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Exploring antibacterial potential of some ayurvedic preparations to control bacterial enteric infections

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ABSTRACT

Herbal medicines are the major remedy in traditional medical systems from thousand of years and made a great contribution in maintaining human health and in preventing many infectious diseases. Ayurvedic herbal preparations based on the medicinal plants are used in modern health care to prevent common bacterial diseases but their antibacterial potential was not evaluated in detail. Therefore, an effort was made to evaluate the antibacterial potential of herbal Ayurvedic product against enteric bacterial pathogens. The antibacterial potentials of some herbal preparations used in Ayurvedic system of medicine namely Ashwagandhadi churna, Bilwadi churna, Chandanadi churna, Chopchinyadi churna, Dashmula churna, Dhatupaushtic churna, Eladi churna, Gangadhar churna, Hingwashtak churna, Jatiphaladi churna, Lavangadi churna, Kutuja churna, Narayan churna, Sarswat churna, Shatawaryadi churna, Talisadi churna and Shivkshar Pachan churna were investigated by disc diffusion method against enteric bacterial pathogens such as Escherichia coli, Staphylococcus aureus, Enterobacter aerogenes, Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumoniae, Salmonella typhi, Staphylococcus epidermidis, Salmonella typhimurium, Proteus vulgaris. The study in vitro corroborated the antibacterial potential of the ayurvedic preparation used in Indian system of medicine and showed antibacterial activities against Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi, Staphylococcus aureus, Staphylococcus epidermidis and Proteus vulgaris. Thus study showed that these herbal preparations might be alternative medicine to combat enteric bacterial infection in human being.

Key words: Antibacterial activity, ayurvedic preparations, enteric bacterial pathogens.

INTRODUCTION

India has a unique position in the world, where a number of recognized indigenous systems of medicine viz., Ayurveda, Siddha, Unani, Homeopathy, Yoga and Naturopathy are being

used for the health care of people [1]. Ayurvedic herbal preparations based on the medicinal plants are used in modern health care as dietary supplements to prevent common bacterial diseases [2] as plant products are thought to be non-toxic have less side effects and easily available at affordable cost [3-5]. The most frequently used type of herbal preparations is churna, a powdery preparation of medicinal plants that may be single or in combinations. The combinations of medicinal plants may increases the antimicrobial spectrum and potency of the preparations. More than 1500 herbal preparations are sold as dietary supplements or ethnic traditional medicines in India [6].

Enteric or diarrhoeal infections are major public health problems in developing countries and contribute to the death of 3.3 to 6.0 million children annually [7]. Enteric bacteria comprised of *Salmonella* sp., *Shigella* sp., *Proteus* sp., *Klebsiella* sp., *E. coli, Pseudomonas* sp., *Vibrio cholerae* and *S. aureus* which are major etiologic agents of sporadic and epidemic diarrhea both in children and adults [7]. Recently, it has been demonstrated that many human pathogenic bacteria have developed resistance against several synthetic drugs indicating need to search for alternative medicine [8-10]. A lack of scientific studies on herbal medicine in the peer reviewed literature poses a conundrum for health care professionals when dealing with these products [11]. In addition only a limited number of *in vivo* and *in vitro* studies on antimicrobial properties of herbal products have been published, also it has not been determined whether they are superior or equivalent to antibiotics [12, 13]. Many herbal products claim to have antimicrobial properties but very little research has been conducted to investigate their claims [14, 15]. In order to promote Indian herbal medicine, there is an urgent need to evaluate the therapeutic potentials of the herbal preparation available in India. Therefore, an effort was made to evaluate the antibacterial potential of herbal Ayurvedic product against enteric bacterial pathogens**.**

EXPERIMENTAL SECTION

The commercial herbal preparations listed in Table 1 were purchased from the local Ayurvedic market of Amravati. These herbal preparations have multiple botanical ingredients in addition to some chemical substances.

Preparation of extracts: The aqueous extract was prepared by adding 20 g of herbal preparations in 200 mL distilled water, heated at $60^{\circ}C$ for 2 h, filtered through cloth and the filtrate was evaporated on sand bath. The dry mass was then stored at $4^{\circ}C$. The organic solvent extract was prepared by adding 20 g herbal preparation (powder) in 200 mL of organic solvent (acetone, ethanol and methanol) in screw-capped bottles; shake at 190-220 rpm on a rotary shaker. After 24h of shaking, the extract was filtered, evaporated in vacuum and dried by rotary evaporator at $60^{\circ}C$ [16]. Dried extracts were stored in labeled sterile screw capped bottles at $4^{\circ}C$ and later used for the in *vitro* study.

Bacterial cultures: The standard pathogenic bacterial cultures were procured from IMTECH, Chandigarh, India and used in the present study (Table 2). The bacterial cultures were rejuvenated in Mueller- Hinton broth (Hi-media laboratories, Mumbai, India) at 37^0C for 18h and then stocked at 4^0C in Mueller-Hinton Agar. The inoculum size of the bacterial culture was standardized according to the National committee for Clinical Laboratory Standards [17] guideline. The pathogenic bacterial culture was inoculated into sterile Nutrient broth and incubated at 37^0C for 3h until the culture attained a turbidity of 0.5 McFarland

units. The final inoculum size was standardized to 10^5 CFU/mL with the help of SPC and Nephlo-turbidometer.

Preparation of disc for antibacterial activities: The aqueous, ethanol, methanol and acetone extracts were prepared in their respective solvents and the sterile blotting paper disc (10 mm) were soaked in the diluted extract in such concentration that the amount of solution absorbed by each disc was 5 mg of each extracts of herbal preparations. The prepared disc were dried in controlled temperature to remove excess of solvent and used in study.

Antibacterial Activity using disc diffusion method: The modified paper disc diffusion [17] was employed to determine the antibacterial activity of both aqueous and organic solvents extract of herbal preparations. Turbidity of inoculums was matched with McFarland turbidity standard. Inoculums were spread over the Nutrient agar plate using a sterile cotton swab in order to get a uniform microbial growth. Then the prepared antibacterial disc were placed over the lawn and pressed slightly along with positive and negative controls. Ampicillin 10 mcg/disc (Hi-Media, Mumbai) were used as positive control while disc soaked in sterile distilled water or various organic solvents and dried were placed on lawns as negative control. The plates were incubated for 18h at 37°C. The antibacterial activity was evaluated for 5mg/disc and diameter of inhibition zones were measured. Experiment was carried out in triplicate and the averages diameter of zone of inhibition was recorded. The antibacterial activity was classified as strong (>20mm), moderate (15-20mm) and mild (12-15mm) and less than 12mm was taken as inactive. Antimicrobial Sensitivity Index (ASI) was calculated by following formula [18]

$$\text{Antimicrobial Sensitivity Index for Herbal preparation} = \frac{\text{Total zone of growth inhibition}}{\text{No. of Antimicrobial agents tested} \times \text{no. of bacterial Pathogens}}$$

RESULTS AND DISCUSSION

The Ayurvedic herbal preparations are potential source of therapeutics aids and play a significant role in health system. In the present study available herbal preparations were screened for antibacterial potential against various enteric bacterial pathogens. Among them Narayan churna, Sarswat churna, Lavangadi churna, Chandanadi churna, Eladi churna, Chopchinyadi churna, Gangadhar churna were potent antibacterial agent. They exhibited significant antibacterial activity against *S. epidermidis, S. aureus, P. vulgaris, E. coli, K. pneumoniae, P. aeruginosa, B. subtilis, E. aerogenes, S. typhimurium* and *S. typhi.*

Table 1: Herbal preparation tested for antibacterial potential

Herbal Preparation	Manufacturer	Ingredients as per listed on package	Indication
Ashwagandhadi churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Withania somnifera, Argyreia spinosa*	In cerebral and general debility
Bilwadi churna	Ritesh Pharmaceutical Vadodara (GJ)	*Aegle marmelos, Cyperus rotundus, Woodfordia fruticosa, Zingiber officinale, Bombax malabaricum*	Astringent and alterative. indicated in sprue, Diarrhoea and dysentery
Chandanadi Churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Santalum album, Acasia arabica Syzigium cumini, Magnifera indica, Ptychotis ajowan, Tinosporia cordifolia*	Useful in urinary infection, used as antiseptic. cystitis, genito-urinary affections,
Chopchinyadi churna	Ritesh Pharmaceutical Vadodara (GJ)	*Smilax china, Sugar, Piper longum, Piper longum root, Piper nigrum, Syzygium aromaticum, Anacyclus pyrethrum, Asteracantha longifolia, Zingiber officinale, Embelia ribes, Cinnamomum zeylanicum*	Used as diaphoretic, sedative, stimulant and alterative. used in syphilis, gout, rheumatism, epilepsy,
Dashmula churna	Ritesh Pharmaceutical	*Aegle marmelos, Oroxylum indicum,Gmelina arborea, Stereospermum suaveolens, Premna Integrifolia, Desmodium*	Used for cough, influenza, cold, fever and headache.

	Vadodara (GJ)	*gangeticum, Uraria picta, Solanum indicum, Solanum xanthocarpum, Tribulus terrestris*	
Dhatupaushtic churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Asparagus racemosus, Tribulus terrestris, Sida cordifolia, Adhatoda vasica, Piper cubeba, Gymnema sylvestre, Mucuna pruriens, Chlorophytum tuberosum, Zingiber officinale, Withania somnifera, Piper nigrum, Ficus religiosa, Polygonatum verticillatum, Ipomoea digitata, Asparagus adscendens, Mallotus philippensis, Ipomoea turpenthum*	For vitality and virile debility
Eladi churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur (M.S.)	*Elettaria cardamomum,Mesua ferrea, Eclipta alba, Ptychotis ajowan, Coriandrum sativum, Cuminum cyminum, Plumbago zeylanica, Piper longum, Piper nigrum, Zingiber officinale, Bambusa arundinacea, Vitis vinifera, Punica granatum*	Carminative. indicated in vomiting, indigestion and anorexia.
Gangadhar churna	Ritesh Pharmaceutical Vadodara (GJ)	*Cyperus rotundus, Oroxylum indicum, Zingiber officinale, Woodfordia fruticosa, Symplocos racemosa, Valeriana wallichii,Aegle marmelos, Bombax malabaricum, Cissampelos pareira, Holarrhena antidysenterica, Mangifera indica, Aconitum heterophyllum, Mimosa pudica*	Diarrhoea and dysentery
Hingwashtak churna	Dabur India Ltd, Alwar (RJ)	*Zingiber officinale, Piper nigrum, Piper longum, Ptychotis ajowan, Rock salt,Cuminum cyminum Carum carvi, Ferula asafoetida*	Used in constipation, carminative and gastric stimulant.
Jatiphaladi churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Myristica Fragrans, Syzygium aromaticum, Elettaria cardamomum, Cinnamomum tamala, Cinnamomum zeylanicum, Cinnamomum camphora, Bambusa arundinacea, Valeriana wallichii, Emblica officinalis, Plumbago zeylanica,Piper longum, Piper nigrum, Zingiber officinale, Terminalia chebula,*	Used in diarrhoea, dysmenorrhea, Cough.
Kutuja churna	G.M.Pharmacy Bareilly(UP).	*Halarrhea antidysenterica*	Dysentery, diarrhea and fever,
Lavangadi churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Syzygium aromaticum, Myristica fragrans, Cinnamomum zeylanicum, Mesua ferrea, Zingiber officinale, Cuminum cyminum, Piper longum, Valeriana wallichii, Bambusa arundinacea, Nardostachys jatamansi, Santalum album*	Used in cough, diarrhoea, dysentery, mouth disease. dental carries, anemia, fever,
Narayan churna	Ritesh Pharmaceutical Vadodara (GJ)	*Plumbago zeylanica, Terminalia chebula,Terminalia belerica, Emblica officinalis,Zingiber officinale, Piper nigrum, Piper longum.Cuminum cyminum Juneperus communis, Acorus calamus etc*	Chronic constipation, fever,
Sarswat churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur (M.S.)	*Saussurea lappa, Withania somnifera, Rock salt, Trachyspermum ammi, Cuminum cyminum, Carum carvi, Zingiber officinale, Piper nigrum,Piper longum, Cissampelos pareira, Convolvulus pluricaulis, Acorus calamus*	Alterative, brain tonic and stimulant. use in mania, epilepsy, mental weakness nervous strain
Shatawaryadi churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Asparagus racemosus, Sida veronicaefolia, Pueraria tuberosa,Tribulus terrestris, Emblica officinalis*	Demulcent and nutritive tonic. used impotency, general debility, sterility
Shivkshar Pachan churna	Sheetal Medicare-Care Products Pvt.Ltd. Thane (M.S)	*Terminalia chebula, Sodium carbonate, Zingiber officinale, Piper nigrum, Piper longum, Ptychotis ajowan, Rock salt (Sodium chloride), Cuminum cyminum, Carum carvi, Ferula asafoetida*	Useful in digestive disorder.
Talisadi churna	Shree Baidyanath Ayurved Bhavan Pvt. Ltd. Nagpur	*Taxus baccata, Piper nigrum, Zingiber officinale, Piper longum, Bambusa arundinacea, Elettaria cardamomum, Cinnamomum zeylanicum,*	Useful in cough and cold.

Table: 2. Antibacterial Potential of herbal preparations against various enteric bacterial pathogens at 5mg/disc in degree of decreasing order (Zone of inhibition of growth in mm)

Herbal Preparation	Solvent extract	*P. vulgaris (MTCC426)*	*S. epidermidis (MTCC435)*	*S. aureus (MTCC96)*	*E. coli (MTCCi739)*	*P. aeruginosa (MTCC424)*	*B. subtilis (MTCC441)*	*K. pneumoniae (MTCC 109)*	*S. typhi (MTCC i733)*	*E. aerogenes (MTCC 111)*	*S. typhimurium (MTCC 98)*	Antibacterial Sensitivity Index (ASI)	ASI of Product
Narayan churna	Aqueous	++	+++	+++	+	++	+	++	++	+	+	17.4	17.9
	Acetone	++	+++	+++	++	++	++	++	++	+	+	18.2	
	Ethanol	++	+++	+++	+	++	++	+	+	+	++	17.5	
	Methanol	++	+++	+++	++	++	+	++	++	++	++	18.6	
Sarswat churna	Aqueous	++	+++	+++	++	++	++	+	+	+	+	16.3	16.1
	Acetone	++	+++	+++	++	++	++	+	++	++	+	17.5	
	Ethanol	++	+++	++	++	++	+	+	++	+	+	14.8	
	Methanol	++	+++	+++	++	++	++	+	++	+	+	15.7	
Lavangadi churna	Aqueous	++	+++	+++	+	+	+	++	+	+	+	14.1	15.8
	Acetone	++	+++	++	++	++	++	++	+	+	++	16.3	
	Ethanol	++	+++	+++	++	++	+	+	+	+	++	17.2	
	Methanol	++	+++	++	++	++	++	++	++	+	++	15.1	
Chandanadi churna	Aqueous	++	+++	++	++	-	+	++	++	-	++	14.4	15.6
	Acetone	++	+++	++	++	+	+	++	++	++	++	16.1	
	Ethanol	++	+++	+++	++	-	++	++	++	+	+	14.6	
	Methanol	++	+++	+++	++	++	++	++	++	++	+	17.4	

Eladi churna	Aqueous	+	+++	++	++	++	+	++	-	+	-	12.8	15.4
	Acetone	++	++	++	++	+	++	++	+	++	+	15.6	
	Ethanol	++	+++	+++	++	++	++	++	++	+	+	16.2	
	Methanol	+	+++	++	+++	++	++	++	++	+	+	17	
Chopchinyadi churna	Aqueous	++	+++	++	++	++	+	++	+	+	+	14.4	15.3
	Acetone	++	+++	+++	++	+	+	++	++	++	+	15.6	
	Ethanol	++	+++	+++	++	++	+	++	++	+	+	15	
	Methanol	++	+++	+++	++	++	++	++	++	++	+	16	
Gangadhar churna	Aqueous	++	++	+++	++	+	++	+	+	+	+	13.7	15.2
	Acetone	++	++	+++	++	+	++	++	+	++	++	15.8	
	Ethanol	++	++	++	++	+	+	++	+	+	++	13.4	
	Methanol	++	+++	++	++	++	++	++	++	++	+	18	
Kutuja churna	Aqueous	+	++	++	-	+	++	+	++	+	+	12.7	14.7
	Acetone	+	+++	++	+	++	++	++	++	+	++	16.6	
	Ethanol	+	+++	+	+	++	++	++	++	+	+	14.4	
	Methanol	+	++	++	++	+	++	++	++	+	+	15.1	
Shatawaryadi churna	Aqueous	+	++	++	+	-	++	+	++	+	+	12.5	14
	Acetone	+	+++	++	++	-	++	++	++	+	++	15.3	
	Ethanol	+	+++	+++	++	-	++	++	++	+	+	12.8	
	Methanol	+	+++	+++	++	+	++	++	++	+	++	15.3	
Talisadi churna	Aqueous	-	+++	++	++	+	+	+	++	+	-	11.1	12.2
	Acetone	+	+++	++	++	+	+	+	++	-	-	11.9	
	Ethanol	-	++	+	+	-	+	++	+	+	+	10.7	
	Methanol	+	+++	++	++	+	++	++	++	+	+	15.3	
Dhatupaushtic churna	Aqueous	+	++	++	+	+	+	+	-	++	+	10.3	12
	Acetone	++	++	++	++	+	+	+	-	++	++	12.8	
	Ethanol	+	++	++	+	-	+	+	+	++	+	11.3	
	Methanol	+	++	+++	++	+	+	+	+	++	++	13.6	
Dashmula churna	Aqueous	+	+	++	+	+	+	+	+	-	+	10.8	11.9
	Acetone	++	++	++	+	+	+	+	++	-	+	12.7	
	Ethanol	+	++	++	+	+	+	+	++	+	+	11.3	
	Methanol	+	++	++	+	+	+	+	+	+	+	12.9	
Bilwadi churna	Aqueous	++	+++	++	+	+	+	+	++	-	+	10.5	11.5
	Acetone	++	+++	+++	+	+	+	+	++	+	-	11.9	
	Ethanol	++	++	++	+	+	+	+	++	-	+	11.3	
	Methanol	++	+++	+++	+	+	+	+	++	+	+	12.4	
Ashwagandhadi churna	Aqueous	++	++	++	+	+	+	-	+	-	-	9.7	11.4
	Acetone	++	+++	+++	++	+	+	+	++	+	+	12.5	
	Ethanol	++	++	++	++	-	+	-	+	-	+	10.3	
	Methanol	++	+++	+++	++	+	+	+	++	+	+	13.3	
Jatiphaladi churna	Aqueous	+	++	+++	+	-	+	-	+	++	+	10.7	11.3
	Acetone	+	+++	+++	++	+	+	+	-	++	+	11.8	
	Ethanol	++	+++	+++	++	+	+	+	+	+	+	12.6	
	Methanol	+	++	++	+	+	+	+	-	++	+	10.9	
Hingwashtak churna	Aqueous	+	++	++	+	-	-	+	+	+	-	8	10.5
	Acetone	++	++	++	+	+	-	++	++	+	-	12	
	Ethanol	+	++	++	++	+	-	+	+	-	-	9.2	
	Methanol	++	++	++	++	+	+	+	+	++	-	12.8	
Shivkshar Pachan churna	Aqueous	+	++	+++	-	+	+	+	-	-	+	8.3	9.7
	Acetone	+	++	++	+	++	+	-	-	+	+	9.9	
	Ethanol	+	++	+++	-	++	+	+	+	-	+	9.2	
	Methanol	+	++	++	+	++	+	+	+	+	+	11.3	

Where: –: No activity, +: ZOI= 11-14mm (mild antibacterial), ++: ZOI= 15-19mm, (Moderate antibacterial), +++: ZOI= >20 (Strong antibacterial). ZOI= Zone of inhibition

According to the antibacterial profile (Table 2) of herbal preparation it was observed that Ashwagandhadi churna was strong antibacterial against *S. epidermidis, E. coil, S. aureus, S. typhi* and *P. vulgaris*. Ingredients used in Ashwagandhadi churna possess wide range of bioactivity; *Withania somnifera* is an aphrodisiac used as general tonic, diuretic, nervine sedative, adaptogenic, alterative, and immunomodulatory [19]. *Argyreia spinosa* is used as tonic, alterative it is antibacterial against *S. scabies, S. aureus* and *B. subtilis* and *E. coli* [20]. Bilwadi churna and Dashmula churna is useful in cough, fever, dysentery and diarrhoea (Table 1). Our study shows that these herbal preparations are strong antibacterial against *S. aureus, S. epidermidis, B. subtilis,* S. *typhi, S. typhimurium, E. coli, P. vulgaris, P. aeruginosa, E. aerogenes* and *K. pneumoniae.* Ingredients of Dashmula churna and Bilwadi churna i.e. *Aegle marmelos* possess antidiarrhoeal properties against *V. cholerae, E. coli* and *Shigella* sp. [21]. Dhatupaushtic churna is strong antibacterial against *S. aureus* and *S. epidermidis,* moderate antibacterial against *B. subtilis, S. typhimurium, E. coli, E. aerogenes*

and mild antibacterial against *P. aeruginosa, S. typhi, P. vulgaris* and *K. pneumoniae* (Table.2). The antibacterial activity of *Woodfordia fructicosa*; the ingredient of Dhatupaushtic churna is effective antibacterial agent against *E. coli, S. aureus, E. aerogenes, P. aeruginosa, S. typhi, S. paratyphi, S. typhimurium, K. pneumoniae* as this preparation contains steroids, cardiac glycosides, anthraquinone, flavonoids and phenolics [22].

Narayan churna, Gangadhar churna, are widely used in chronic constipation, diarrhoea, dysentery and fever, and our study shows that these preparations are potent antibacterial against *E. coli, S. typhi, E. aerogenes,* and *P. vulgaris*. Hence our study also proved the use of these preparations for diarrhoea, dysentery, fever and other associated infections. Lavangadi churna is strong antibacterial against *S. epidermidis* and *S. aureus,* followed by *B. subtilis, S. typhimurium, E. coli, E. aerogenes,* and *K. pneumoniae* while moderate antibacterial against *P. vulgaris, P. aeruginosa* and *S. typhi* its ingredients *Syzygium aromaticum* and *Myristica fragrans* are antibacterial against *E. coli, K. pneumoniae, S. paratyphi, Citrobacter* sp. and *E. cloacae, S. aureus* and antifungal against *Candida albicans* [23, 24]. Chandanadi churna is used in constipation, digestive disorder and genitourinary infections etc. and it shows potent antibacterial against *P. vulgaris, K. pneumoniae, E. coli, P. aeruginosa* and *S. aureus. Santalum album* and *Holarrhena antidysenterica* are important ingredients of Chandanadi churna and have been reported as antibacterial against *B. subtilis, S. epidermidis, P. pseudoalcaligenes, P. vulgaris* and *S. typhimurium* [16, 25,]

Chopchinyadi churna, Eladi churna, and Sarswat churna are useful in fever, cough, while Sarswat churna used as brain tonic. Our study revealed that these preparations are potent antibacterial against *S. epidermidis, S. aureus, B. subtilis, K. pneumoniae, E. coli* and *P. aeruginosa.* Jatiphaladi churna is strong antibacterial against *S. epidermidis* and *S. aureus,* where as it is moderate antibacterial against *E. coli, S. typhimurium* and *P. aeruginosa*. The common ingredients of these preparation; *Elettaria cardamomum* and *Cuminum cyminum* possess antibacterial properties against *salmonella* sp., *S. typhimurium, C. freundii, E. aerogenes, E. coli, K. pneumoniae, S. marcescens* [16] and against Methicillin Resistant *S.* aureus [26]. *Punica granatum* is one of the important ingredients of the Eladi churna preparation, has antibacterial against *E. aerogenes, S. aureus, S. epidermidis* and *B. subtilis* [27]. Shatawaryadi churna, Kutuja churna and Talisadi churna are traditionally used in fever, cough, diarrehea, dysentery and these products are strong antibacterial against *S. typhimurium, K. pneumoniae, P. vulgaris P. aeruginosa* and *S. typhi,* which are associated with enteric fever (typhoid fever), gastroenteritis, biliary tract infection. In this study Shivkshar Pachan churna is strong antibacterial against *S. aureus, S. epidermidis* and moderate antibacterial against *P. aeruginosa, P. vulgaris, S. typhimurium* and *B. subtilis.*

From the study it can be concluded that overall the herbal preparations are strong antibacterial agent against *S. aureus, S. epidermidis, S. typhi, S. typhimurium, E. coli, P. aeruginosa, K. pneumoniae* and *P. vulgaris,* these bacterial pathogens associated with dysentery and diarrhoea, gastroenteritis, urinary tract infection, invasive diseases (wound infections, osteomyelitis, bacteremia), skin infections (impetigo, folliculitis), endocarditis, septicemia, respiratory tract infection, and eye infections. Scientific evaluation of these herbal preparations gives better information regarding the antibacterial efficacy of herbal medicine available in India. Our study also indicated that the organic solvent extracts are strong antibacterial as compare to aqueous extracts; this may be due to higher solubility of phytochemicals in organic solvents. Thus our study supports the use of these herbal preparations in the control the enteric bacterial infection.

CONCLUSION

Our findings suggest that, ayurvedic herbal preparations extracts have great potential as antimicrobial agent against most enteric bacterial pathogens and they can be used in the treatment of infectious diseases. Scientific evaluation of these herbal preparations gives better information regarding the antibacterial efficacy of herbal medicine available in India. This study supports the use of these herbal preparations not only as the dietary supplement but also as agent to prevent or control the enteric bacterial infections. Further research is deserved to isolate the compounds responsible for the observed antibacterial activity.

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