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Phytotherapy for *Streptococcus pyogenes*

Somayeh Delfani[1], Reza Mohammadrezaei-Khorramabadi[2], Saber Abbaszadeh[2], Nasrollah Naghdi[3*], Somayeh Shahsavari[4]

[1]*Razi Herbal Medicines Research Center, Lorestan University of Medical Sciences, Khorramabad, Iran*
[2]*Student Research Committee, Lorestan University of Medical Sciences, Khorramabad, Iran*
[3]*Biotechnology and Medicinal Plants Research Center, Ilam University of Medical Sciences, Ilam, Iran*
[4]*Leishmaniasis Research Center, Ilam University of Medical Sciences, Ilam, Iran*

Abstract

Streptococcus pyogenes is a gram-positive extracellular bacteria. *S. pyogenes* can cause skin and upper respiratory tract infections that lead to certain complications such as rheumatic fever, impetigo, scarlet fever, and glomerulonephritis. Nowadays, increasing development of antibiotic resistance is being addressed as one of the most important and challenging medical issues. The use of medicinal plants to treat diseases dates back to thousands of years ago. The aim of the current review is to report medicinal plants with antibacterial effects against *S. pyogenes*. To achieve this purpose, *bacterium*, *Streptococcus pyogenes*, and *medicinal plants* were used as search terms to retrieve relevant publications from the *Institute for Scientific Information* of *Web of Science*, *PubMed*, *Scopus*, *Google Scholar*, and ScienceDirect. According to the findings, 82 medicinal plants were reported to have antibacterial effects against *S. pyogenes*. Hence these medicinal plants also have antimicrobial activities. The antibacterial properties of the herbal plants reported in this review have been confirmed, this active ingredients of these plants are natural antibiotics.

Keywords: Medicinal plants, infection, *Streptococcus pyogenes*

INTRODUCTION

Infectious diseases represent one of the most important causes of mortality especially in the developing countries [1]. *Streptococcus pyogenes* is an important pathogenic, gram-positive, and extracellular becterium. Group A Streptococcus are commonly found in the throat or on the skin [2]. *S. pyogenes* is one of the most important streptococcal causes of skin and upper respiratory tract infections that lead to certain complications such as rheumatic fever, impetigo, scarlet fever, and glomerulonephritis [3,4]. Nowadays, increasing development of antibiotic resistance is being addressed as one of the most important and challenging medical issues [3,4]. Available antibiotics are costly and uneconomical to be produced, no need to mention problems related to the potential resistance of pathogenic isolates to them [3-6]. The use of medicinal plants to treat diseases dates back to thousands of years ago [7-10]. Medicinal plants are a regional heritage yet globally important and have bestowed a vast wealth on the world [11-20].

Medicinal plants have always been especially agreeable to humans and their pharmaceutical effects and uses are widely known or researched [21-29]. The diversity of medicinal plants with therapeutic properties is surprising [30-37]. Hence, numerous researches have been done to scientifically evaluate their effects [38-47]. The aim of the current review is to report medicinal plants with antibacterial effects against *S. pyogenes*.

METHODOLOGY

In the current review, *bacterium*, *Streptococcus pyogenes*, and *medicinal plants* were used as search terms to retrieve relevant publications from the *Institute for Scientific Information* of *Web of Science*, *PubMed*, *Scopus*, *Google Scholar*, and *ScuenceDirect*.

RESULTS

The number of identified plants

Based on the results, 82 medicinal plants are used as antimicrobials against *Streptococcus pyogenes*.

Additional information on medicinal plants

Medicinal herbs with anti-*Streptococcus pyogenes* effects along with their additional information are shown in Table 1.

Table 1. List of Medicinal Plants against *Streptococcus pyogenes*.

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
1	*Cyclea peltata* (Extract)	tuber	Menispermaceae	India	India	In vitro 2011	Streptococcus pyogenes	The inhibition zone diameter of 0.5 and 0.75 mg/ml methanolic *C. paltata* extract was 12 mm .	[14]
2	*Euphorbia hirta* (Extract)	Entire plant	Euphorbiaceae	India	India	In vitro 2011	Streptococcus pyogenes	The inhibition zone diameter of 0.75 mg/ml methanolic and hexane *E. hirta* extract was 13 mm and 11 mm, respectively.	[14]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
3	*Mahonia aquifolium* (Extract)	Root	Berberidaceae	USA	USA	In vitro 2012	Streptococcus pyogenes (ATCC 19615)	The inhibition zone diameter of ethanolic (50%, 70%, and 90%) *M. aquifolium* extract was reported 28, 28, and 25 mm, respectively. The MBC * of ethanolic (50%, 70%, and 90%) *M. aquifolium* extracts was reported 64, 32, and 32, respectively, while the inhibition zone diameter and MBC of ampicillin (10 µg), as an antibiotic, was 35 mm and 256.	[15]
4	*Humulus lupulus* (Extract)	Strobile	Cannabaceae	USA	USA	In vitro 2012	Streptococcus pyogenes (ATCC 19615)	The inhibition zone diameter of ethanolic (50%, 70%, and 90%) *H. lupulus* extract was reported 24, 24, and 25 mm, respectively. The MBC * of all ethanolic (50%, 70%, and 90%) *H. lupulus* extracts was reported 128, while the inhibition zone diameter and MBC of ampicillin (10 µg), as an antibiotic, was 35 mm and 256.	[15]
5	*Peumus boldus* (Extract)	Leaf	Monimiaceae	USA	USA	In vitro 2012	Streptococcus pyogenes (ATCC 19615)	The inhibition zone diameter of ethanolic (50%, 70%, and 90%) *P. boldus* extract was reported 20, 22, and 21 mm, respectively. The MBC * of all ethanolic (50%, 70%, and 90%) *P. boldus* extracts was reported 128, while the inhibition zone diameter and MBC * of ampicillin (10 µg), as an antibiotic, was 35 mm and 256.	[15]
6	*Glycyrrhiza glabra* (Extract)	Root	Fabaceae	USA	USA	In vitro 2012	Streptococcus pyogenes (ATCC 19615)	The inhibition zone diameter of ethanolic (50%, 70%, and 90%) *G. glabra* extract was reported 20, 25, and 25 mm, respectively. The MBC * of all ethanolic (50%, 70%, and 90%) *G. glabra* extract was reported 128, while the inhibition zone diameter and MBC of ampicillin (10 µg), as an antibiotic, was 35 mm and 256.	[15]
7	*Anemopsis californica* (Extract)	Root	Saururaceae	USA	USA	In vitro 2012	Streptococcus pyogenes (ATCC 19615)	The inhibition zone diameter of ethanolic (50%, 70%, and 90%) *A. californica* extract was reported 19, 19, and 20 mm, respectively. The MBC * of all ethanolic (50%, 70%, and 90%) *A. californica* extract was reported 128, while the inhibition zone diameter and MBC * of ampicillin (10 µg), as an antibiotic, was 35 mm and 256.	[15]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
8	*Crescentia alata* (Crude extract)	fruit	Bignoniaceae	Mexico	Mexico	In vitro 2001	Streptococcus pyogenes(ATCC06 301)	The antibacterial property of chloroform *C. alata* extract was confirmed with MI**C 1.2, while the** MIC ** of gentamicin, as control, was 0.005.	[16]
9	*Bougainvillea glabra* (Crude extract)	flower	Nyctaginaceae	Mexico	Mexico	In vitro 2001	Streptococcus pyogenes (ATCC06301)	The antibacterial property of methanolic *B. glabra* extract was confirmed with MI**C 5, while the** MIC ** of gentamicin, as control, was 0.005.	[16]
10	*Cunila lythrifolia* (Crude extract)	Aerial part	Lamiaceae	Mexico	Mexico	In vitro 2001	Streptococcus pyogenes (ATCC06301)	The antibacterial property of methanolic *C. lythrifolia* extract was confirmed with MI**C 1.2, while the** MIC ** of gentamicin, as control, was 0.005.	[16]
11	*Gnaphalium americanum* (Crude extract)	Aerial part	Compositae	Mexico	Mexico	In vitro 2001	Streptococcus pyogenes (ATCC06301)	The antibacterial property of chloroform *G. americanum* extract was confirmed with MI**C 1.2, while the** MIC ** of gentamicin, as control, was 0.005.	[16]
12	*Gnaphalium oxyphyllum* (Crude extract)	Aerial part	Compositae	Mexico	Mexico	In vitro 2001	Streptococcus pyogenes (ATCC06301)	The antibacterial property of chloroform *G. oxyphyllum* extract was confirmed with MI**C 2.5, while the** MIC ** of gentamicin, as control, was 0.005.	[16]
13	*Gossypium hirsutum* (Crude extract)	leaf	Malvaceae	Mexico	Mexico	In vitro 2001	Streptococcus pyogenes (ATCC06301)	The antibacterial property of chloroform *G. hirsutum* extract was confirmed with MI**C 2.5, while the** MIC ** of gentamicin, as control, was 0.005.	[16]
14	*Lantana trifolia* (Extract)	leaves	Tiliaceae	Rwanda	Belgium	In vitro 2002	Streptococcus pyogenes ATCC 12344	The antibacterial property of *L. trifolia* extract was confirmed by MIC ** < 1.28 and MBC * 1.32.	[17]
15	*Aspilia pluriseta* (Extract)	Leaves, stem	Asteraceae	Rwanda	Belgium	In vitro 2002	Streptococcus pyogenes ATCC 12344	The antibacterial property of *A. pluriseta* extract was confirmed by MIC ** < 1.64 and MBC * > 1.2.	[17]
16	*Senecio maranguensis* (Extract)	leaves	Asteraceae	Rwanda	Belgium	In vitro 2002	Streptococcus pyogenes ATCC 12344	The antibacterial property of *S. maranguensis* extract was confirmed by MIC ** < 1.65 and MBC * > 1.2.	[17]
17	*Tithonia diversifolia* (Extract)	leaves	Asteraceae	Rwanda	Belgium	In vitro 2002	Streptococcus pyogenes ATCC 12344	The antibacterial property of *T. diversifolia* extract was confirmed by MIC ** 1.32 and MBC * 1.8.	[17]
18	*Chenopodium ugandae* (Extract)	leaves	Chenopodiaceae	Rwanda	Belgium	In vitro 2002	Streptococcus pyogenes ATCC 12344	The antibacterial property of *C. ugandae* extract was confirmed by MIC ** 1.32 and MBC * 1.8.	[17]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
19	*Papaver macrostomum* (Extract)	Aerial parts	Papaveraceae	Iran	Iran	In vitro 1388	Streptococcus Pyogenes (RITCC 1940)	The antibacterial property of ethanolic extract of *P. macrostomum* aerial parts was confirmed by inhibition zone diameter 20 mm and MIC ** 6.25.	[18]
20	*Papaver dubium* (Extract)	flower	Papaveraceae	Iran	Iran	In vitro 1388	Streptococcus Pyogenes (RITCC 1940)	The antibacterial property of the ethanolic extract of *P. dubium* flower was confirmed by inhibition zone diameter 15 mm and MIC ** 6.25.	[18]
21	*Papaver argemone* subsp. Minus (Extract)	root	Papaveraceae	Iran	Iran	In vitro 1388	Streptococcus Pyogenes (RITCC 1940)	The antibacterial property of the ethanolic extracts of *P. argemone* root and aerial parts was confirmed by inhibition zone diameter 30 and 25 mm and MIC ** 3.125 and 12.5, respectively.	[18]
22	*Papaver bracteatum* (Extract)	Aerial parts	Papaveraceae	Iran	Iran	In vitro 1388	Streptococcus Pyogenes (RITCC 1940)	The antibacterial property of the methanolic extract of *P. bracteatum* aerial part was confirmed by inhibition zone diameter 20 mm and MIC ** 25.	[18]
23	*Papaver armeniacum* subsp. Microstigma (Extract)	Aerial parts	Papaveraceae	Iran	Iran	In vitro 1388	Streptococcus Pyogenes (RITCC 1940)	The antibacterial property of the ethanolic extract of *P. armeniacum* flower was confirmed by inhibition zone diameter 25 mm and MIC ** 6.25.	[18]
24	*Papaver chelidonifolium* (Extract)	Aerial parts	Papaveraceae	Iran	Iran	In vitro 1388	Streptococcus Pyogenes (RITCC 1940)	The antibacterial property of the methanolic extract of *P. chelidonifolium* aerial parts was confirmed by inhibition zone diameter 16 mm and MIC ** 25.	[18]
25	*Triticum sativum* Lam (Extract)	seed	Poaceae	Iran	Iran	In vitro 1387	Streptococcus Pyogenes (PTTC 1447)	The antibacterial property of 100 mg/kg methanolic and petroleum ether extracts of *T. sativum* seed was confirmed by inhibition zone diameter 23 and 22 mm, respectively, while the inhibition zone diameter of chloramphenicol, as positive control, was 28 mm.	[19]
26	*Aloe vera* (Hydroalcholic extract)	leaves	Asphodelaceae	India	India	In vitro 2009	Streptococcus pyogenes	The antibacterial property of ethanolic and stoniberg *A. vera* extracts was confirmed by inhibition zone diameter 20 mm.	[20]
27	*Pistacia atlantica* (Hydroalcholic extract)	Crust	Anacardiaceae	iran	Iran	In vitro 1394	Streptococcus pyogenes (PTCC 1447)	The antibacterial property of the methanolic extract of 15 µg *P. atlantica* skin was confirmed by inhibition zone diameter 32 mm, while the inhibition zone diameter of clindamycin (2 µg), as control, was 31 mm.	[21]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
28	*Terminalia sericea* (Methanolic extract)	Bark	Combretaceae	South Africa	South Africa	In vitro 2004	Clinical isolate of Streptococcus pyogenes	The antibacterial property of aqueous and methanolic *T. sericea* extract was confirmed with MIC ** 1 mg/ml.	[22]
29	*Gunnera perpensa* (Methanolic extract)	Root	Haloragaceae	South Africa	South Africa	In vitro 2004	clinical isolate of Streptococcus pyogenes	The antibacterial property of methanolic *G. perpensa* extract was confirmed with MIC ** 2 mg/ml.	[22]
30	*Glycyrriza glabra* (Crude extract)	root	Fabaceae	India	India	In vitro 2009	Clinical isolates of Streptococcus pyogenes	The antibacterial property of methanolic *G. glabra* was confirmed with inhibition zone diameter 11 mm, while the inhibition zone diameter of chloramphenicol, as control, was 10 mm.	[23]
31	*Zingiber officinale* (Ethanolic extract)	rhizome	Zingiberaceae	Cameroon	Cameroon	In vitro 2002	Clinical isolates of Streptococcus pyogenes	The antibacterial property of ethanolic *Z. officinale* was confirmed with inhibition zone diameter 6 mm, MI**C **** 0.0005 µg/ml, and MBC * 0.15 µg/ml, while the inhibition zone diameters of tetracycline, penicillin, erythromycin, tetrasacline chloramphenicol, and clindamycin, as antibiotics, were lower than that of this extract.	[24]
32	*Garcinia kola* (Ethanolic extract)	seed	Clusiaceae	cameroon	Cameroon	In vitro 2002	Clinical isolates of Streptococcus pyogenes	The antibacterial property of ethanolic *G. kola* was confirmed with inhibition zone diameter 6 mm, MI**C **** 0.0005 µg/ml, and MBC * 0.15 µg/ml, while the inhibition zone diameters of tetracycline, penicillin, erythromycin, tetrasacline chloramphenicol, and clindamycin, as antibiotics, were lower than that of this extract.	[24]
33	*Boesenbergia pandurate* (Ethanolic extract)	rhizome	Zingiberaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of chloroform *B. pandurata* extract was confirmed with inhibition zone diameter 7 mm, MI**C ** 3.91-31.2**5 µg/ml, and MBC * 7.81-62.50 µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
34	*Cinnamomum bejolghota* (Ethanolic extract)	bark wood	Lauraceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *C. bejolghota* extract was confirmed with inhibition zone diameter 19 mm, MI**C ** 31.25-1000** µg/ml, and MBC * **31.25-1000** µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
35	*Cinnamomum porrectum* (Ethanolic extract)	bark wood	Lauraceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *C. porrectum* extract was confirmed with inhibition zone diameter 19 mm, MI**C ** 62.5-1000** µg/ml, and MBC * **62.5-1000** µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
36	*Eleutherine Americana* (Ethanolic extract)	bulb	Iridaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *E. americana* extract was confirmed with inhibition zone diameter 23 mm, MI**C ** 250** µg/ml, and MBC * 250-500 µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
37	*Gymnopetalum cochinchinensis* (Ethanolic extract)	fruit	Cucurbitaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *G. cochinchinensis* extract was confirmed with inhibition zone diameter 15 mm, MI**C ** 31.25->1000** µg/ml, and MBC * **31.25->1000** µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
38	*Piper betle* (Ethanolic extract)	leaf	Piperaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *P. betle* extract was confirmed with inhibition zone diameter 26 mm, MI**C ** 500-1000** µg/ml, and MBC * 500-1000 µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
39	*Quercus infectoria* (Ethanolic extract)	nut gall	Fagaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *Q. infectoria* extract was confirmed with inhibition zone diameter 23 mm, MI**C ** 125->1000** µg/ml, and MBC * **125->1000** µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
40	*Quisqualis indica* (Ethanolic extract)	flower	Combretaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *Q. indica* extract was confirmed with inhibition zone diameter 17 mm, MI**C ** 250->1000** µg/ml, and MBC * 250-**>1000** µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
41	*Rhodomyrtus tomentosa* (Ethanolic extract)	leaf	Myrtaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *R. tomentosa* extract was confirmed with inhibition zone diameter 18 mm, MI**C** ** 3.91-31.25 µg/m, and MBC * 3.91-62.5 µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
42	*Walsura robusta* (Ethanolic extract)	leaf, branch	Meliaceae	Thailand	Thailand	In vitro 2013	clinical isolates of S. pyogenes (NPRC101-111)	The antibacterial property of ethanolic *W. robusta* extract was confirmed with inhibition zone diameter 17 mm, MI**C** ** **62.5->1000** µg/ml, and MBC * **62.5->1000** µg/m, while both MIC ** and MBC * of erythromycin, as antibiotic, was ≤ 0.015-0.125 µg/ml.	[25]
43	*Salvadora persica* (Aqueous and methanol extracts)	stems	Salvadoraceae	IRAQ	IRAQ	In vitro 2008	Clinical isolates ofStreptococcus pyogenes	The antibacterial property of aqueous *S. persica* extract was confirmed with inhibition zone diameter 18.2 mm and MI**C** ** **3.12** µg/ml, while the inhibition zone diameter and MI**C** ** of streptomycin, as control, was 19.2 mm and 0.048 mg/ml.	[26]
44	*Allium sativum* (Aqueous extract)	bulb	Amaryllidaceae	USA	USA	In vitro 1996	treptococcus pyogenes (ATCC 19615	Aqueous *A. sativum* extract caused complete bacterial growth inhibition with growth inhibition zone 29.8 ± 3.6 mm.	[27]
45	*Hypericum hyssopifolium* var. Microcalycinum (Essential oil)	whole plants	Guttiferae	Turkey	Turkey	In vitro 2006	Streptococcus pyogenes DMC41	Sixty µg disks of *H. hyssopifolium* displayed antibacterial effect with inhibition zone diameter 14 mm, while the inhibition zone diameter of ampicillin (10 µg)/sulbactam (10 µg), as antibiotic control, was 14 mm.	[28]
46	*Hypericum lysimachioides* var. lysimachioides (Essential oil)	whole plants	Guttiferae	Turkey	Turkey	In vitro 2006	Streptococcus pyogenes DMC41	Eighty µg disks of *H. lysimachioides* displayed antibacterial effect with inhibition zone diameter 12 mm, while the inhibition zone diameter of ampicillin (10 µg)/sulbactam (10 µg), as antibiotic control, was 14 mm.	[28]
47	*Actinidia chinensis* (Extract)	Fruits, stams and leave	Actinidiaceae	China	ITALY	In vitro 1997	Streptococcus pyogenes (ATCC 21059)	The antibacterial effect of acetone *A. chinensis* seed extract was confirmed with MI**C** ** 1 µg/ml, while the MI**C** of tetracycline, as antibiotic control, was 1 µg/ml.	[29]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
48	*Feijoa sellowiana* (Extract)	Fruits, stams and leave	Myrtaceae	South America	ITALY	In vitro 1997	Streptococcus pyogenes (ATCC 21059)	The antibacterial effect of acetone *F. sellowiana* seed extract was confirmed with MIC ** 4 µg/ml, while the MIC of tetracycline, as antibiotic control, was 1 µg/ml.	[29]
49	*Aberia caffra* (Extract)	Fruits, stams and leave	Flacourtiaceae	Southern Africa	ITALY	In vitro 1997	Streptococcus pyogenes (ATCC 21059)	The antibacterial effect of acetone *A. caffra* seed extract was confirmed with MIC ** 2 µg/ml, while the MIC of tetracycline, as antibiotic control, was 1 µg/ml.	[29]
50	*Jacaranda cuspidifolia* (Hexane extract)	bark	Bignoniaceae	Brazil	Brazil	In vitro 2011	Streptococcus pyogenes (ATCC 19615)	Methanolic *J. cuspidifolia* extract displayed antibacterial property with inhibition zone diameter 14.7 mm and MIC ** 16.3 mg/ml.	[30]
51	*Dodonaea viscosa* (Crude extract)	leaves	Sapindaceae	Ethiopia	Germany	In vitro 2003	Clinical isolate of Streptococcus pyogenes	One hundred mg/ml methanolic *D. viscosa* extract displayed antibacterial property with inhibition zone diameter 10 mm.	[31]
52	*Rumex nervosus* (Crude extract)	leaves	Polygonaceae	Ethiopia	Germany	In vitro 2003	Clinical isolate of Streptococcus pyogenes	One hundred mg/ml methanolic *R. nervosus* extract displayed antibacterial property with inhibition zone diameter 8 mm.	[31]
53	*Rumex abyssinicus* (Crude extract)	roots	Polygonaceae	Ethiopia	Germany	In vitro 2003	Clinical isolate of Streptococcus pyogenes	One hundred mg/ml methanolic *R. abyssinicus* extract displayed antibacterial property with inhibition zone diameter 8 mm.	[31]
54	*Lippia turbinate* (Methanolic extract)	aerial parts	Verbenaceae	Argentina	Argentina	In vitro 2000	Streptococcus pyogenes	Methanolic *L. turbinata* extract displayed antibacterial property with inhibition zone diameter 68.3 mm.	[32]
55	*Satureja parvifolia* (Methanolic extract)	aerial parts	Labiateae	Argentina	Argentina	In vitro 2000	Streptococcus pyogenes	Methanolic *S. parvifolia* extract displayed antibacterial property with inhibition zone diameter 68.3 mm.	[32]
56	*Eremophila duttonii* (Eethanolic extract)	leaves	Myoporaceae	Australia	Australia	In vitro 2001	Streptococcus pyogenes (ACM 178)	Ethanolic *E. duttonii* extract displayed antibacterial property with inhibition zone diameter 14 mm.	[33]
57	*Amyema quandang* (Eethanolic extract)	leaves	Loranthaceae	Australia	Australia	In vitro 2001	Streptococcus pyogenes (ACM 178)	Ethanolic *A. quandang* extract displayed antibacterial property with inhibition zone diameter 7 mm.	[33]
58	*Lepidosperma viscidum* (Eethanolic extract)	stem base	Cyperaceae	Australia	Australia	In vitro 2001	Streptococcus pyogenes (ACM 178)	Ethanolic *L. viscidum* extract displayed antibacterial property with inhibition zone diameter 7 mm.	[33]
59	*Acacia kempeana* (Eethanolic extract)	leaves	Mimosaceae	Australia	Australia	In vitro 2001	Streptococcus pyogenes (ACM 178)	Ethanolic *A. kempeana* extract displayed antibacterial property with inhibition zone diameter 7 mm.	[33]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
60	*Anredera diffusa* (Eethanolic extract)	leaf	Basellaceae	Peru	USA	In vitro 2002	Streptococcus pyogenes (Group A, ATCC19615)	Ethanolic *A. diffusa* extract displayed antibacterial property with inhibition zone diameter 0.7 cm, while the inhibition zone diameter of vancomycin, as positive control, was over 0.7 cm.	[34]
61	*Cassia tomentosa* (Eethanolic extract)	leaf	Fabaceae	Peru	USA	In vitro 2002	Streptococcus pyogenes (Group A, ATCC19615)	Ethanolic *C. tomentosa* extract displayed antibacterial property with inhibition zone diameter 0.7 cm, while the inhibition zone diameter of vancomycin, as positive control, was over 0.7 cm.	[34]
62	*Krameria triandra* (Eethanolic extract)	Root/stem	Krameriaceae	Peru	USA	In vitro 2002	Streptococcus pyogenes (Group A, ATCC19615)	Ethanolic *K. triandra* extract displayed antibacterial property with inhibition zone diameter 0.7 cm, while the inhibition zone diameter of vancomycin, as positive control, was over 0.7 cm.	[34]
63	*Equisetum giganteum* (Crude extract)	Aerial part	Equisetaceae	Peru	Czech Republic	In vitro 2005	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *E. giganteum* extract was 4 mg/ml, while the MIC of ciprofloxacin was 1 mg/ml.	[35]
64	*Piper aduncum* (Crude extract)	Aerial part	Piperaceae	Peru	Czech Republic	In vitro 2005	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *P. aduncum* extract was 2 mg/ml, while the MIC of ciprofloxacin was 1 mg/ml.	[35]
65	*Phyllanthus amarus* (Crude extract)	Aerial part	Euphorbiaceae	Peru	Czech Republic	In vitro 2005	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *P. amarus* extract was 4 mg/ml, while the MIC of ciprofloxacin was 1 mg/ml.	[35]
66	*Terminalia catappa* (Crude extract)	Leaves	Combretaceae	Peru	Czech Republic	In vitro 2005		The MIC ** of ethanolic *T. catappa* extract was 16 mg/ml, while the MIC ** of ciprofloxacin was 1 mg/ml.	[35]
67	*Abuta grandifolia* (Crude extract)	bark	Menispermaceae	Peru	Czech Republic	In vitro 2007	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *A. grandifolia* extract was 1 mg/ml, while the MIC ** of ciprofloxacin was 1 mg/ml.	[36]
68	*Dipteryx micrantha* (Crude extract)	bark	Leguminosae	Peru	Czech Republic	In vitro 2007	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *D. micrantha* extract was 8 mg/ml, while the MIC ** of ciprofloxacin was 1 mg/ml.	[36]
69	*Maytenus macrocarpa* (Crude extract)	bark	Celastraceae	Peru	Czech Republic	In vitro 2007	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *M. macrocarpa* extract was 0.125 mg/ml, while the MIC ** of ciprofloxacin was 1 mg/ml.	[36]
70	*Naucleopsis glabra* (Crude extract)	bark	Moraceae	Peru	Czech Republic	In vitro 2007	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *N. glabra* extract was 0.0625 mg/ml, while the MIC ** of ciprofloxacin was 1 mg/ml.	[36]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
71	*Pterocarpus rohrii* (Crude extract)	bark	Leguminosae	Peru	Czech Republic	In vitro 2007	Streptococcus pyogenes ATCC 19615	The MIC ** of ethanolic *P. rohrii* extract was 4 mg/ml, while the MIC ** of ciprofloxacin was 1 mg/ml.	[36]
72	*Rumex obtusifolius* (Hydroalcholic extract)	Aerial parts	Polygonaceae	Iran	Iran	In vitro 2010	Clinical isolate of Streptococcus pyogenes	Ethanolic *R. obtusifolius* extract (0.4 g/ml) displayed antibacterial property with inhibition zone diameter 16 mm, and MIC ** and MBC * 5 mg/ml.	[37]
73	*Polygonum patulum* (Hydroalcholic extract)	Aerial parts	Polygonaceae	Iran	Iran	In vitro 2010	Clinical isolate of Streptococcus pyogenes	Ethanolic *P. patulum* extract (0.4 g/ml) displayed antibacterial property with inhibition zone diameter 28 mm, and MIC ** and MBC * 5 mg/ml.	[37]
74	*Passiflora foetida* (Ethanol and Acetone extract)	Leaf	Passifloraceae	India	India	In vitro 2007	Streptococcus pyogenes(MTCC)	Ethanolic *P. foetida* extract (100 and 200 µg/ml) was confirmed with inhibition zone diameter 20 mm, while the inhibition zone diameter of streptomycin was 23 mm.	[38]
75	*Certonia silique* (Ethanol extract)	dry pods	Leguminosae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *C. siliqua* was confirmed with inhibition zone diameter 14 mm, while the inhibition zone diameter of augmentin 30 ug, as antibiotic control, was 12 mm.	[39]
76	*Glycyrrhiza glabra* (Ethanol extract)	roots and rhizomes	Leguminosae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *G. glabra* was confirmed with inhibition zone diameter 18 mm, while the inhibition zone diameter of augmentin 30 ug and lincomycin 2 ug, as antibiotic controls, was 12 and 18 m, respectively.	[39]
77	*Matricaria chamomilla* (Ethanol extract)	flowers	Compositae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *M. chamomilla* was confirmed with inhibition zone diameter 11 mm, while the inhibition zone diameter of augmentin 30 ug, as antibiotic control, was 12 mm.	[39]
78	*Punica granatum* (Ethanol extract)	bark and the rind of the fruit	Punicaceae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *P. granatum* was confirmed with inhibition zone diameter 26 mm, while the inhibition zone diameter of augmentin 30 ug, lincomycin 2 ug, erythromycin 15 ug, tetracycline 10 ug, and tobramicin 10 ug, as antibiotic controls, was 12, 18, 25, 22, and 25 mm, respectively.	[39]
79	*Quercus infectoria* (Ethanol extract)	nuts	Fagaceae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *Q. infactoria* was confirmed with inhibition zone diameter 25 mm, while the inhibition zone diameter of augmentin 30 ug, lincomycin 2 ug, erythromycin 15 ug, tetracycline 10 ug, and	[39]

No.	Botanical Name	Part of plant	Family Name	Origin of plant	Country Of study	year	Bacteria	Result	Ref.
								tobramicin 10 ug, as antibiotic controls, was 12, 18, 25, 22, and 25 mm, respectively.	
80	*Rhus Coriaria* (Ethanol extract)	fruits	Anacardiaceae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *R. coriaria* was confirmed with inhibition zone diameter 20 mm, while the inhibition zone diameter of augmentin 30 ug and lincomycin 2 ug, as antibiotic controls, was 12 and 18 m, respectively.	[39]
81	*Salvia triloba* (Ethanol extract)	leaves	Labiatae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *S. triloba* was confirmed with inhibition zone diameter 15 mm, while the inhibition zone diameter of augmentin 30 ug, as antibiotic control, was 12 mm.	[39]
82	*Thymus capitatus* (Ethanol extract)	leaves	Labiatae	Jordan	Jordan	In vitro 1999	Streptococcus pyogenes (ATCC 12351)	Ethanolic *T. capitatus* was confirmed with inhibition zone diameter 32 mm, while the inhibition zone diameter of augmentin 30 ug, lincomycin 2 ug, erythromycin 15 ug, tetracycline 10 ug, and tobramicin 10 ug, as antibiotic controls, was 12, 18, 25, 22, and 25 mm, respectively.	[39]

* Minimum bactericidal concentration; ** minimum inhibitory concentration

DISCUSSION

Streptococcus pyogenes is an extracellular bacteria made up of non-sporing cocci. It is clinically important in human illness. Streptococcus pyogenes is a pathogenic part of the skin flora and is often called group A streptococcus. S. anginosus and the S. dysgalactiae both can possess group A antigen and typically produces small zones of beta-hemolysis. Hence, it is also called group A streptococcus and is able to make colonies greater than 5 mm in size [1].

An estimated 700 million infections from this bacterium occur worldwide each year. The mortality rate for these infections is more than 0.1%, from them; more than 650,000 cases are severe, with a mortality rate of 25% [2]. Early recognition and treatment are very important, because diagnostic failure may result in sepsis and death [3,4]. Hence, preparation of new and safe drugs is very important. Antimicrobials and antibacterials refer to those drugs that are used to eliminate bacteria or other pathogenic microorganisms. Medicinal plants and their compounds have been used for prevention and treatment various diseases. They can be used for discovering new effective drugs [48-51]. Plants, plant-based and other nature-based antibiotics are active and bioactive compounds derived from medicinal plants or other nature based sources [52-58]. Clinical trials have demonstrated that certain plant-based compounds such as organo oil and garlic are some of the most active plant-based compounds that can eliminate even many of the resistant bacteria in the body. Demand for nature-based alternatives has increased as people become more and more informed about dangerous side effects of the antibiotics [59-72]. Nature-based compounds reduce the risk of developing such side effects and may even result in useful effects other than antibacterial activities [73-83]. The mechanism action of these plants is not clear. Phenolic compounds in plants have been shown to possess antimicrobial activities [84]. Given that these are abundantly present in these plants, hence the antimicrobial activities of these plants, in part, might be due to presence of these compounds. There, are a lot of other agents and medicinal plants which have phenolic compounds with antioxidant activity [85-101]. These plants and agents may also have these properties.

CONCLUSION:

Hence these plants may also have antimicrobial activitie. The antibacterial properties of the medicinal plants reported in this review have been confirmed, it is recommended to identify pharmacologically active and bioactive compounds of these medicinal plants in phytochemical investigations, and study them in pharmacological research. Then, they can be used to produce effective antibiotics against *S. pyogenes* if their antimicrobial properties are confirmed.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interests with respect to the authorship and/or publication of this paper.

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