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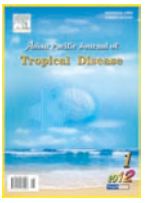

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Evaluation of antibacterial activity of selected medicinal plant extracts from south India against human pathogens

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ABSTRACT

Objective: The present study was to evaluate the antibacterial properties of 21 crude extracts from leaf and flower of *Aristolochia indica (A. indica)*, *Cassia angustifolia (C.angustifolia)*, leaf of *Catharanthus roseus (C. roseus)*, *Diospyros melanoxylon (D.melanoxylon)*, *Dolichos biflorus (D. biflorus)*, *Gymnema sylvestre (G. sylvestre)* and *Justicia procumbens (J. procumbens)*. **Methods:** The ethyl acetate, acetone and methanol extract of medicinal plants were evaluated against Gram-positive *Bacillus cereus (B. cereus)* and Gram-negative bacteria *Aeromonas hydrophila (A. hydrophila)*, *Enterobacter aerogenes (E. aerogenes)*, *Escherichia coli (E. coli)* and *Klebsiella pneumoniae (K. pneumoniae)* by using well diffusion assay and minimum inhibitory concentration (MIC). **Results:** The crude plant extracts demonstrated broad spectrum activity against all bacteria. The highest inhibitory zone was observed in leaf methanol extract of *A. indica* against *E. aerogenes* (25 mm), and *E. coli* (20 mm), flower methanol extract of *C. angustifolia* against *B. cereus* (22 mm) and leaf acetone extract of *G. sylvestre* against *B. cereus* (22mm). The MIC values of leaf methanol extract of *A. indica* against *K. pneumonia* (22.6 μg/ml), and flower extract showed against *E. coli* (MIC: 24.2 μg/ml), leaf ethyl acetate extract of *C. angustifolia* against *K. pneumoniae* (MIC: 28.4 μg/ml). Acetone ethyl acetate and methanol extracts of *D. melanoxylon* and *D. biflorus* showed the lowest MIC activity value of >30 μg/ml against all tested pathogens. **Conclusion:** The antibacterial activity could be confirmed in most species used in traditional medicine in South India. Nevertheless, traditional knowledge might provide some leads to elucidate potential candidates for future development of new antibiotic agents.

1. Introduction

Anti-microbial agents are undeniably one of the most important therapeutic discoveries of the 20th century. However, with the 'antibiotic era' barely five decades old, mankind is now faced with the global problem of emerging resistance in virtually all pathogens [1]. During the last decade, the use of traditional medicine has expanded globally and is gaining popularity. Traditional medicines are used not only for primary health care of the poor in developing countries, but also in countries where conventional medicine is predominant in the national health care system [2]. The herbal medicines serve the health needs of about 80% of the world's population, especially for millions of people in the vast rural areas of developing countries; more than 65% of the global population uses medicinal plants as a primary health care modality [3].

In recent years, many possible sources of natural antibiotics have been in use for several infectious diseases, mostly bacterial and fungal. In view of this, the searches for new anti-microbial agents from medicinal plants are even more urgent in the countries like India where infectious diseases of bacterial origin are not only rampant, but the causative agents are also developing an increasing resistance against many of the commonly used antibiotics [4]. Considering the high costs of the synthetic drugs and their various side effects, the search for alternative products from plants used in folklore medicine is further justified. It is believed that plants which

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are rich in a wide variety of secondary metabolites belonging to chemical classes such as sterols, alkaloids, glycosides, saponins, flavonoids, tannins, and carbohydrates are generally superior in their anti-microbial activities [5]. Leaves and flower of experimental plants have been used for treating many diseases in traditional medicines. The leaf of *A. indica* is commonly used against intestinal worms and all types of poisonous bites and stings to treat inflammation, cholera, useful in [6] and the essential oil possess anti-microbial activity against *Pseudomonas aeruginosa (P. aeruginosa), Basillus subtilis (B. subtilis), Staphylococcus aureus (S.aureus), E. coli, Basillus sphaericus (B.sphaericus)* and *Salmonella typhimurium (S. typhimurium)* [7]. *C. angustifolia* is widely used in the treatment of intestinal constipation. The aqueous extract of *C. angustifolia* was used in determining genotoxic and mutagenic effects in *E. coli* [8]. The leaves of *C. roseus* are used for using numerous diseases, including diabetes, malaria, and Hodgkin's disease. The root, stem, leaf and flower of methanol, acetone and ethyl acetate extracts of *C. roseus* were tested against *B. subtilis* , *Klebsiella* sp. , *Streptococcus* sp. and *S. aureus* [9]. The seeds of *D. biflorus* have been used to treat diarrhoea in the indigenous system of medicine [10]. *G. sylvestre* leaves were used against glycosuria and urinary disorders [11]. *J. procumbens* possess anthelmintic, antiphlogistic, depurative, diaphoretic, diuretic, expectorant, febrifuge and laxative properties [12].

The purpose of this study was to carry out preclinical evaluation of some popular medicinal plant species, i.e., biological and phytochemical screening with particular emphasis on those that seems to have very little scientific information in the areas intended for the investigation. This study facilitated the selection of plants with relatively high level of potency and wide range of biological activities suggesting that the strength of biological activities of a natural product is dependent on the diversity and quantity of such constituents. Therefore, simultaneous determination of the compounds those are possibly responsible for any biological activity would facilitate decision-making process as in the selection of the plants for in-depth future investigation.

2. Materials and methods

2.1. Plant Collection and identification

The leaf and flower of *A. indica* (Aristolochiaceae), *C. angustifolia* (Caesalpiniaceae), leaf of *C. roseus* (Apocynaceae), *D. melanoxylon* (Ebenaceae), *D. biflorus* (Fabaceae), *G. sylvestre* (Asclepiadaceae), and *J. procumben* (Acanthaceae) were collected from Javadhu Hills, Tiruvannamalai district (12°36′10″N,078°53′07″E, altitude 705 m) and Chitheri Hills, Dharmapuri District, (11°53′28″N, 078°30′26″E, altitude 959 m), Tamil Nadu, India from September 2009 to February 2010 (Table1). The plants identified by Dr. C. Hema, Department of Botany, Arignar Anna Govt. Arts College for Women, Walajapet, Vellore, India. Voucher specimen has been deposited in the laboratory of Zoology, C. Abdul Hakeem College, Melvisharam, India.

2.2. Preparation of extracts

The leaf and flower of *A. indica* (8 days), flower (3 days) *C. angustifolia* (5 days), flower (6 days), leaf of *C. roseus* (8 days), *D. melanoxylon* (6 days), *D. biflorus* (5 days), *G.sylvestre* (10 days) and *J. procumbens* (11days) were dried in the shade at the environmental temperatures (27-37 ℃ day time). The dried leaf 800 g and flower 500 g were powdered mechanically using commercial electrical stainless steel blender and extracted with ethyl acetate (3,500 ml, SRL chemicals), acetone (3,000 ml, Fine chemicals), and methanol (3,800 ml, Qualigens) in a soxhlet apparatus (boiling point range 60-80 ℃) for 8 h. The extracts were filtered through a buchner funnel with Whatman number 1 filter paper. The extract was concentrated under reduced pressure of 22-26 mmHg at 45 ℃, and the residue obtained was stored at 4 ℃. All residues were kept in tightly stoppered bottle until used for the anti-microbial test. Dimethyl sulfoxide (DMSO) (Qualigens) was used as an emulsifier at the concentration of 0.05% in the final test solution. The percent of yields of the ethyl acetate, acetone and methanol extracts of the seven plant species are given in Table 2.

Table 1
List of plants and their parts used in this study with reference to their source.

Scientific name	Family	Vernacular name	Habit	Parts used	Source
Aristolochia indica L.,	Aristolochiaceae	Ishwari, Sapsan	Climber	Leaf, Flower	Malaiyur
Cassia angustifolia Vahl	Caesalpiniaceae	Senna, Sonamukhi	Shrub	Leaf, Flower	Javadu Hills
Catharanthus roseus (L.) G.Don	Apocynaceae	Nithyakalyani	Sub Shrub	Leaf	Chitheri Hills
Diospyros melanoxylon Roxb	Ebenaceae	Temburini	Tree	Leaf	Chitheri Hills
Dolichos biflorus viz.,	Fabaceae	Kulthi	Herb	Leaf	Javadu Hills
Justicia procumbens Linn.	Acanthaceae	Palkodi,Nerei potti	Herb	Leaf	Chennai
Gymnema sylvestre R.Br	Asclepiadaceae	Sirukurinchaan	Herb	Leaf	Chennai

Table 2

Percent of yield of the solvent extracts of the dried and powdered plant materials (*n*=3)

Plant species	Part extracted	solvents	Percentage yield (w/w) (average± S.D.)
A. indica	Leaf	Ethyl acetate	15.12±1.25
		Acetone	12.86±1.86
		Methanol	28.35±2.36
	Flower	Ethyl acetate	10.23±2.56
		Acetone	12.48±3.15
		Methanol	24.56±1.28
C. angustifolia	Leaf	Ethyl acetate	13.45±2.37
		Acetone	11.74±1.69
		Methanol	26.34±1.75
	Flower	Ethyl acetate	09.19±3.02
		Acetone	11.98±2.85
		Methanol	19.68±3.45
C. roseus	Leaf	Ethyl acetate	15.24±2.36
		Acetone	19.57±1.78
		Methanol	29.75±1.98
D. melanoxylon	Leaf	Ethyl acetate	14.36±2.48
		Acetone	16.85±1.47
		Methanol	25.37±1.69
D. biflorus	Leaf	Ethyl acetate	19.68±2.11
		Acetone	15.86±1.56
		Methanol	32.58±1.79
G. sylvestre	Leaf	Ethyl acetate	13.47±0.89
		Acetone	16.85±1.26
		Methanol	28.64±0.75
J. procumbens	Leaf	Ethyl acetate	15.36±1.74
		Acetone	17.98±2.64
		Methanol	35.37±0.67

S.D: standard deviation

2.3. Bacterial strains

The plant extracts were tested against Gram positive bacteria, *Bacillus cereus (B.cereus)* (MTCC-1307), and Gram negative bacteria, *Aeromonas hydrophila (A.hydrophila)* (MTCC-1939), *Enterobacter aerogenes (E. aerogenes)* (MTCC-1324), *Escherichia coli (E.coli)* (MTCC-293) and *Klebsiella pneumoniae* (*K. pneumoniae*) (MTCC-3384).

2.4. Determination of antibacterial activity

2.4.1 Well diffusion method

The antimicrobial activity was tested against crude ethyl acetate, acetone and methanol extracts of *A. indica*, *C. angustifolia*, *C. roseus*, *D. melanoxylon*, *D. biflorus*, *G.sylvestre* and *J.procumbens*. The inoculation of microorganism was prepared from bacterial culture [13]. The inoculums suspension was spread uniformly over the agar plates using spreader, for uniform distribution of bacteria. Subsequently, using a sterile borer, well of 0.5cm diameter was made in the inoculated media in addition to 0.2 ml of each extract was aseptically filled into the well. Later the plates were placed at room temperature for an hour to allow diffusion of extract into the agar. Then the plates were incubated for 24 h at 37 °C for room temperature. Tetracycline (30 mcg/ml) was used as positive control. The results were recorded by measuring the diameter of inhibition zone at the end of 24-72 h. Zone of inhibition surrounding the discs was measured using a transparent ruler and the diameter was recorded in mm.

2.4.2. Minimum inhibitory concentration (MIC) determination

The antibacterial activity of the plant extracts was determined using sterile 2ml 96-well plates [14]. 12 wells of each row were filled with 0.5 ml sterilized Mueller Hinton agar. Sequentially, wells 2-11 received an additional 0.5 ml of a mixture of culture medium and plant extract was serially diluted to create a concentration sequence from 20 and 40 μg/ml. Well 1 served as growth control, well 12 as antibiotic control. Tetracycline (30 μg/ml) was used as control for the Gram positive bacteria *B. cereus*, and Gram negative bacteria *A. hydrophila*, *E. aerogenes*, *E. coli* and *K. pneumonia*, respectively. All plant extracts volume to broth medium volume (v/v) were 1:2, 1:2.5, 1:3, 1:3.5, and 1:4. Each plant extract dilution was inoculated with 20 μl of an individual microbe present were 12 h culture. All inoculated dilutions were set at 37 ℃ for 24 h. The lowest dilution of the plant extract that retained its inhibitory effect resulting in no growth (absence of turbidity) of a microorganism was recorded as the MIC value of the extract. It is worth noting that the nutrient broth diluent used in dilutions of 1:2, 1:2.5, 1:3, and 1:3.5 was a double strength while that used for preparing the 1:4 dilutions were single strength.

A control experiment was run parallel to study the impact of the solvent itself (without plant components) on growth of the five test organisms. The solvent (distilled water and acetone) was each diluted in a similar pattern with sterile nutrient broth, as indicated above, and inoculation by microorganisms followed by incubation was done similarly.

2.5. Statistical analysis

Analysis was performed using Microsoft Excel 2007. The one way ANOVA test was used to determine any statistically significant difference in the MIC of the extracts and the antibiotics. *P*-values <0.05 were considered significant.

3. Results

3.1. Yield of plant extracts

Maximum yield was obtained from the leaf of *J. procumbens* and minimum yield was obtained from flower of *C. angustifolia*. The leaf methanol extracts yield of *J. procumbens* (35.37%), *A. indica* (28.35%), *C. roseus* (29.75%) and *D. biflorus* (32.58%), while minimum yield was obtained from flower ethyl acetate of *C. angustifolia* (09.17%). In general, the yields obtained from these plants are quite adequate thereby making further development of these herbal drugs economically feasible (Table 2).

3.2. Well diffusion method

Results of inhibition zones in the well diffusion assay using crude ethyl acetate, acetone and methanol extracts of *A. indica*, *C. angustifolia*, *C. roseus* , *D. melanoxylon* , *D. biflorus*, *G.sylvestre* and *J.procumbens* showed significant zone of inhibition (ZOI) against Gram positive bacteria, *B. cereus*, and Gram negative bacteria, *K. pneumonia*, *A. hydrophila*,

E. aerogenes, and *E. coli* of five tested bacterial organisms as compared to the standard antibiotic, Tetracycline (30 mcg/ml). The highest zone of inhibition was observed in leaf methanol extract of *A. indica* against *E. aerogenes* (25 mm), *K. pneumoniae* (18mm) and *E. coli* (20 mm), and flower acetone extract of *A. indica* against *E.coli* (19 mm), flower methanol extract of *C. angustifolia*, leaf acetone extract of *G. sylvestre* against *B. cereus* (22 mm), respectively and very low zone of inhibition was observed in ethyl acetate, acetone and methanol extract of *D. biflorus* against *A. hydrophila*, *B. cereus*, and *K. pneumoniae* , *E. aerogenes* (Table 3).

3.3. Minimum inhibitory concentration (MIC)

The table 4 shows the MIC values of plant extracts of all tested microorganisms.The MIC concentrations ranged between 22 to 39 μg/ml. The MIC value of leaf methanol extract of *A. indica* exhibited stronger activity against *K. pneumoniae* (MIC: 22.6 μg/ml) and flower extract showed against *E. coli* (24.2 μg/ml), leaf ethyl acetate extract of *C. angustifolia* against *K. pneumoniae* (28.4 μg/ml) and leaf ethyl acetate extract of *J. procumbens* showed against *A. hydrophila* (26.2 μg/ml). The acetone ethyl acetate and methanol extracts of *D. melanoxylon* and *D. biflorus* showed the lowest MIC activity value > 30 μg/

Table 3

Antibacterial activities of ethyl acetate, acetone and methanol extracts (40 μg/ml) of medicinal plants used traditionally in South India

Plant species	Parts used and solvents	Zone of inhibition (mm)				
		Bacterial strains				
		Kp	Ah	Ea	Ec	Bc
A. indica	Leaf					
	Ethyl acetate	17±1.16	13±1.76	11±1.48	19±0.72	10±0.46
	Acetone	14±0.94	18±1.13	16±0.76	17±1.22	13±.27
	Methanol	18±1.04	10±1.41	25±0.94	20±1.21	16±0.84
	Flower					
	Ethyl acetate	18±1.67	10±0.26	13±1.23	14±0.36	10±0.42
	Acetone	12±0.56	16±0.46	11±0.68	19±0.91	15±0.82
	Methanol	10±0.03	12±0.54	10±4.98	12±2.85	12±0.07
C.angustifolia	Leaf					
	Ethyl acetate	11±1.21	8±0.24	10±3.58	6±2.14	7±4.12
	Acetone	14±2.04	18±0.94	6±1.11	12±1.04	10±2.01
	Methanol	11±1.94	10±1.86	6±0.67	08±0.02	10±1.23
	Flower					
	Ethyl acetate	11±0.24	6±0.07	4±1.34	18±0.91	10±2.14
	Acetone	14±2.41	11±1.22	6±1.70	6±0.36	8±0.92
	Methanol	13±1.17	12±0.62	18±1.11	6±1.45	22±0.69
C.roseus	Leaf					
	Ethyl acetate	17±1.16	13±1.76	11±1.48	9±0.72	10±0.46
	Acetone	7±0.94	10±0.42	8±2.10	6±0.21	10±2.01
	Methanol	11±1.047	10±1.41	9±2.10	11±1.21	9±0.84
D.melanoxylon	Leaf					
	Ethyl acetate	10±1.13	14±1.52	8±0.76	16±1.20	5±1.3
	Acetone	7±2.36	5±2.01	6±0.57	7±1.54	8±0.54
	Methanol	12±1.02	15±1.36	17±1.89	12±1.47	14±1.71
D.biflorus	Leaf					
	Ethyl acetate	8±0.84	5±1.74	7±2.34	5±1.94	6±0.85
	Acetone	5±1.02	8±2.01	7±0.78	2±0.46	5±0.59
	Methanol	6±1.25	5±0.25	4±1.84	6±0.71	4±0.48
G.sylvestre	Leaf					
	Ethyl acetate	8±3.01	5±1.96	6±.076	5±1.23	6±1.27
	Acetone	6±2.3	12±1.95	17±0.58	11±1.36	22±1.27
	Methanol	15±2.45	15±2.34	19±2.64	16±1.25	19±1.11
J. procumbens	Leaf					
	Ethyl acetate	6±0.41	8±0.79	5±1.64	6±1.26	4±2.46
	Acetone	4±0.23	7±1.78	6±1.72	5±1.25	5±1.26
	Methanol	15±1.45	19±2.45	15±0.24	11±2.98	14±0.49
Tetracycline	–	26±2.60	22±4.62	17±2.08	24±2.40	24±2.07
Distilled water	–	0±0.00	0±0.00	0±0.00	0±0.00	0±0.00
DMSO	–	0±0.00	0±0.00	0±0.00	0±0.00	0±0.00

Kp: *Klebsiella pneumonia*; Ah: *Aeromonas hydrophila*; Ea: *Enterobacter aerogenes*; Ec: *Escherichia coli*; Bc: *Bacillus cereus*.

ml against all microorganisms, respectively.

Table 4

Antibacterial activities (MIC) of ethyl acetate, acetone and methanol extracts (20 μg/ml) from medicinal plants used traditionally in Southern India

Plant species

Plant species	Pp	Ethyl acetate extract inhibited microorganisms				
		Kp	Ah	Ea	Ec	Bc
		20	20	20	20	20
A. indica	L	38.0	37.0	35.0	32.4	37.5
	F	36.2	34.2	36.4	32.8	26.0
C. angustifolia	L	28.4	28.6	36.2	34.2	34.0
	F	38.1	36.2	34.7	28.2	37.4
C. roseus	L	33.1	34.5	38.9	34.5	29.3
D. melanoxylon	L	38.4	37.2	34.5	36.4	30.1
D. biflorus	L	28.1	32.1	37.1	29.6	36.2
G.sylvestre	L	36.4	34.0	32.1	32.0	28.6
J.procumbens	L	32.2	26.2	36.8	34.2	34.2
Plant species	Pp	Acetone extract inhibited microorganisms				
		Kp	Ah	Ea	Ec	Bc
		20	20	20	20	20
A. indica	L	L	32.6	38.2	38.0	25.0
	F	29.5	29.2	34.7	34.3	32.4
C. angustifolia	L	28.0	44.0	38.6	39.6	30.8
	F	38.9	38.6	34.9	34.6	29.4
C. roseus	L	31.2	37.6	30.2	38.6	30.8
D. melanoxylon	L	31.4	39.2	29.6	37.4	36.2
D. biflorus	L	36.2	34.2	34.1	30.6	32.1
G.sylvestre	L	37.4	34.2	29.8	29.8	37.6
J.procumbens	L	38.8	36.2	34.0	28.0	38.0
Plant species	Pp	Methanol extract inhibited microorganisms				
		Kp	Ah	Ea	Ec	Bc
		20	20	20	20	20
A. indica	L	22.6	34.6	30.2	38.6	29.6
	F	32.8	36.2	35.6	24.2	38.2
C. angustifolia	L	38.1	38.2	39.6	30.2	36.4
	F	30.6	36.8	35.6	36.2	34.2
C. roseus	L	36.0	37.0	34.2	32.4	38.2
D. melanoxylon	L	30.1	36.4	35.1	37.0	32.8
D. biflorus	L	32.4	34.8	34.6	34.8	34.2
G.sylvestre	L	36.2	38.0	36.6	36.1	29.4
J.procumbens	L	28.6	34.9	28.9	38.0	28.7

Pp: plant parts; L: Leaf, F: Flower; Kp: *Klebsiella pneumonia*; Ah: *Aeromonas hydrophila*; Ea: *Enterobacter aerogenes*; Ec: *Escherichia coli*; Bc: *Bacillus cereus*.

4. Discussion

Medicinal herbs possess curative properties due to the presence of various complex chemical substance of different composition, which are found as secondary plant metabolites in one or more parts of these plants [15]. There is continuous and urgent need for discovery of new antimicrobial compounds with diverse chemical structures and novel mechanisms of action because of alarming increase in the incidence of new and re-emerging infectious diseases [16]. Natural products are known to play an important role in both drug discovery and chemical biology. In fact, many of the current drugs either mimic naturally occurring molecules or have structures that are fully or in part derived from natural motifs.

Shafia et al [7] have reported that the essential oil of *A. indica* showed good antimicrobial activity against *P. aeruginosa*, *B. subtilis*, *S. aureus*, *E. coli*, *B. sphaericus* and *S. typhimurium* ranging from 5 μl of 50 mg/ml. Antimicrobial activity of *Cassia fistula* (*C. fistula*) leaves, stem bark, and pods were carried out against 14 pathogenic bacteria and 6 fungi at 400 μg/disc [17]. In the present observation, the flower ethyl acetate extract of *C. angustifolia* showed MIC value of 10.0 μg/ml against *K. pneumoniae* and 10.1 μg/ml against *E. coli*. Samy et al [18] have reported that the leaf extracts of *C. fistula* showed significant activity against *E. coli*, *Klebsiella aerogenes* (*K. aerogenes*), *P. aeruginosa* and *Proteus vulgaris* (*P. vulgaris*) at 1000-5000 ppm. The higher concentration (1000 mg/L) of *C. roseus* extracts exhibited highest inhibitory activity against these microorganisms of 7.50, 5.60, 4.54 and 3.26 mm against *B. subtilis*, *Klebsiella* sp., *S. aureus* and *Streptococcus* sp., respectively [9]. In our observation the methanol extract of *C. roseus* showed highest inhibition of 11mm against *K. pneumonia* and *E. coli*. Mallavadhani et al [19] have reported that the *D. melanoxylon* extract was found to exhibit antimicrobial activity against Gram negative bacteria *Pseudomonas syringae (P. syringae)* (MIC: 12.5 μg/ml) and Gram positive bacteria, *Bacillus sphaericus (B. sphaericus)* (MIC: 25.0 μg/ml) and *B. subtilis* (MIC: 25.0 μg/ml).

The acetone extract of the roots of *Senna italica (S. italica)* (Fabaceae) significantly inhibited the growth of *P. aeruginosa*, *Enterococcus faecalis* (*E. faecalis*), *E. coli* and *S. aureus* with MICs ranging from 0.08 to 0.16 mg/ml [20]. The aqueous extracts of *Acacia nilotica (A. nilotica)* showed significant antibacterial activity, and the zone of inhibition varied between 9 mm to 35.5 mm against *S. aureus* [21] and leaf chloroform extract of *Indigofera aspalathiods (I. aspalathiods)* showed high inhibition zone against *S. aureus*, *E. coli* (25 mm) [22]. The petroleum ether, chloroform and methanol extracts of *Asclepias curassavica (A. curassavica)* of Asclepiadaceae family showed high inhibition zones in chloroform (30 mm), methanol (22 mm) and petroleum ether extracts (15 mm) against *E. coli* [23]. The methanol extracts of the aerial parts of *Acacia karroo* (A. karroo) (Fabaceae) showed highest activity against *S. aureus* (MIC=7.5 μg/mL) and the n-hexane and methanol extracts of *Gomphocarpus fruticosus (G. fruticosus)* (Asclepiadaceae) exhibited significant activity against *P. aeruginosa* (MIC=31 μg/mL) [24].

The ethanolic extract of *G. sylvestre* leaves possessed highest antimicrobial activity against *Bacillus pumilis (B. pumilis)* and the zone of inhibition (29 mm), *B. subtilis* (29 mm), *P. aeruginosa* (27.5 mm) and *S. aureus* (30.5 mm) [25]. The MIC exhibited by the pure saponin fraction of *G. sylvestre* was found to be in the range of 600-1,200 mg/l against bacterial strains and 1,400 mg/l for fungal strains [26]. The methanolic extract of *J. procumbens* suppressed the multiplication of vesicular stomatitis virus in the screening test [27]. The leaf ethyl acetate extract of *Rhinacanthus naustus (R. naustus)* (Acanthaceae) showed significant activity against *S. aureus* (20 mm) and *Candida albicans (C.albicans)* (20 mm) and *E. coli* (10 mm) [28], the stem chloroform extract of *Andrographis paniculata (A. paniculata)* showed considerable antibacterial and antifungal activities against *S. aureus* (12 mm), *B. subtilis* (12 mm), *E. coli* (13 mm) and *Proteus vulgaris (P. vulgaris)* (13 mm) [29] and *Hemigraphis colorata (H. colorata)* leaves and stem of benzene extracts demonstrated maximum zone of inhibition against *Acinetobacter* sp. (14 mm) and *S. aureus* (12 mm) [30].

In Conclusion, this study highlights some plants including *A. indica, C. angustifolia C. roseus* and *J.procumbens* which are worthy of further investigation for their antimicrobial activities Our results support the use of these plants as traditional medicine and suggest that some of the plant extracts possess compounds with good antibacterial and antifungal properties that can be used as effective antimicrobial agents in the search of new drugs.

Conflict of interest statement

We declare that we have no conflict of interest.

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