Turkish Journal of Biology

Volume 32 | Number 1 Article 10

1-1-2008

Antibacterial Activities of Aqueous and Alcoholic Extracts of 34 Indian Medicinal Plants against some Staphylococcus species

JIGNA PAREKH

SUMITRA CHANDA

Turk J Biol
32 (2008) 63-71
© TÜBİTAK

Antibacterial Activity of Aqueous and Alcoholic Extracts of 34 Indian Medicinal Plants against Some *Staphylococcus* Species

Jıgna PAREKH, Sumitra V. CHANDA

Phytochemical, Pharmacological and Microbiological Laboratory,

Department of Biosciences, Saurashtra University, Rajkot, 360 005, Gujarat - INDIA

Received: 20.07.2007

Abstract: Thirty-four Indian medicinal plants belonging to 28 different families were screened for potential antibacterial activity against 3 *Staphylococcus* species, namely *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Staphylococcus subflava*. Antibacterial activity of aqueous and alcoholic extracts was performed by agar disc diffusion method and agar well diffusion method. The alcoholic extracts were more active than aqueous extracts for all the plants studied. The most susceptible bacterium was *S. aureus*. The methanol extract of *Woodfordia fruticosa* showed the best antibacterial activity. The *in vitro* susceptibility testing of the studied staphylococcus strains was done against standard antibiotics.

Key Words: Medicinal plants, antibacterial activity, *Staphylococcus* species

Otuzdört adet Hindistan'a ait Tıbbi Bitkinin Sıvı ve Alkolik Ekstraktının Bazı *Staphylococcus* Türlerine Karşı Antibakteriyal Aktivitesi

Özet: Hindistan'da yetişen Yirmi sekiz farklı familyaya ait 34 farklı tıbbi bitkinin üç Staphylococcus species viz. *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Staphylococcus subflava* bakterisi üzerine sıvı alkolik ektraktların antibakteriyal aktivitesi agar disk diffüzyon ve agar well diffüzyon yöntemi ile çalışılmıştır. En hassas bakteri *S. aureus* olarak belirlenmiştir. *Woodfordia fruticosa* bitkisinin methanol ekstraktı iyi antibakteriyal aktivite göstermiştir. In vitro duyarlılık testi *Staphylococcus* türlerine karşı standart antibiyotikler kullanılarak yapılmıştır.

Anahtar Sözcükler: Tıbbi bitki, antibakteriyal aktivite, *Staphylococcus* species

Introduction

There is a continuous and urgent need to discover new antimicrobial compounds with diverse chemical structures and novel mechanisms of action because there has been an alarming increase in the incidence of new and reemerging infectious diseases. Another big concern is the development of resistance to the antibiotics in current clinical use.

Gram-positive cocci, and particularly Staphylococcus species, are predominant among the organisms that are responsible for infective complications following surgical vascular grafts or the implantation of prosthetic devices (1). Treatment of postoperative infections is further complicated by the emergence of antibiotic-resistant pathogens, which has contributed significantly to the morbidity and mortality of hospitalized patients. Most staphylococcus infections result in acute diseases.

Staphylococcus aureus is a facultatively anaerobic, gram positive bacterium, which causes food poisoning and usually grows on the nasal membrane and skin. It is also found in the gastrointestinal and urinary tracts of warm-blooded animals (2). It also causes boils, abscesses, wound infection, pneumonia, toxic shock syndrome, and other diseases (2). *S. aureus* rapidly develops resistance to many antimicrobial agents. *Staphylococcus epidermidis* is the most common cause of nosocomial bacteremia and is the principal organism responsible for infections of implanted prosthetic medical devices such as prosthetic heart valves, artificial joints, and cerebrospinal fluid shunts (3). Infections caused by *S. epidermidis* are often persistent and relapsing. Although it is generally causative organism in the majority of device related infections (4), the proportions vary depending on the type of infection and centre surveyed.

In light of the recent emergence of the bacteria that are resistant to multiple antimicrobial drugs posing a challenge for the treatment of infections, the need to discover new antimicrobial substances for use in combating such micro-organisms becomes pertinent. Resistant bacteria representing a challenge in the treatments of various well-known infections necessitated the need to find new substances with antimicrobial properties to be used in the combat against these micro-organisms (5).

Besides small molecules from medicinal chemistry, natural products are still major sources of innovative therapeutic agents for various conditions, including infectious diseases (6). Current research on natural molecules and products primarily focuses on plants since they can be sourced more easily and selected on the basis of their ethno-medicinal use (7). The antimicrobial compounds produced by plants are active against plant and human pathogenic microorganisms (8). There are several reports in the literature regarding the antimicrobial activity of plant crude extracts and the bioassay-guided fractionation to yield active principles (9-13). The present study was aimed to evaluate the potentiality of aqueous and alcoholic extracts of 34 Indian medicinal plants against some *Staphylococcus* species. A similar screening study was done against selected pathogens of Enterobacteriaceae (14).

Materials and Methods

Ethno medical information and plant collection

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

Plant extraction

For aqueous extraction, 10 g of air-dried powder was taken in 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. After 6 h, the supernatant was collected at an interval of 2 h, pooled together, and concentrated to make the final volume one-fourth of the original volume. It was then autoclaved at 121 °C under 15 lbs pressure and stored at 4 °C.

For solvent extraction, 10 g of air-dried powder was taken in 100 ml of organic solvent (methanol 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 °C in airtight bottles.

Microorganisms

The microbial strains investigated are identified strains and were obtained from National Chemical Laboratory (NCL), Pune, India. The studied bacterial strains include *Staphylococcus aureus* ATCC 25923, *Staphylococcus epidermidis* ATCC 12228, and *Staphylococcus subflava* NCIM 2178. Microorganisms were maintained at 4 °C on nutrient agar slants.

Antibacterial activity

The antibacterial assay was performed by 2 methods: Agar disc diffusion method (15,16) for aqueous extract and Agar well diffusion method (17,18) for solvent extract. The media (Mueller Hinton Agar No.2) along with the inoculum (10^8 cfu/ml) was poured into the petri plate (Hi-media). For agar disc diffusion method, the disc (0.7cm, Hi-Media) was saturated with 100 µl of the test compound, allowed to dry, and introduced on the upper layer of the seeded agar plate. For agar well diffusion method, a well was prepared in the plates with the help of a cup-borer (0.85cm). Into the well, 100 µl of the test compound was introduced. The plates were incubated overnight at 37 °C. Microbial growth was determined by measuring the diameter of the zone of inhibition. For each bacterial strain, negative controls were maintained where pure solvents were used instead of the extract (16). The control zones were subtracted from the test zones and the resulting zone diameter is shown in the Table 2. For positive control, 5 antibiotics, namely Chloramphenicol (30 mcg/disc), Gentamicin (10 mcg/disc), Ciprofloxacin (5 mcg/disc), Piperacillin (100 mcg/disc), and Imipenem (10 mcg/disc) were used. The experiment was performed 3 times and the mean values are presented.

Table 1. Ethnobotanical information of 34 Indian medicinal plant species screened for antibacterial activity.

Botanical name (family, genus, species) - [Chemical constituent/s present]	Vernacular name	Habit	Voucher number	Part(s) extracted	Action/Therapeutic use
AMARANTHACEAE					
Celosia argentea L. [cellogenamide-a cyclic peptide, phenols, flavanoids	Lambadi	Herb	PSN645	Whole	anpy, aphro, bl dis, dia, gon, infl, sor
ASCLEPIADACEAE					
Tylophora indica (Burm.f.) Merr. [alkaloids tylophorine, tylophorinine]	Damnivel	Climber	PSN462	Leaf	car, dip, em, expec, pur, stm, ath, bron, dia, dys, dyspep, fla, gou, ul, wo
ASTERACEAE					
Vernonia anthelmintica (L.) Willd. [resin, essential oil]	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. [Saponin, argenic acid, mucilage and sugar, fatty acids]	Engoria	Shrub	PSN112	Whole	alex, anal, anth, pur, verm, bo, bu, co, fra, leucd, sb, sk, sls
BIGNONACEAE					
Spathodea campanulata Beauv. [glucosides, phenols, tannins]	Kesudo	Tree	PSN563	Aerial parts	Pur, sk
CAESALPINIACEAE					
Cassia fistula L. [anthraquinone derivatives, tannin, volatile oil, gluten, sugar, gum]	Garmalo	Tree	PSN250	Leaf	cat, em, feb, lax, pur, bil, bron, fev, rheu, rw
CHENOPODIACEAE					
Beta vulgaris L. [betin]	Beet	Herb	PSN654	Leaf	aphro, car, diu, emmen, exp, pur, ton, con, eac, hac, infl, itc, para, sor, ul
Spinacia oleracea L. [vitamins, minerals]	Palak ni Bhaji	Herb	SU/BIO/495/Thakrar	Leaf	cat, feb, stm, infl
COMMELINACEAE					
Commelina benghalensis L. [alkaloids, caffeine, volatile oil, wax]	Motishumliyu	Herb	PSN731	Whole	diu, sti, dia, fev, lep
CONNARACEAE					
Rourea santaloides (Vahl.) Wight &. Arnott [rourinoside, rouremin]	Vardharo	Herb	SU/BIO/496/Thakrar	Root	ton, diab, rheu, sk
CONVOLVULACEAE					
Cressa cretica L. [flavanoids]	Paliyo	Herb	PSN496	Whole	anth, aphro, stm, ath, con, ton
CRUCIFERAE					
Lepidium sativum L. [alpha-tocopherol, ascorbic acid, benzyl-isothiocyanate, beta-sitosterol, iodine, niacin, l inoleic acid]	Ashal/Aserio	Herb	PSN13	Seed	antc
CUCURBITACEAE					
Lagenaria vulgaris Seringe [fixed oils, saponins, vitamins, minerals]	Tumbada	Climber	PSN328	Fruit	ton, pur
Momordica charantia L. [5-hydroxytryptamine, alkaloids, ascorbic acid, beta-carotene, citrulline, cryptoxanthine, diosgenin, lanoscharantin, cryptoxanthin, lutein, lycopene, momordicin, niacin, s tigmasterol, zeaxanthin, zeinoxanthin]	Karela	Climber	PSN333	Fruit	anth, lax, sed, bron, co, elph, pil, ul
Mukia maderaspatana (L.) M.Roem. [Spinasterol, dihydrospinasterol glucoside, fatty acids]	Chadakachima	Climber	PSN335	Aerial parts	exp, sti
CYPERACEAE					
Cyperus scarious R.Br. [essential oil, myristic, stearic acid, b-selinne, cyperenone]	Nagarmoth	Herb	PSN765	Seed	aro, ast, dip, stm, dia
EHRETIACEAE					
Cordia dichotoma Forst. [Tannin, catharin, sugar, gum ash]	Gunda	Tree	PSN472	Leaf	anth, ast, diu, dmu, exp, pur, ton, co, dyspep, fev, hac, jp, rw, sb, ul

Table 1. (Continued)

Botanical name (family, genus, species) - [Chemical constituent/s present]	Vernacular name	Habit	Voucher number	Part(s) extracted	Action/Therapeutic use
EUPHORBIACEAE					
Ricinus communis L. [ricin, ricin oil, palmitin, sterine]	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. [palmitic acid, oleic acid, protein, vitamin B1, B2, B6 and contains lecithin]	Magfali	Herb	PSN152	Leaf	ast, adp, bron, con, fla
Canavalia gladiata DC. [protein, starch]	Talvardi	Climber	PSN157	Leaf	can
Vigna radiata L. [proteins, arachidic acid, arginine, ascorbic acid, genstein, shikimic acid]	Mag	Herb	PSN235	Whole	aphro, dig, feb, gal, ton, co, con, dia, dyspep, fev, fla, hae, infl, lep, pyr, sk
FUMARIACEAE					
Fumaria indica (Haussk.) Pugsley. [alkaloids]	Pitpopdo	Herb	SU/BIO/497/Thakrar	Seed	dip, diu
GUTTIFERAE					
Mesua ferra Linn. [mesuanic acid, mesuaferol, mesuaferrone-A&B, β-sitosterol, xanthones, coumarins]	Nagkesar	Tree	SU/BIO/498/Thakrar	Seed	aro, ast, col
LABIATAE					
Ocimum kilimanjaricum L. [methyl cinamate, camphor]	Kapur tulsi	Herb	SU/BIO/499/Thakrar	Whole	col, diu
LAURACEAE					
Cinnamomum tamala Nees & Ebern. [Essential oil, eugenol, terpene, cinnamic aldehyde oil saffral]	Tamal patra	Tree	SU/BIO/500/Thakrar	Leaf	car, diu, dip, gal, sti, co, dyspep, fev, fla
LYTHRACEAE					
Woodfordia fruticosa Kurz. [tannin, sugar and naturally acquired yeast microflora]	Dhawadi phool	Shrub	PSN303	Flower	anth, ast, em, feb, sed, sti, bil, bu, diab, hae, lep, sk
MALVACEAE					
Thespesia populnea (L.) Sol ex Correa. [gossypol, herbacetin, kaempferol]	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. [Gyanomacloin, starch, ash fibre]	Fanas	Tree	SU/BIO/501/Thakrar	Whole	abor, aphro, car, ton, bil, bo, dia, lep, sb, sk, ul, wo
Ficus elastica Roxb. [Tannin, wax, ash.]	Rubber plant	Tree	PSN705	Leaf	-
PIPERACEAE					
Piper longum L. [piperlongumine, piperlonguminine, piperine, sesamin]	Piplimul	Climber	SU/BIO/502/Thakrar	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. [Silicious concretion, tabasbir, choline, betain, nuclease, urease, cyanogenetic, glucoside]	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. [resinous gum called dikamali]	Dikamali	Tree	PSN351	Gum exudate	car, fla, indi, sk
SAPOTACEAE					
Manilkara hexandra (Roxb.) Dubard. [tannins]	Rayan	Tree	PSN428	Leaf	aphro, col, ton, bil, bron, lep, ul, urd
VITACEAE					
Cissus quadrangularis L. [carotene, ascorbic acid, fibre, calcium oxalate]	Hadsankar	Climber	PSN127	Stem	anal, fra, mup, pil, tum, ul, wo

Table 1. (Continued)

Key to abbreviations in Table 1

DISEASES						
A	C		H	L	pil - piles	swe - swellings
abs - abscesses	calc - calculi	dysame -	hac - headache	leucd - leucoderma	pim - pimples	syp - syphilis
adp - abdominal	can - cancer	dysamenorrhoea	hae - haemmorrhage	leuch - leucorrhoea	pneu - pneumonia	T
pain	cd - cold	dyspep - dyspepsia	haem - haemorrhoids	lep – leprosy	psor - psoriasis	toac - tooth ache
aly - allergy	chl- cholera	E	her - hernia	lum - lumbago	psy - psycopathy	tum - tumors
ame - amentia	chp - chest pain	eac-earache	hp - hydrophobia	M	pyr - pyrexia	typh – typhoid
amen -	co - cough	ecz - eczema	hys - hysteria	mal - malaria	R	U
amenorrhoea	con - constipation	elph - elephantiasis		mig - migraine	rheu - rheumatism	ul - ulcers
anm - anaemia	D	epi - epilpsy	I	mum - mumps	rw - ringworm	urd - urinary
ano - anorexia	deli -delirium	F	indi - indigestion	mup - muscular	S	disorders
arth - arthritis	den fev - dengue	fat - fatigue	infl - inflammations	pain	sb - snake bite	V
ath - asthma	fever	fev - fever	ins - insomnia	N	sca - scabies	vom - vomiting
B	der - dermatitis	fla - flatulence	itc - itch	neu - neuralgia	scia - sciatica	W
bil - biliousness	dia - diarrohea	fra - fracture	J	O	sk - skin disease	wo - wounds
bl dis - blood diseases	diab - diabetes	G	jaun - jaundice	ob - obesity	sls - sleeping	wor - worms
bo - boils	diph - diphtheria	gin - gingivitis	jp - joint pain	P	sickness	
bron - bronchitis	drop - dropsy	gon - gonorrhoea		para - paralysis	smp - small pox	
bu - burns	dys - dysentry	gou - gout		phg - pharyngitis	sor - sores	
MEDICINAL PROPERTIES						
A	antpy - antipyretic	B	D	emmen - emmenagogue	P	sed - sedative
abor - abortifacient	antsp - antiseptic	b.ton - brain tonic	dig - digestive	exp - expectorant	pec - pectoral	sti - stimulant
alex - alexipharmic	antsp - antispasmodic	C	dip - diphoretic	F	pur - purgative	T
anal - analgesic	aphro - aphrodisiac	c.ton - cardiotonic	diu - diuretic	feb - febrifuge	R	ton - tonic
antd - antidote	apt - apetiser	car - carminative	dmu - demulcent	G	rub - rubefacient	
anth - anthelmentic	aro - aromatic	cat - cathartic	E	gal - galactagogue	S	V
anthy - antihypertensive	ast - astringent	col - coolant	em - emetic	L	stm - stomachic	verm - vermifuge
antpr - antiperiodic				lax - laxative		

Results and Discussion

The traditional medicinal methods, especially the use of medicinal plants, still play a vital role to cover the basic health needs in the developing countries, and moreover, the use of herbal remedies has risen in the developed countries in the last decade. In this manner, plants continue to be a rich source of therapeutic agents. It is anticipated that phytochemicals with adequate antibacterial efficacy will be used for the treatment of bacterial infections (19). The need of the hour is to screen a number of plants that are traditionally used and also to evaluate their probable phyto constituents (13, 20).

Table 1 summarizes the ethobotanical information of the 34 plant species belonging to 28 different families. The antibacterial activity of the 3 bacteria against the plants screened is shown in Table 2. *Tylophora indica, Spinacia oleracea, Commelina benghalensis, Ficus elastic,* and *Bambusa arundinaceae* did not show any activity in aqueous or alcoholic extract. However, negative results do not indicate the absence of bioactive constituents, nor that the plant is inactive. Active compound(s) may be present in insufficient quantities in the crude extracts to show activity with the dose levels employed (21). Lack of activity can thus only be proven by using large doses (22). Alternatively, if the active principle is present in high enough quantities, there could be other constituents exerting antagonistic effects or negating the positive effects of the bioactive agents (23). With no antibacterial activity, extracts may be active against other bacterial species which were not tested (24). Out of 34 plants screened, 5 plants did not show any activity in aqueous or alcoholic extract while the aqueous extract of 9 plants and alcoholic extract of 3 plants did not show any antibacterial activity; the rest of the plants showed varied levels of activity towards any one of the staphylococcus species (Table 2). Maximum antibacterial activity amongst aqueous extract was shown by *Lepidium sativum*, followed by *Rourea santaloides* and *Woodfordia fruticosa*; and amongst alcoholic extracts, maximum activity was shown by *Mesua ferra* and *Woodfordia fruticosa*. However, methanol extract of *Woodfordia fruticosa* showed activity towards all 3 species while that of *Mesua ferra* did not show any activity against *S. epidermididis*. The most susceptible bacterium was *S. aureus* and methanol extract of *Woodfordia fruticosa* showed the best antibacterial activity. The potentiality of *Woodfordia fruticosa* is already reported (25).

Table 2. Screening of 34 Indian plant species for potential antimicrobial activity against some *Staphylococcus* species.

Botanical name (family, genus, species)	Extract	*Sa**	*Se**	*Ss**
AMARANTHACEAE				
Celosia argentea L.	H_2O	3	7	-
	EtOH	-	-	1
ASCLEPIADACEAE				
Tylophora indica (Burm.f.) Merr.	H_2O	-	-	-
	EtOH	-	-	-
ASTERACEAE				
Vernonia anthelmintica (L.) Willd.	H_2O	2	-	-
	EtOH	-	-	2
BALANITACEAE				
Balanites aegyptiaca (L.) Del.	H_2O	4	11	-
	EtOH	-	-	3
BIGNONACEAE				
Spathodea campanulata Beauv.	H_2O	3	-	-
	MeOH	-	-	2
CAESALPINIACEAE				
Cassia fistula L.	H_2O	-	-	-
	MeOH	3	-	1
CHENOPODIACEAE				
Beta vulgaris L.	H_2O	2	4	-
	EtOH	-	-	1
Spinacia oleracea L.	H_2O	-	-	-
	MeOH	-	-	-
COMMELINACEAE				
Commelina benghalensis L.	H_2O	-	-	-
	EtOH	-	-	-
CONNARACEAE				
Rourea santaloides (Vahl.) Wight &. Arnott	H_2O	3	9	2
	EtOH	-	-	4
CONVOLVULACEAE				
Cressa cretica L.	H_2O	3	6	-
	EtOH	-	-	-
CRUCIFERAE				
Lepidium sativum L.	H_2O	12	2	2
	MeOH	-	-	2
CUCURBITACEAE				
Lagenaria vulgaris Seringe	H_2O	-	-	-
	MeOH	1	-	3
Momordica charantia L.	H_2O	-	2	-
	MeOH	7	2	4
Mukia maderaspatana (L.) M.Roem.	H_2O	2	-	-
	EtOH	-	-	-
CYPERACEAE				
Cyperus scarious R.Br.	H_2O	-	-	-
	MeOH	3	-	3
EHRETIACEAE				
Cordia dichotoma Forst.	H_2O	5	1	-
	EtOH	-	-	2
EUPHORBIACEAE				
Ricinus communis L.	H_2O	-	-	-
	MeOH	8	-	2

Table 2. (Continued)

Botanical name (family, genus, species)	Extract	*Sa**	*Se**	*Ss**
FABACEAE				
Arachis hypogaea L.	H_2O	-	-	-
	EtOH	3	7	3
Canavalia gladiata DC.	H_2O	-	-	-
	EtOH	-	-	-
Vigna radiata L.	H_2O	3	1	-
	EtOH	-	-	2
FUMARIACEAE				
Fumaria indica (Haussk.) Pugsley.	H_2O	5	1	-
	EtOH	-	1	1
GUTTIFERAE				
Mesua ferra Linn.	H_2O	2	-	4
	MeOH	13	-	16
LABIATAE				
Ocimum kilimanjaricum L.	H_2O	-	-	-
	EtOH	2	-	4
LAURACEAE				
Cinnamomum tamala Nees & Ebern.	H_2O	3	1	-
	EtOH	-	3	4
LYTHRACEAE				
Woodfordia fruticosa Kurz.	H_2O	9	-	3
	MeOH	15	9	10
MALVACEAE				
Thespesia populnea (L.) Sol ex Correa.	H_2O	3	-	-
	EtOH	4	-	2
MORACEAE				
Artocarpus hetrophyllus Lam.	H_2O	3	9	-
	EtOH	4	-	6
Ficus elastica Roxb.	H_2O	-	-	-
	MeOH	-	-	-
PIPERACEAE				
Piper longum L.	H_2O	-	3	-
	EtOH	-	-	6
POACEAE				
Bambusa arundinaceae (Retz.) Roxb.	H_2O	-	-	-
	EtOH	-	-	-
RUBIACEAE				
Gardenia resinifera Roth.	H_2O	-	-	-
	MeOH	3	-	7
SAPOTACEAE				
Manilkara hexandra (Roxb.) Dubard.	H_2O	2	4	2
	MeOH	7	10	4
VITACEAE				
Cissus quadrangularis L.	H_2O	-	-	-
	MeOH	-	-	1

H_2O: aqueous extract, EtOH: ethanol extract, MeOH: methanol extract
#values are the mean of inhibition zone diameter and subtracted from the control
Sa: Staphylococcus aureus, Se: Staphylococcus epidermidis, Ss: Staphylococcus subfava

Table 3. Antibacterial susceptibility testing of various standard antibiotics against *Staphylococcus* species.

Antibiotics	Zone of Inhibition (mm)		
	S. aureus	*S. epidermidis*	*S. subflava*
Chloramphenicol (30 mcg/disc)	20	19	18
Ciprofloxacin (5 mcg/disc)	15	23	19
Gentamicin (10 mcg/disc)	18	18	14
Piperacillin (100 mcg/disc)	22	-	21
Imipenem (10 mcg/disc)	30	28	29

Table 3 reports the antibacterial susceptibility of various standard antibiotics against *S. aureus*, *S. epidiermidis,* and *S. subflava*. The antibacterial activity of different plant species can be compared with the standard antibiotics. The results show significant activity of the plants, like *Woodfordia fruticosa* followed by *Mesua ferra* and *Manilkara hexandra,* against investigated *Staphylococcus* species.

This work may provide essential information in the selection of plant extract for further isolation of constituents responsible for the activity against the studied species, thereby aiding to explore an antibacterial lead that is helpful in combating the diseases caused by *Staphylococcus* species.

Corresponding author:
Sumitra V. CHANDA
Phytochemical, Pharmacological and
Microbiological Laboratory,
Department of Biosciences, Saurashtra University,
Rajkot, 360 005, Gujarat, INDIA
E-mail: sumitrachanda@yahoo.com

References

1. De Lalla F. Antimicrobial chemotherapy in the control of surgical infectious complications. J Chemotherap 11: 440-445, 1999.
2. Cheesbrough M. Medical Laboratory Manual for Tropical Countries. Microbiology, Linacre house, Jordan Hill Oxford, pp. 260, 2000.
3. Rupp ME, Archer GL. Coagulase-negative staphylococci: pathogens associated with medical progress. Clin Infect Dis 19: 231–245, 1994.
4. Huebner J, Goldmann D. Coagulase-negaive staphylococci: role as pathogens. Annu Rev Med 50: 223-226, 1999.
5. Martins AP, Salgueiro L, Goncalves MJ et al. Essential oil composition and antimicrobial activity of three Zingiberaceae from *S. Tome* e Principle. Planta Med 67: 580-584, 2001.
6. Clardy J, Walsh C. Lessons from natural molecules. Nature 432:829-837, 2004.
7. Verpoorte R, Choi YH, Kim HK. Ethanopharmacology and system biology: a perfect holistic match. J Ethnopharmacol 100: 53-56, 2005.
8. Mitscher LA, Drake S, Gollapudi SR et al. A modern look at folkloric use of anti-infective agents. J Nat Prod 50: 1025-1040, 1987.
9. Palombo EA, Semple SJ. Antibacterial activity of traditional Australian medicinal plants. J Ethnopharmacol 77: 151-157 2001.
10. Zgoda-Pols JR, Freyer AJ, Killner LB et al. Antimicrobial resveratrol tetramers from the stem bark of *Vatica oblongifolia* ssp. *oblongifolia*. J Nat Prod 65: 1554-1559, 2002.
11. Parekh J, Jadeja D, Chands S. Efficacy of aqueous and methanol extracts of some medicinal plants for potential antibacterial activity. Turk J Biol 29: 203-210, 2005.
12. Nair R, Chanda S. Antibacterial activity of some medicinal plants against some medically important bacterial strains. Indian J Pharmacol 38: 142-144, 2006.
13. Parekh J, Chands S. *In vitro* antimicrobial activity and phytochemical analysis of some Indian medicinal plants. Turk J Biol 31: 53-58, 2007a.
14. Parekh J, Chands S. *In vitro* antibacterial activity of some aqueous and alcoholic extracts of various Indian plant species against selected pathogens from Enterobacteriaceae. Afr J Microbiol Res 1: 92-99, 2007b
15. Bauer AW, Kirby WMM, Sherris JC et al. Antibiotic susceptibility testing by a standardized single disk method. Am J Clin Pathol 45: 493-496, 1966.

16. Parekh J, Chands S. *In vitro* antimicrobial activities of extracts of *Launaea procumbens* Roxb. (Labiateae), *Vitis vinifera* L. (Vitaceae) and *Cyperus rotundus* L. (Cyperaceae). Afr J Biomed Res 9: 89-93, 2006.

17. Perez C, Paul M, Bazerque P An antibiotic assay by the agar well diffusion method. Acta Biol Med Exp 15: 113-115, 1990.

18. Nair R, Chanda S. Antibacterial activity of *Punica granatum* in different solvents. Indian J Pharm Sci 67: 239-243, 2005.

19. Balandrin MF, Kjocke AJ, Wurtele et al. Natural plant chemicals: sources of industrial and mechanical materials. Science 228: 1154-1160, 1985.

20. Parekh J, Chanda S. Antibacterial and phytochemical studies on twelve species of Indian medicinal plants. Afr J Biomed Res 10: 175-184, 2007c.

21. Taylor JLS, Rabe T, McGraw LJ et al. Towards the scientific validation of traditional medicinal plants. Plant Growth Regul 34: 23-37, 2001.

22. Farnsworth NR. Biological approaches to the screening and evaluation of natural products. In: Rasoanaivo P, Ratsimamanga-Urverg S (Eds) Biological Evaluation of Plants with Reference to the Malagasy Flora, Madagascar, pp. 35-43, 1993.

23. Jager AK, Hutchings A, van Staden J. Screening of Zulu medicinal plants for prostaglandin-synthesis inhibitors. J Ethnopharmacol 52: 95-100, 1996.

24. Shale TL, Strik WA, van Staden J. Screening of plants used by southern African traditional healers in the treatment of dysmenorrhoea for prostaglandin-synthesis inhibitors and uterine relaxing activity. J Ethnopharmacol 64: 9-14, 1999.

25. Parekh J, Chands S. *In vitro* antibacterial activity of the crude methanol extract of *Woodfordia fruticosa* Kurz. flower (Lythraceae), Braz J Microbiol 38: 204-207, 2007d.