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In vitro screening of antibacterial activity of aqueous and alcoholic extracts of various Indian plant species against selected pathogens from Enterobacteriaceae

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Thirty four medicinal plants, belonging to twenty eight different families, were screened for potential antibacterial activity against six bacterial strains belonging to Enterobacteriaceae, viz. *Enterobacter aerogenes* ATCC13048, *Escherichia coli* ATCC25922, *Klebsiella pneumoniae* NCIM2719, *Proteus mirabilis* NCIM 2241, *Proteus vulgaris* NCTC8313, *and Salmonella typhimurium* ATCC23564. Antibacterial activity of aqueous and alcoholic extracts was tested by the agar disc diffusion and agar well diffusion methods. The ethanol/methanol extracts were more active than aqueous extracts for all the plants studied. The most susceptible bacterium was *K. pneumoniae*, while the most resistant bacteria were *S. typhimurium* and *E. coli*. From the screening experiment, *Woodfordia fruticosa* Kurz. showed best antibacterial activity. Hence, this plant may be used further to isolate and evaluate the therapeutic antimicrobials.

Key words: Medicinal plants, antibacterial activity, aqueous extracts, alcoholic extracts, Enterobacteriaceae.

INTRODUCTION

Infectious diseases are the leading cause of death worldwide. The clinical efficacy of many existing antibiotics is being threatened by the emergence of multidrug-resistant pathogens (Bandow et al., 2003). Bacterial and fungal pathogens have evolved numerous defense mechanisms against antimicrobial agents, and resistance to old and newly produced drugs is on the rise. The increasing failure of chemotherapeutics and antibiotic resistance exhibited by pathogenic microbial infectious agents has led to the screening of several medicinal plants for their potential antimicrobial activity (Colombo and Bosisio 1996; Scazzocchio et al., 2001). There are several reports in the literature regarding the antimicrobial activity of crude extracts prepared form plants (El-Seedi et al., 2002; Rojas et al., 2003; Duraipandiyan et al., 2006; Parekh and Chanda, 2007a).

Risk factors for nosocomial Enterobacter infections include the prior use of antimicrobial agents, a prolonged hospital stay, a serious underlying illness, and immunosuppression. From a clinical point of view, *Klebsiella pneumoniae* is the most important member of the *Klebsiella* genus of Enterobacteriaceae and it is emerging as an important cause of neonatal nosocomial infection (Gupta et al., 1993). *Escherichia coli* causes septice mias and can infect the gall bladder, meninges, surgical wounds, skin lesions and the lungs especially in debilitate and immunodeficient patients (Black, 1996). Infection caused by *Salmonella typhimurium* is a serious public health problem in developing countries and represents a constant concern for the food industry (Mastroeni, 2002). *Proteus mirabilis* causes wound infections and urinary tract infections in the elderly and young males often following catheterization or cystoscopy, and it is a secondary invader of ulcers, pressure sores, etc. (Cheesbrough, 2000).

There are various reports in the literature regarding characterization of medicinal plant extracts that may inhibit the above mentioned bacteria. For example, the antibacterial potential of *Mesua ferrea* Linn. flowers has been reported (Mazumder et al. 2004), and organic solvent extracts of *P. commutate* showed inhibitory activity against *E. coli, Enterobacter aerogenes* and *K. pneumoniae* (Ilhan et al., 2006). The methanol extract of *Phyllanthus amarus* inhibited *E. coli* and *S. typhimurium*

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Table 1. Ethnobotanical information of some plant species screened.

Botanical name (family, genus, species)	Vernacular name	Habit	Voucher number	Part(s) extracted	Action/Therapeutic use
AMARANTHACEAE					
Celosia argentea L.	Lambadi	Herb	PSN645	Whole	anpy, aphro, bl dis, dia, gon, infl, sor
ASCLEPIADACEAE					
Tylophora indica (Burm.f.) Merr.	Damnivel	Climber	PSN462	Leaf	car, dip, em, expec, pur, stm, ath, bron, dia, dys, dyspep, fla, gou, ul, wo
ASTERACEAE					
Vernonia anthelmintica (L.) Willd.	Kalijiri	Herb	PSN415	Whole	fev, ath, co, ul, sk, leucd, lep, dyspep, infl, ast, anth, exp, dmu, diu, stm, feb, gal, ton, pur
BALANITACEAE					
Balanites aegyptiaca (L.) Del.	Engoria	Shrub	PSN112	Whole	alex, anal, anth, pur, verm, bo, bu, co, fra, leucd, sb, sk, sls
BIGNONACEAE					
Spathodea campanulata Beauv.	Kesudo	Tree	PSN563	Aerial parts	Pur, sk
CAESALPINIACEAE					
Cassia fistula L.	Garmalo	Tree	PSN250	Leaf	cat, em, feb, lax, pur, bil, bron, fev, rheu, rw
CHENOPODIACEAE					
Beta vulgaris L.	Beet	Herb	PSN654	Leaf	aphro, car, diu, emmen, exp, pur, ton, con, eac, hac, infl, itc, para, sor, ul
Spinacia oleracea L.	Palak ni Bhaji	Herb	-	Leaf	cat, feb, stm, infl
COMMELINACEAE					
Commelina benghalensis L.	Motishumliyu	Herb	PSN731	Whole	diu, sti, dia, fev, lep
CONNARACEAE					
Rourea santaloides (Vahl.) Wight &. Arnott	Vardharo	Herb	-	Root	ton, diab, rheu, sk
CONVOLVULACEAE					
Cressa cretica L.	Paliyo	Herb	PSN496	Whole	anth, aphro, stm, ath, con, ton
CRUCIFERAE					
Lepidium sativum L.	Ashal/Aserio	Herb	PSN13	Seed	antc
CUCURBITACEAE					
Lagenaria vulgaris Seringe	Tumbada	Climber	PSN328	Fruit	ton, pur
Momordica charantia L.	Karela	Climber	PSN333	Fruit	anth, lax, sed, bron, co, elph, pil, ul
Mukia maderaspatana (L.) M.Roem.	Chadakachima	Climber	PSN335	Aerial parts	exp, sti
CYPERACEAE					
Cyperus scarious R.Br.	Nagarmoth	Herb	PSN765	Seed	aro, ast, dip, stm, dia
EHRETIACEAE					
Cordia dichotoma Forst.	Gunda	Tree	PSN472	Leaf	anth, ast, diu, dmu, exp, pur, ton, co, dyspep, fev, hac, jp, rw, sb, ul
EUPHORBIACEAE					
Ricinus communis L.	Erado	Shrub	PSN699	Leaf	anth, aphro, car, cat, diu, gal, pur, ath, bron, co, con, drop, dyspep, fev, hac, infla, lep, lum, para, rheu, rw, sk
FABACEAE					
Arachis hypogaea L.	Magfali	Herb	PSN152	Leaf	ast, adp, bron, con, fla
Canavalia gladiata DC.	Talvardi	Climber	PSN157	Leaf	can
Vigna radiata L.	Mag	Herb	PSN235	Whole	aphro, dig, feb, gal, ton, co, con, dia, dyspep, fev, fla, hae, infl, lep, pyr, sk

Table 1. Contd.

FUMARIACEAE					
Fumaria indica (Haussk.) Pugsley.	Pitpopdo	Herb	-	Seed	dip, diu
GUTTIFERAE					
Mesua ferrea Linn.	Nagkesar	Tree	-	Seed	aro, ast, col
LABIATAE					
Ocimum kilimanjaricum L.	Kapurtulsi	Herb	-	Whole	col, diu
LAURACEAE					
Cinnamomum tamala Nees & Ebern.	Tamal patra	Tree	-	Leaf	car, diu, dip, gal, sti, co, dyspep, fev, fla
LYTHRACEAE					
Woodfordia fruticosa Kurz.	Dhawadi phool	Shrub	PSN303	Flower	anth, ast, em, feb, sed, sti, bil, bu, diab, hae, lep, sk
MALVACEAE					
Thespesia populnea (L.) Sol ex Correa.	Paras piplo	Tree	PSN71	Leaf	ast, col, ath, chl, co, dia, diab, dys, gon, haem, her, infl, lep, psor, rw, sca, ul, wo
MORACEAE					
Artocarpus hetrophyllus Lam.	Fanas	Tree	-	Whole	abor, aphro, car, ton, bil, bo, dia, lep, sb, sk, ul, wo
Ficus elastica Roxb.	Rubber plant	Tree	PSN705	Leaf	-
PIPERACEAE					
Piper longum L.	Piplimul	Climber	-	Root	anth, aphro, apt car, col, lax, sti, adp, ath, bil, bron, co, fev, gou, ins, infl, jaun, lep, leucd, lum, pil, tum
POACEAE					
Bambusa arundinaceae (Retz.) Roxb.	Vans, bamboo	Tree	PSN793	Leaf	aphro, ast, col, diu, emmen, feb, lax, sti, ton, bil, bron, bu, co, dia, eac, fev, gon, jp, lep, lum, pil, rw
RUBIACEAE					
Gardenia resinifera Roth.	Dikamari	Tree	PSN351	Gum exudate	car, fla, indi, sk
SAPOTACEAE					
Manilkara hexandra (Roxb.) Dubard.	Rayan	Tree	PSN428	Leaf	aphro, col, ton, bil, bron, lep, ul, urd
VITACEAE					
Cissus quadrangularis L.	Hadsankar	Climber	PSN127	Stem	anal, fra, mup, pil, tum, ul, wo

Key to abbreviations in Table 1.

DISEASES

A
abs - abscesses
adp - abdominal pain
aly - allergy
ame - amentia
amen -amenorrhoea
anm - anaemia
ano - anorexia
arth - arthritis
ath - asthma

B
bil - biliousness
bl dis - blood diseases
bo - boils
bron - bronchitis
bu - burns

C
calc - calculi
can - cancer
cd - cold
chl- cholera
chp - chest pain
co - cough
con - constipation

D
deli -delirium
den fev - dengue fever
der - dermatitis
dia - diarrohea
diab - diabetes
diph - diphtheria
drop - dropsy
dys - dysentry
dysame - dysanenorrhoea
dyspep - dyspepsia

E
eac-earache
ecz - eczema
elph - elephantiasis
epi - epilpsy

F
fat - fatigue
fev - fever
fla - flatulence
fra - fracture

G
gin - gingivitis
gon - gonorrhoea
gou - gout

H
hac - headache
hae - haemmorrhage
haem - haemorrhoids
her - hernia
hp - hydrophobia
hys - hysteria

I
indi - indigestion
infl - inflammations
ins - insomnia
itc - itch

J
jaun - jaundice
jp - joint pain

L
leucd - leucoderma
leuch-leucorrhoea
lep – leprosy
lum - lumbago

M
mal - malaria
mig - migraine
mum - mumps
mup - muscular pain

N
neu - neuralgia

O
ob - obesity

P
para - paralysis
phg - pharyngitis
pil - piles
pim - pimples
pneu - pneumonia
psor- psoriasis
psy - psycopathy
pyr - pyrexia

R
rheu - rheumatism
rw - ringworm

S
sb - snake bite
sca - scabies
scia - sciatica
sk - skin disease
sls - sleeping sickness
smp - small pox
sor - sores
swe - swellings
syp - syphilis

T
toac - tooth ache
tum - tumors
typh – typhoid

U
ul - ulcers
urd - urinary disorders

V
vom - vomiting

W
wo - wounds
wor - worms

MEDICINAL PROPERTIES

A
abor - abortifacient
alex - alexipharmic
anal - analgesic
antd - antidote
anth - anthelmentic
anthy - antihypertensive
antpr - antiperiodic
antpy - antipyretic
antsp - antiseptic
antsp - antispasmodic
aphro - aphrodisiac
apt - apetiser
aro - aromatic
ast - astringent

B
b.ton - brain tonic

C
c.ton - cardiotonic
car - carminative
cat - cathartic
col - coolant

D
dig - digestive
dip - diphoretic
diu - diuretic
dmu - demulcent

E
em – emetic
emmen - emmenagogue
exp - expectorant

F
feb - febrifuge

G
gal - galactagogue

L
lax - laxative

P
pec - pectoral
pur - purgative

R
rub - rubefacient

S
stm - stomachic

T
ton - tonic

V
verm - vermifuge

(Mazumder et al., 2006), while the flower heads and leaves of *Setaria italica* showed strong inhibition against *S. typhimurium, Proteus vulgaris* and *P. mirabilis* (Basile et al., 2006). Dabur et al. (2007) studied antibacterial activity of some Indian medicinal plants that could inhibit various bacterial strains, including *E. coli, S. typhimurium* and *P. vulgaris*. Various solvent extracts of *Aegle marmelos, Lawsonia inermis* and *Albizzia libbeck* showed good antibacterial activity against *E. coli and P. vulgaris* (Sudharameshwari and Radices, 2007), whereas *Emilia coccinea* inhibited *S. typhimurium* and *E. coli* (Teke et al., 2007).Thus, there is a continuous and urgent need to discover new antimicrobial compounds with diverse chemical structures and novel mechanisms of action.

Natural products, either as pure compounds or as standardized plant extracts, provide unlimited opportunities for new drug leads because of the unmatched availability of chemical diversity (Cos et al., 2006). Therefore, in the present study, 34 Indian plant species were screened for their antimicrobial potential against selected members of the Enterobacteriaceae.

MATERIALS AND METHODS

Ethno-medical information and plant collection

Fresh plant or plant parts were collected randomly from the semi arid region of Rajkot Gujarat, India. The taxonomic identities of plants were confirmed by Dr. P.S. Nagar and Dr. N.K. Thakrar, Department of Biosciences, Saurashtra University, Rajkot, Gujarat, India with the help of Flora of Bombay. The ethno-medical information is reported in Table 1. Fresh plant material were washed with tap water, air dried and then homogenized to a fine powder and stored in air-tight bottles.

Plant extraction

For aqueous extraction, 10 g of air-dried powder was mixed with distilled water and boiled on slow heat for 2 h. It was then filtered through 8 layers of muslin cloth and centrifuged at 5000 *g* for 10 min. The supernatant was collected. This procedure was repeated twice more. After 6 h, the supernatant, collected at an interval of every 2 h, was pooled and concentrated to make the final volume one-fourth of the original volume. It was then autoclaved (121°C, 15 lbs pressure) and stored at 4^{O}C. For solvent extraction, 10 g of air-dried powder was mixed with 100 ml of organic solvent (methanol

Table 2. Screening of some plant species for potential antimicrobial activity

Botanical name		**Inhibition Of Zone (Mean ± SEM)**					
(family, genus,species)	**Extract**	***Ea*****	***Ec*****	***Kp*****	***Pm*****	***Pv*****	***St*****
AMARANTHACEAE							
	H_20	-	-	3 ± 0.1	-	-	-
Celosia argentea L.	EtOH	-	-	1 ± 0.0	-	-	-
ASCLEPIADACEAE							
	H_20						
	EtOH	-	-		-	-	-
Tylophora indica (Burm.f.) Merr.		-	-	3 ± 0.0	-	-	-
ASTERACEAE							
	H_20	-	-	-	-	-	-
Vernonia anthelmintica (L.) Willd.	EtOH	-	-	4 ± 0.0	-	-	-
BALANITACEAE							
	H_20	-	-	-	-	-	4 ± 0.4
Balanites aegyptiaca (L.) Del.	EtOH	-	-	2.5 ± 0.0	-	-	-
BIGNONACEAE							
	H_20	-		-			
Spathodea campanulata Beauv.	MeOH	3.0 ± 0.0	-	3 ± 0.0	-	-	-
CAESALPINIACEAE							
	H_20	-	-	-	-	-	-
Cassia fistula L.	MeOH	-	-	3 ± 0.0	2 ± 0.0	-	-
CHENOPODIACEAE							
	H_20	-	-	1 ± 0.6			
	EtOH	-	-	1 ± 0.0	-	-	-
Beta vulgaris L.	H_20	-	-	-	-	-	-
Spinacia oleracea L.	MeOH	-	-	1 ± 0.0	2 ± 0.0	-	-
COMMELINACEAE							
	H_20	-	-	1.5 ± 0.3	-	-	-
Commelina benghalensis L.	EtOH	-	-	2 ± 0.0	-	-	-
CONNARACEAE							
	H_20	-		-	-		
Rourea santaloides (Vahl.) Wight &. Arnott	EtOH	2.5 ± .0	-	6 ± 0.0	0.2 ± 0.1	-	-
CONVOLVULACEAE							
Cressa cretica L.	H_20	-	-	-	-	-	-
	EtOH	-	-	04 ± 0.0	-	-	-
CRUCIFERAE							
Lepidium sativum L.	H_20	-	-	-	-	-	
	MeOH	-	-	-	-	-	3 ± 0.6
CUCURBITACEAE							
	H_20	-	-	-	-		
Lagenaria vulgaris Seringe	MeOH	-	-	7± 0.0	3± 0.6	-	-
	H_20	-	-	-	-	-	-
Momordica charantia L.	MeOH	2 ± 0.1	-	10.5 ± 0.3	1.25 ± 0.0	-	-
	H_20	-	-	-	-	-	-
Mukia maderaspatana (L.) M. Roem.	EtOH	-	-	4± 0.0	-	-	-
CYPERACEAE							
	H_20	-	-	-	1± 0.0	-	-
Cyperus scarious R.Br.	MeOH	1± 0.0	-	4± 0.0	4.5± 0.30	-	-

Table 2. Contd.

EHRETIACEAE							
Cordia dichotoma Forst.	H_20	-	-	-	1 ± 0.0	-	-
	EtOH	-	-	4 ± 0.0	1 ± 0.3	-	-
EUPHORBIACEAE							
Ricinus communis L.	H_20	-	-	1.7± 0.3	1.8 ± 0.2	-	-
	MeOH	-	-	4.5± 0.3	1.3 ± 0.3	-	-
FABACEAE							
Arachis hypogaea L.	H_20	1 ± 0.6	-	1 ± 0.6	-	-	-
	EtOH	-	-	3 ± 0.0	-	-	-
Canavalia gladiata DC.	H_20	-	-				
	EtOH	-	-	1 ± 0.0	-	-	-
Vigna radiata L.	H_20	-	-		1 ± 0.0	-	-
	EtOH	-	-	3 ± 0.6	1 ± 0.0	-	-
FUMARIACEAE							
Fumaria indica (Haussk.) Pugsley.	H_20	-	-	-	1 ± 0.0	-	-
	EtOH	-	-	2 ± 0.0	-	-	-
GUTTIFERAE							
Mesua ferra Linn.	H_20	-	-	4.5 ± 0.3	3.5 ± 0.3	-	-
	MeOH	1 ± 0.0	-	19.5 ± 0.9	22.5 ± 0.9	3 ± 0.0	-
LABIATAE							
Ocimum kilimanjaricum L.	H_20					-	
	EtOH	-	-	-	-	3.25 ±	-
		1.5 ± 0.3	2.25 ± 0.1	4.5 ± 0.3	5 ± 0.6	0.1	-
LAURACEAE							
Cinnamomum tamala Nees & Ebern.	H_20	-	-	-	1 ± 0.0	-	-
	EtOH	-	-	7 ± 0.0	3.25 ± 0.01	-	-
LYTHRACEAE							
Woodfordia fruticosa Kurz.	H_20					-	
	MeOH	9.5 ± 0.3	1.0 ± 0.0	10 ± 0.0	6 ± 0.06	7.5 ±	8.5 ± 0.03
		7.5 ± 0.9	14 ± 0.0	19 ± 0.0	10 ± 0.06	0.3	4.25 ± 0.25
MALVACEAE							
Thespesia populnea (L.) Sol ex Correa.	H_20	-	-	2 ± 0.0			
	EtOH	-	-	7 ± 0.0	1 ± 0.6	-	-
MORACEAE							
Artocarpus hetrophyllus Lam.	H_20	-			-		
	EtOH	3.2± 0.2	-	-	3.5 ± 0.3		
Ficus elastica Roxb.	H_20	-	-	-	-	-	-
	MeOH	-	-	6 ± 0.0	3 ± 0.0	-	-
PIPERACEAE							
Piper longum L.	H_20	-	-	-	-	-	-
	EtOH	4 ± 0.0	-	8 ± 0.0	5 ± 0.6	-	6 ± 0.0
POACEAE							
Bambusa arundinaceae (Retz.) Roxb.	H_20	-	-	-	-	-	-
	EtOH	-	-	4 ± 0.12	-	-	-
RUBIACEAE							
Gardenia resinifera Roth.	H_20	-	-	13 ± 0.0	6 ± 0.6	-	-
	MeOH	-	-	-	-	-	-
SAPOTACEAE							

Table 2. Contd.

Manilkara hexandra (Roxb.) Dubard.	H_20 MeOH	- 2± 0.0	- 2± 0.0	2± 0.0 10± 0.0	- 7± 0.0	2± 0.0 5± 0.0	-
VITACEAE							
Cissus quadrangularis L.	H_20 MeOH	- -	- -	- -	- 2 ± 0.0	- -	- -

H20: aqueous extract, EtOH: ethanol extract, MeOH: methanol extract; #values are the mean of inhibition zone diameter and subtracted from the control; - means no activity. Ea: *Enterobacter aerogenes*, Ec: *Escherichia coli*, Kp: *Klebsiella pneumoniae*, Pm: *Proteus mirabilis*, Pv: *Proteus vulgaris*, St: *Salmonella typhimurium*;

or ethanol) in a conical flask, plugged with cotton and then kept on a rotary shaker at 190 - 220 rpm for 24 h. After 24 h, it was filtered through 8 layers of muslin cloth and centrifuged at 5000 *g* for 10 min. The supernatant was collected and the solvent was evaporated to make the final volume one-fourth of the original volume, and stored at 4^{o}C in air-tight bottles.

Microorganisms

The microbial strains used in this study were obtained from the National Chemical Laboratory (NCL), Pune, India. The studied bacterial strains comprised: *E. aerogenes* ATCC13048, *E. coli* ATCC25922, *K. pneumoniae* NCIM2719, *P. mirabilis* NCIM 2241, *P. vulgaris* NCTC8313 *and S. typhimurium* ATCC23564. Microorganisms were maintained at 4°C on nutrient agar slants.

Antibacterial activity

The antibacterial assay was performed by two methods. The agar disc diffusion method (Bauer et al., 1966; Parekh and Chanda, 2006) was used for aqueous extracts and the agar well diffusion method (Perez et al., 1990; Nair and Chanda, 2005) was used for solvent extracts. The media (Mueller Hinton Agar No.2), along with the inoculum (10^{8} cfu/ml), was poured into the Petri plate (Hi-Media). For the agar disc diffusion method, the disc (0.7 cm) (Hi-Media) was saturated with 100 µl of the test compound, allowed to dry and then placed on the upper layer of the seeded agar plate. For the agar well diffusion method, a well was prepared in the plates with a cup-borer (0.85 cm) and 100 µl of the test compound was pipetted directly into the well. The plates were incubated overnight at 37°C. Antibacterial activity was determined by measuring the diameter of the zone of inhibition surrounding bacterial growth. For each bacterial strain, controls were included that comprised pure solvents instead of the extract (Parekh and Chanda, 2007b). The control zones were subtracted from the test zones and the resulting zone diameter is shown in the Table 2. The experiments were repeated three times and the mean values are presented with ± Standard Deviation (SD).

RESULTS AND DISCUSSION

Since ancient times, plants have been a veritable source of drugs. However, man tends to ignore the importance of herbal medicine. Different extracts from traditional medicinal plants have been tested to identify the source of the therapeutic effects. As a result, some natural products have been approved as new antibacterial drugs, but there is still an urgent need to identify novel substances that are active towards pathogens with high resistance. Continued further exploration of plant-derived antimicrobials is needed today.

Successive isolation of botanical compounds from plant material is largely dependent on the type of solvent used in the extraction procedure. The traditional healers use primarily water as the solvent, but we found in this study that plant extracts prepared with methanol and ethanol as solvents provided more consistent antimicrobial activity, as also reported earlier (Allero and Afolayan, 2006; Parekh and Chanda, 2007b). The antibacterial activity of the 34 Indian plants against seven members of Enterobacteriaceae are shown in Table 2. None of the aqueous extracts (except one or two) produced zones of inhibition in the Kirby- Bauer analysis. This might have resulted from the lack of solubility of the active constituents in aqueous solutions. Alternatively, active compound(s) may be present in insufficient quantities in the crude extracts to show activity with the dose levels employed (Taylor et al., 2001).

Alcoholic plant extracts, on the other hand, showed some activity. Maximum antibacterial activity was shown by *Mesua ferra*, but it was active only against *P. mirabilis* (23 mm) and *K. pneumoniae* (20 mm), while *Woodfordia fruitcosa* showed activity against all six members investigated, maximum activity being against *K. pneumoniae* (19 mm). *K. pneumoniae* was the most susceptible bacterium followed by *P. mirabilis*, while the most resistant bacteria were *S. typhimurium* and *E. coli*. Amongst *Proteus* species, *P. mirabilis* was susceptible, while *P. vulgaris* was resistant. Earlier work from this laboratory reported the inhibitory activity of some medicinal plant extracts on the studied members of Enterobacteriaceae (Nair and Chanda, 2007; Parekh and Chanda, 2007c).

Recently, multiple drug resistance has developed due to indiscriminate use of commercial antimicrobial drugs that are commonly used in the treatment of infectious diseases, making it a global growing problem. There is an urgent need to develop new antimicrobial drugs for the treatment of infectious diseases from medicinal plants, which may be less toxic to humans and possibly with a novel mechanism of action. There are numerous examples of antimicrobials of plant origin that have an enormous therapeutic potential (Parekh and Chanda, 2007d).

From the screening experiment, *Woodfordia fruticosa* Kurz. Showed best antibacterial activity; and hence this

plant can be further subjected to isolation of the therapeutic antimicrobials and carry out further pharmacological evaluation. The potential of *W. fruticosa* has already been reported (Parekh and Chanda, 2007d; Das et al., 2007). The potential for developing antimicrobial drugs from higher plants appears rewarding, as it will lead to the development of a phytomedicine to act against mic-robes. Therefore, such screening experiments form a pri-mary platform for further phytochemical and pharmaco-logical studies that may open the possibility of finding new clinically effective antibacterial compounds.

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