bacterial growth. The bacterium ability to bind to the glass plate was also inhibited.	[61]
Mikania glomerata	aerial parts	Asteraceae	Brazil	Brazil	culture collection and clinical isolates of Streptococcus mutans	Hexane extract of the plant with MIC between 12.5 and 400µg / ml and MBC between 25 and 400µg / ml proved to inhibit the bacterial growth. The bacterium ability to bind to the glass plate was also inhibited.	[62]
Glycyrrhiza glabra	rhizomes	Fabaceae	Thailand	Thailand	Streptococcus mutans (DMST18777)	It is proved that the ethanol extract inhibits the bacterial growth at a concentration of 20µg / ml with inhibition zone diameter of 15 mm and MIC<12.5µg / ml and MBC = 25µg / ml. However, the inhibition zone diameter of 15µg / ml erythromycin was 40 mm.	[63]
Terminalia bellirica	fruit	Combretaceae	Thailand	Thailand	Streptococcus mutans (DMST18777)	It is proved that the ethanol extract inhibits the bacterial growth at a concentration of 20µg / ml with inhibition zone diameter of 10 mm and MIC<12.5µg / ml and MBC = 25µg / ml. However, the inhibition zone diameter of 15µg / ml erythromycin was 40 mm.	[63]
Syzygium aromaticum	Flower bud	Myrtaceae	Thailand	Thailand	Streptococcus mutans (DMST18777)	It is proved that the ethanol extract inhibits the bacterial growth at a concentration of 20µg / ml with inhibition zone diameter of 14 mm and MIC<12.5µg / ml and MBC = 50µg / ml proved. However, the inhibition zone diameter of 15µg / ml erythromycin was 40 mm.	[63]

Scientific Name	Part of plant	Family Name	Origin of plant	Country of study	Bacteria	Result	Ref.
Rosmarinus officinalis	Leaves	Lamiaceae	Taiwan	Taiwan	Streptococcus mutans (BCRC10793)	The methanolic plant extract inhibits the growth of bacterium at MIC = 4 mg / ml.	[64]
Haematoxyl onbrasiletto	Stem bark	Leguminosae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 10.5µg / ml and MBC = 125µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Punica granatum	Pericarp	Punicaceae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 12.5µg / ml and MBC = 125µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Iostephaneheterophylla	Roots	Compositae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 67.5µg / ml and MBC = 125µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Bursera simaruba	Stem bark	Burseraceae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 100µg / ml and MBC = 500µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Cedrela odorata	Seeds	Meliaceae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 32.5µg / ml and MBC = 250µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Rhus standleyi	Aerial parts	Anacardiaceae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 32.5µg / ml and MBC = 125µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Syzygium aromaticum	Flower bud	Myrtaceae	Mexico	Mexico	Streptococcus mutans (ATCC 10449)	Antibacterial property of aqueous extract of this plant was proved at MIC = 25µg / ml and MBC = 250µg / ml. This is despite the fact that chlorhexidine, as control, has MIC = 1.2µg / ml and MBC = 2.7µg / ml.	[65]
Helichrysum odoratissimum	Aerial part	ASTERACEAE	Uganda	Uganda	Streptococcusmutans (CCUG6519 T)	Anti-bacterial property of the hexane extract of this plant was proved at a minimum inhibitory concentration of 0.25 mg / ml. However, the minimum inhibitory concentration of doxycycline, as control, was reported 1.56 × 10-4 mg / ml.	[66]
Lantana trifolia	Leaves	VERBENACEAE	Uganda	Uganda	Streptococcusmutans (CCUG6519 T)	Anti-bacterial property of hexane and methanol extracts of this plant was proved at minimum inhibitory concentration of1 mg / ml. However, the minimum inhibitory concentration of doxycycline, as control, was reported to be 1.56 × 10-4 mg / ml were.	[66]

Scientific Name	Part of plant	Family Name	Origin of plant	Country of study	Bacteria	Result	Ref.
Kaempferiapandurata	rhizome	Zingiberaceae	Indonesia	South Korea	Streptococcus mutans ATCC 25175	Anti-bacterial property of isopanduratin A compound in this plant was proved at MIC = 4 mg / ml and MBC = 8 mg / ml. This is despite the fact that chlorhexidine and vancomycin, as antibiotics, have MIC = 1 mg / ml and MBC = 2 mg / ml. On the other hand, 20 mg /ml isopanduratin A deactivates the bacteria within 1 minute.	[67]
Rheedia brasiliensis	fruits		Brazil	Brazil	Streptococcus mutans UA159	The antibacterial property of hexane extract of the fruit peels was proved at MIC = 12.5-25µg / ml or MBC = 25-50 µg / ml. Hexane extract of the fruit seeds of this plant also has MIC = 12.5-25µg / ml and MBC = 50-100µg / ml. Anti-bacterial property of the active ingredient of the plant (7-epiclusianone) was proved at MIC = 1.25-2.5µg / ml and MBC = 10-20µg / ml.	[68]
Stevia rebaudiana	leaves	Asteraceae	India	India	S. mutans (MTCC 497)	Antibacterial property of methanol extract of this plant was proved at a zone diameter of 11mm. However, inhibition zone diameter of the antibiotic control was 10 mm.	[69]
Cinnamomumspp.		Lauraceae	India	India	Streptococcus mutans (MTCC 497)	Anti-bacterial property of the active ingredient of Cinnamaldehyde was proved as discs with concentrations of 20mM (diameter of inhibition zone of 30 mm), 80mM (diameter of inhibition zone of32mm) and 120mM (diameter of inhibition zone of 30mm). Inhibition zone diameter of was 16 mm was obtained for the active ingredient eugenol disc with a concentration of 120 mM. However, inhibition zone diameter of 18mm was obtaned for vancomycin (antibiotic 30 mcg disc) ,as a positive control.	[70]
Salvadorapersica	stems	Salvadoraceae	IRAQ	IRAQ	Clinical isolates of Streptococcus mutans	Antibacterial property of the aqueous extract of this plant was proved at a concentration of 200 mg / ml, with a inhibition zone diameter of 19.3 mm and MIC = 1.56 mg / ml. This is despite the fact that streptomycin as control has a inhibition zone diameter of 19.5 mm and MIC = 0.097 mg/ml.	[71]
Spilanthescalva	Floral parts	Asteraceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 11.6 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]

Scientific Name	Part of plant	Family Name	Origin of plant	Country of study	Bacteria	Result	Ref.
Azardirachtaindica	Foliage	meliaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 11.6 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), gentamicin (12.3 mm), carbenicillin (13 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]
Acacia nilotica	Foliage	Fabaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 19.3 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), gentamicin (12.3 mm), carbenicillin (13 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]
Ocimumbasilicum	Foliage	Lamiaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 14 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), gentamicin (12.3 mm), carbenicillin (13 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]
Emblica officinalis	Foliage	Euphorbiaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 29.6 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), gentamicin (12.3 mm), carbenicillin (13 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]
Hemidesmusindicus	Foliage	Asclepiadaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 10.3 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), and tetracycline (10 mm).	[72]
Terminaliabellirica	Foliage	Combretaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 33.6 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), gentamicin (12.3 mm), carbenicillin (13 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]

Scientific Name	Part of plant	Family Name	Origin of plant	Country of study	Bacteria	Result	Ref.
Syzygiumcuminii	Foliage	Myrtaceae	India	India	Clinical isolates of Streptococcus mutans	Antibacterial property of aqueous extract of this plant was proved with the inhibition zone diameter of 26.3 mm. However, the inhibition zone diameter of following antibiotic controls was as follows: ampicillin (10 mm), gentamicin (12.3 mm), carbenicillin (13 mm), nalidixic acid (11 mm), nitrofurantoin (10.6 mm) and tetracycline (10 mm).	[72]
Baeckeafrutescens	Leaf		Indonesia	South Korea	Streptococcus mutans ATCC 25175	Methanol extract of this plant showed strong antibacterial property at a concentration of 20 mg / ml with zone of inhibition of 14 mm.	[73]
Glycyrrhizaglabra	Root	Fabaceae	Indonesia	South Korea	Streptococcus mutans ATCC 25175	Methanol extract of this plant showed strong antibacterial property at a concentration of 20 mg / ml with zone of inhibition of 20 mm. Rapid bactericidal effect of this extract also be observed at a concentration of 50 µg / ml within 2 minutes.	[73]
Kaempferiapandurata	Root	Zingiberaceae	Indonesia	South Korea	Streptococcus mutans ATCC 25175	Methanol extract of this plant showed strong antibacterial property at a concentration of 20 mg / ml with zone of inhibition of 14 mm. Rapid bactericidal effect of this extract must also be observed at a concentration of 50 µg / ml within 2 minutes.	[73]
Physalisangulata	Flower	Solanaceae	Indonesia	South Korea	Streptococcus mutans ATCC 25175	Methanol extract of the plant at a concentration of 20 mg / ml with a diameter of 21 mm zone of inhibition showed strong antibacterial properties. Rapid bactericidal effect of this extract at a concentration of 50 µg / ml within 2 minutes must also be observed.	[73]
Quercusinfectoria	Gall	Fagaceae	Indonesia	South Korea	Streptococcus mutans ATCC 25175	Methanol extract of this plant showed strong antibacterial property at a concentration of 20 mg / ml with zone of inhibition of 22 mm.	[73]
SchinusterebinthifoliusRaddi	Barks	Anacardiaceae	Brazil	Brazil	Streptococcusmutans (ATCC25175)	Antibacterial property of ethanol extract of this plant was proved at a concentration of 100 mg / ml with an inhibition zone of 20 mm. However, inhibition zone diameter of 20 mm was also observed for antibiotic control of 0.12% chlorhexidine.	[74]
Psidiumguajava L.	leaves	Myrtaceae	Brazil	Brazil	Streptococcusmutans (ATCC25175)	Antibacterial property of ethanol extract of this plant was proved at a concentration of 100 mg / ml with an inhibition zone of 19 mm. However, inhibition zone diameter of 20 mm was also observed for antibiotic control of 0.12% chlorhexidine.	[74]
Punicagranatum L.	leaves	Punicaceae	Brazil	Brazil	Streptococcusmutans (ATCC25175)	Antibacterial property of ethanol extract of this plant was proved at a concentration of 100 mg / ml with an inhibition zone of 18 mm. However, inhibition zone diameter of 20 mm was also observed for antibiotic control of 0.12% chlorhexidine.	[74]

Scientific Name	Part of plant	Family Name	Origin of plant	Country of study	Bacteria	Result	Ref.
Annonasenegalensis	Bark	Annonaceae	South Africa	South Africa	Streptococcus mutans (ATCC 25175)	Antibacterial property of ethanol extract of this plant was proved with an inhibition zone of 4.5 mm and MIC and MBC equivalent to 12.5 mg / ml. This is despite the fact that MIC and MBC of chlorhexidine, as the antibiotic control, was equal to 1.6 mg / ml.	[75]
Englerophytummagalis montanum	Bark	Sapotaceae	South Africa	South Africa	Streptococcus mutans (ATCC 25175)	Antibacterial property of ethanol extract of this plant was proved with an inhibition zone of 3.5 mm and MIC (12.5 mg / ml) and MBC (6.3 mg / ml). This is despite the fact that MIC and MBC of chlorhexidine, as the antibiotic control, was equal to 1.6 mg / ml.	[75]
Dicerocarymsenecioides	Roots	Pedaliaceae	South Africa	South Africa	Streptococcus mutans (ATCC 25175)	Antibacterial property of ethanol extract of this plant was proved with an inhibition zone of 3.5 mm and MIC (12.5 mg / ml) and MBC (25 mg / ml). This is despite the fact that MIC and MBC of chlorhexidine, as the antibiotic control, was equal to 1.6 mg / ml.	[75]
Eucleadivinorum	Bark, Leaves	Ebenaceae	South Africa	South Africa	Streptococcus mutans (ATCC 25175)	Antibacterial property of ethanol extract of this plant was proved with an inhibition zone of 6 mm and MIC (25 mg / ml) and MBC (25 mg / ml). This is despite the fact that MIC and MBC of chlorhexidine, as the antibiotic control, was equal to 1.6 mg / ml.	[75]
Eucleanatalensis	Leave s	Ebenaceae	South Africa	South Africa	Streptococcus mutans (ATCC 25175)	Antibacterial property of ethanol extract of this plant was proved with an inhibition zone of 7.6 mm and MIC (6.3 mg / ml) and MBC (6.3 mg / ml). This is despite the fact that MIC and MBC of chlorhexidine, as the antibiotic control, was equal to 1.6 mg / ml.	[75]
Parinaricuratellifolia	Bark	Chrysobalanceae	South Africa	South Africa	Streptococcus mutans (ATCC 25175)	Antibacterial property of ethanol extract of this plant was proved with an inhibition zone of 4.2 mm and MIC (6.3 mg / ml) and MBC (6.3 mg / ml). This is despite the fact that MIC and MBC of chlorhexidine, as the antibiotic control, was equal to 1.6 mg / ml.	[75]

DISCUSSION

Although there are various ways to control infections such as chemotherapeutics which are able to eliminate microbes selectively, but most of microbes get resistant to antibiotics very soon and also they mostly have side effects. A lot of studies on medicinal plant extracts not only have shown antibacterial activities but also they have various other effects [76-85]. Medicinal herbs since ancient times have been a source of traditional medicine and the treatment of diseases. These herbs contain bioactive substances and antioxidant activities [86-89]. Most of them belong to the same therapeutic effects of active pharmaceutical ingredients in them [86-93]. Bioactive compounds from medicinal plants have therapeutic effects on various diseases [94-101].

Today, the incidence of infectious diseases, particularly bacterial diseases have expanded. These batteries induce infections by various mechanisms [102-104]. These diseases have been exposed to drug resistance. A good strategy to address antibiotic resistance is the source of medicinal plants [105]. The extracts of some medicinal plants including Baeckea frutescens, Quercus infectoria Glycyrrhiza glabra, Physalis angulata and Kaempferia pandurata have shown potent antibacterial activities against Streptococcus mutans. P. angulate, G. glabra and K. pandurata, in particular showed fast bactericidal impact on S. mutans at 50 µg/ml of extract, in 2 min [73].

CONCLUSION

The mechanism actions of these plants are not known, however, phenolic compound have shown to have antibacterial activities. Most of the plants presented in this study have phenolic compounds and may have antibacterial activity by these compounds. There are a lot of other plants which have these or similar compounds [106-112]. Hence they also may have antibacterial activities.

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