IJPSR (2017), Volume 8, Issue 12 (Research Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 10 April, 2017; received in revised form, 27 June, 2017; accepted, 17 September, 2017; published 01 December, 2017

PREPARATION AND EVALUATION OF ANTIMICROBIAL HERBAL FORMULATION OF *PTEROSPERMUM ACERIFOLIUM* WILLD

Ashis Kumar Manna*, Upendranath Nanda and Subrat Kar

Seemanta Institute of Pharmaceutical Sciences, Jharpokharia, Mayurbhanj - 757086, Odisha, India.

Keywords:

Pterospermum acerifolium, Antimicrobial, Minimum Inhibitory Concentration (MIC), Gel formulation

Correspondence to Author:
Ashis Kumar Manna

Senior Lecturer,
Seemanta Institute of Pharmaceutical Sciences,
Jharpokharia, Mayurbhanj - 757086, Odisha, India.

E-mail: amanna73@ymail.com

ABSTRACT: The present work deals with formulation of topical gels containing aqueous extract of *P. acerifolium* seeds and also to evaluate the prepared gels against some Gram-positive and Gram-negative bacteria. The antibacterial activity of various *P. acerifolium* seed extracts was measured through determining minimum inhibitory concentration (MIC) by cube dilution method and zone of inhibition by disc diffusion method against *E. coli*, *P. aeruginosa* and *S. aureus*. Aqueous *P. acerifolium* seed extracts exhibited comparatively higher antibacterial potential in comparison with that of other extracts and employed to formulate topical herbal gels using 4.5 % sodium carboxymethyl cellulose as gel base. Prepared herbal gels were tested for pH, viscosity, extrudability and spreadability. All the prepared gels were subjected to antibacterial study by determining zone of inhibition by disc diffusion method. Herbal gels containing 15 % aqueous *P. acerifolium* seed extract exhibited better zones of inhibition against *E. coli*, *P. aeruginosa* and *S. aureus* in comparison with that of 5 % and 10 %. From the results of this study, it can be concluded that herbal gels containing 15 % aqueous *P. acerifolium* seed extract is found suitable for topical use against bacterial infections.

INTRODUCTION: In recent years, considerable research efforts have been directed towards the use of naturally derived materials in various medicinal, biomedical as well as pharmaceutical applications [1-11]. Amongst these naturally derived materials, herbal medicines have been recognized as the most important remedy in the traditional medicine system all over the world by the people to treat various diseases since antiquity [12-18].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.8(12).5308-14

Article can be accessed online on: www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.8 (12).5308-14

According to World Health Organization (WHO 1993), a major fraction (almost 80 %) of the global population is dependent on the traditional medicine systems with the use of extracts derived from plant parts like leaves, pods, bark, fruits, seed, roots, exudates, *etc* [12, 19 - 20].

Moreover, these herbal medicines are cheap, safe and devoid of side effects on long term use [18-21]. Extensive survey of the ethnomedicinal and phytochemical literature reveals that numerous herbal extracts have already been studied for their anti-microbial activities against many microbial infections [22-25].

Pterospermum acerifolium willd (family, Sterculiaceae, commonly known as 'Kanak champa') is a shrub distributed in tropical Asia [26].

It is a popular ornamental plant having wide range of medicinal properties [27]. Various part of *P. acerifolium* plant is used for the treatment of different diseases like conjunctivitis, anorexia, dysmenorrheoea and fever. *P. acerifolium* is also reported as bitter, acidic, anti-inflammatory, analgesic, sedative, carminative, digestive, antimicrobial, anthelmintic [26, 28 - 33]. Extensive survey of literature reveals the fact that very little work has been done in the direction of its use as antibacterial through topical gels. No topical gel formulation yet is prepared using this herbal drug towards the antibacterial dermatological treatment. Therefore, in the present work, attempt has been taken to develop topical gels containing aqueous extract of *P. acerifolium* seeds and also to evaluate the prepared gels against some Gram-positive and Gram-negative bacteria.

MATERIALS AND METHODS:

Collection and authentification of plant material: Seeds of *P. acerifolium* were collected in the month of January, 2009, from the hill area near the bank of Subarnarekha River in the district of Mayurbhanj, Odisha. The collected plant with complete herbarium was authenticated at Botanical survey of India, Central National Herbarium, Botanical Garden, Howrah, Kolkata (vide Letter No. CNH/1-1(15)/2009/Tech 11/413). Also a sample specimen was deposited there.

Preparation of Extract: 1 kg of the air dried seeds of *P. acerifolium* was reduced to fine powder and extracted using Soxhelet apparatus with petroleum ether, ethanol and purified water up to 30 siphons each one after another. Each extract was concentrated using a Rota evaporator. The marc left after extraction was dried in an air oven below 30°C.

Microorganism: The microorganisms were obtained from the microbiological laboratory of Dept. of Pharmaceutical Technology, Jadavpur University, Kolkata. The details about the micro organism are shown in **Table 1.**

TABLE 1: DETAILS ABOUT THE MICROORGANISMS USED IN THE CURRENT STUDY

Sl. no.	Name of the microorganism	Stain no	Causative organism
1	*Escherichia coli*	ATCC25922	Skin and soft tissue infection
2	*Pseudomonas aeruginosa*	ATCC25619	Gonorrhea
3	*Staphylococcus aureus*	ATCC25923	Skin infections

Antimicrobial Screening: Determination of Minimum Inhibitory Concentration (MIC).

MIC of each extract was determined by cube dilution method. 10 Test tubes for each extract per microorganism were thoroughly washed and sterilized. 0.5 ml of test solutions (7.8 µg/ml to 1000 µg/ml) was taken in 8 test tubes. 0.5 ml of freshly prepared and sterilized nutrient broth & 0.5 ml 6 % DMSO was added to each of 8 test tubes. Test tubes were thoroughly shaken. To each test tube, 50 µg of 24 hours sub culture of bacteria was added and shaken properly. The 9th test tube contained 0.5 ml of nutrient broth & 0.5 ml 6 % DMSO and 50 µg of sub culture of bacteria to act as positive control and 10th test tube contained 0.5 ml of nutrient broth &1 ml of 6 % DMSO to act as negative control. All the test tubes were incubated in an incubator (Remi Corporation, India) at 37 °C for 24 hours and observed for turbidity comparing with both the controls. Same procedure was adopted for all extracts and all the three bacteria.

Determination of Zone of Inhibition: Zone of inhibition was determined for each extract at a concentration of 1000 µg/ml and compare to that of standard ciprofloxacin 5 µg/disc by disc diffusion method. Agar plates were made by pouring nutrient agar suspension (sterilized) in cleaned petridish to get 4 mm thickness (approx). Plates were kept under laminar air flow.

Stock solution of each extract 100 mg/ml were prepared by dissolving the extract in 6 % DMSO, paper disc (Whatman® No. 1) of 6 mm diameter were cut and sterilized in hot air oven. 10 µl (1000 µg/disc) of each extract was taken in a sterile pipette and soaked in paper disc. The disc was dried. The discs were carefully kept on the agar media and slightly pressed for proper fixing. Standard disc of ciprofloxacin (5 µg/disc) was taken and placed on the media and fixed properly. The plates were incubated at 37°C for 24 hours. Plates were observed for zone of inhibition.

Formulation and Preparation of Herbal Gels: Accurately weighed quantity of Sodium Carboxymethyl Cellulose was soaked in distilled water and was allowed to swell. Accurate quantity of aqueous extract was weighed and dispersed in distilled water. The drug dispersion was added to the soaked polymer with stirring, until a gel was formed. The prepared gel was filled in collapsible tube and sealed by crimping the ends. Different formulations for the herbal gels by using sodium carboxymethyl cellulose are given in **Table 2**.

TABLE 2: FORMULA OF HERBAL GELS BY USING SODIUM CARBOXYMETHYL CELLULOSE

Ingredients	Formulations		
	1	2	3
Aqueous extract of *P. acerifolium* seeds	7.5 %	10 %	15 %
Sodium carboxy methyl cellulose	4.5 %	4.5 %	4.5 %
Distilled water q.s. to	100 %	100 %	100 %

Evaluation of Herbal Gels:

pH measurements: The pH of the gels was measured by using digital pH meter (Systronics Instruments, India). The glass electrode was completely dipped into the gel system so as to cover the electrode and the pHs of gels were measured within 5 min.

Determination of Viscosity: The viscosity of formulated gels was determined using Brookfield viscometer (DV-III Units Programmable Rheometer, USA) using the spindle No. 4 at 1.5 rpm.

Determination of extrudability: It is a useful empirical test to measure the force required to extrude the material from a bottle or tube since the passing of gels have gained a considerable importance in the delivery of desired quantity of gel from collapsible tubes. Therefore, the measurement of extrudability becomes an important criterion for gels. While not strictly a test of product characteristics due to inclusion of force necessary to deform the whitener the method applied is for the determination of applied shear in the region of the rheogram corresponding to the shear rate exceeding. The yield value was exhibiting. Consequent plug flow on such apparatus is described by Wood *et al.*, [35]. The gels were filled in standard capped collapsible tubes and sealed by crimping the ends. The weight of tube was recorded. The tube was placed between two glass slides and was clamped. A 500 gm weight was placed over the glass slide and then the cap was removed. The amount of gel extruded was collected and weighted.

Determination of Spreadability: Two glass slides 6 cm long were used containing gel in between. Lower slide was fixed on a wooden plate and the upper one was tied to a hook having a balance at the other end in which a weight was kept in order to pull that slide. Five gram of gel was uniformly placed on the lower slide and the upper slide was placed on it. A one kilogram weight was kept on the slides for five minutes to expel the entrapped air. The excess discharged gel was carefully scrapped off. A weight of 80 gm. was kept on the balance. The time in seconds required to separate the slides completely was noted. Less time indicates more slip and better spreadability. The experiments were repeated thrice and mean value was taken.

Spreadability is calculated using the formula:

$$S = M \times L/t$$

where, S = Spreadability of gel; M = weight tied to the upper slide; L = length of glass slide; t = time taken.

RESULTS AND DISCUSSION: Topical gels are semisolid formulations, which have gained a greater deal of importance in the medical field for their topical effect in the treatment of pain, strain, inflammation, infections and other diseases [36 - 40]. In the current work, topical herbal gels containing aqueous extract of *P. acerifolium* seeds was developed using sodium carboxymethyl cellulose. The antibacterial potential of these formulated herbal gels were also investigated against *Escherichia coli, Pseudomonas aeruginosa* and *Staphylococcus aureus.* MIC of *P. acerifolium* seed extracts was determined by cube dilution method. It was observed that all the seed extracts showed MIC ranging from 31.25 to 1000 μg/ml (**Table 3**). The aqueous extract showed lowest MIC value against

all three bacteria. The aqueous extract was found to possess MIC value of 31.25 μg/ml, against *E. coli* and *S. aureus.* Against *P. aeruginosa*, it was 125 μg/ml. From the above observation, it was clearly concluded that aqueous extract of seeds showed lowest MIC value.

TABLE 3: MIC OF *P. ACERIFOLIUM* SEED EXTRACTS BY DILUTION METHOD

Sl. No.	Bacteria	*P. acerifolium* seed extracts (MIC/μg/ml)		
		Petroleum ether	Ethanol	Aqueous
1	*Escherichia coli*	62.50	125.00	31.25
2.	*Pseudomonas aeruginosa*	62.50	1000.00	125.00
3.	*Staphylococcus aureus*	1000.00	500.00	31.25

In order to evaluate the antibacterial activity of extracts having MIC up to 1000 μg/ml, disc diffusion method was adopted and zone of inhibition was recorded. The antibacterial sensitivity of extracts and that of standard (ciprofloxacin) were compared. Aqueous extract of *P. acerifolium* seeds at 1000 μg/disc showed higher zone of inhibition against *P. aeruginosa* (22 mm) than that of S. *aureus* and *E. Coli* (17 mm) while comparing to ciprofloxacin (standard, 5 μg/disc) (32 – 36 mm). Other extracts showed less zone of inhibitions. Thus, antibacterial screening of *P. acerifolium* seed extracts by disc diffusion method finally showed comparatively higher antibacterial potential in case of aqueous extract of seeds and hence, it was taken for further formulation study.

TABLE 4: ZONE OF INHIBITION OF *P. ACERIFOLIUM* SEED EXTRACTS AND CIPROFLOXACIN (STANDARD) BY DISC DIFFUSION METHOD

Sl. No.	Bacteria	Zone of inhibition (mm)			
		P. acerifolium seed extracts			Ciprofloxacin (standard)
		Petroleum ether	Ethanol	Aqueous	
1.	*Escherichia coli*	14	8	17	32
2.	*Pseudomonas aeruginosa*	10	8	22	36
3.	*Staphylococcus aureus*	13	7	19	35

Prepared herbal gels of aqueous *P. acerifolium* seed extract prepared using 4.5% sodium carboxymethyl cellulose were tested for pH, viscosity, extrudability and spreadability. pHs of these gels were within the range between, 6.28 – 7.30. Viscosities of these herbal gels were measured within 42000 – 52000 cps. It was observed that gel containing 15 % aqueous *P. acerifolium* seed extract showed good extrudabilty in comparison with other formulated gels. The spreadability of these gels was found almost similar. From these results, it can be suggested that the gel containing 15% aqueous extract exhibited satisfactory extrudability and spreadability. The extrusion of gels from the collapsible tube is important during application; whereas, spreadability plays an important role in helping of uniform application of gels. A good gel takes less time to spread and should have high spreadability.

TABLE 5: pH, VISCOSITY, EXTRUDABILITY AND SPREADABILITY OF HERBAL GELS CONTAINING AQUEOUS *P. ACERIFOLIUM* SEED EXTRACT

Formulation No.	pH	Viscosity	Extrudablity*	Spreadability
1.	7.30	52000	++	27.10
2.	6.60	45000	++	26.00
3.	6.38	42000	+++	25.00

* +++ = Good; ++ = Average; + = Poor

All the prepared gels were subjected to antibacterial study by determining zones of inhibition disc diffusion method. Zone of inhibitions against *E. coli, P. aeruginosa* and *S. aureus* were compared with the standard gels containing clarithromycin (1%). Clarithromycin gel (1%) exhibited zones of inhibition in the range of 28 – 37 mm for all these 3 bacteria. It was observed that herbal gel containing 15 % aqueous *P. acerifolium* seed extract exhibited better zones of inhibition against *E. coli*, *P. aeruginosa* and *S. aureus* in comparison with that of 5 % and 10 %.

Zones of inhibitions of herbal gel containing 15 % aqueous *P. acerifolium* seed extract against *E. coli*, *P. aeruginosa* and *S. aureus* is shown in **Fig. 1**.The antibacterial potential of these herbal gels were found to be increased with the increasing percentage content of the aqueous *P. acerifolium* seed extract present in herbal gels.

TABLE 6: ZONE OF INHIBITION OF HERBAL GELS CONTAINING AQUEOUS *P. ACERIFOLIUM* SEED EXTRACT AND CLARITHROMYCIN GEL (1%) AS STANDARD BY DISC DIFFUSION METHOD

Sl. No.	Bacteria	Zone of inhibition (mm)			
		Herbal gels containing aqueous *P. acerifolium* seed extract			Clarithromycin gel (1%)
		1	2	3	
1.	*Escherichia coli*	12	15	16	32
2.	*Pseudomonas aeruginosa*	13	14	17	28
3.	*Staphylococcus aureus*	14	16	18	37

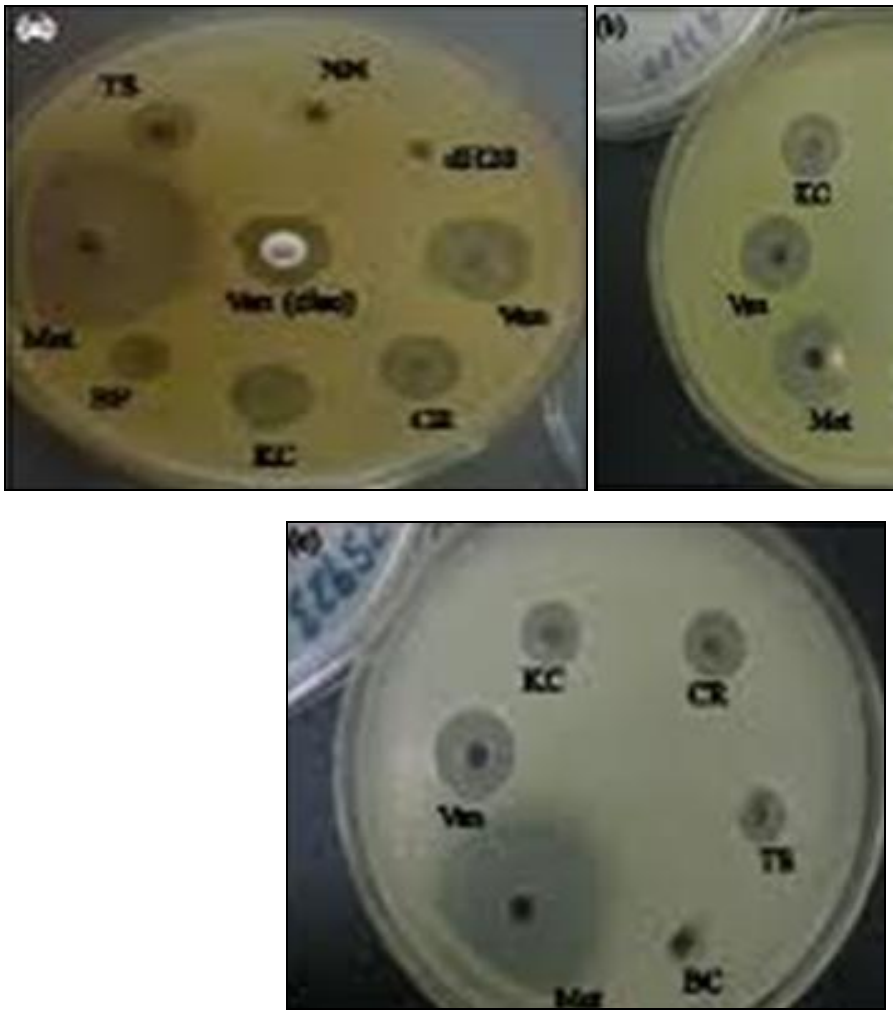

FIG. 1: ZONES OF INHIBITIONS OF HERBAL GEL CONTAINING 15 % AQUEOUS *P. ACERIFOLIUM* SEED EXTRACT AGAINST (A) *E. COLI*, (B) *P. AERUGINOSA* AND (C) *S. AUREUS*

CONCLUSION: Extracts from *P. acerifolium* seeds were tested for antibacterial activity against some Gram-positive and Gram-negative bacteria like *E. coli*, *P. aeruginosa* and *S. aureus*. MIC (by cube dilution method) and zone of inhibition (by disc diffusion method) of aqueous *P. acerifolium* seed extracts exhibited comparatively higher antibacterial potential in comparison with that of other extracts. On the basis of it, topical herbal gels containing aqueous extract of *P. acerifolium* seeds were formulated using 4.5 % sodium carboxymethyl cellulose as gel base and evaluated for their antibacterial potential against *E. coli*, *P. aeruginosa* and *S. aureus.* pHs and viscosities of

these gels were within the range, 6.28 – 7.30and 42000 – 52000 cps, respectively. Gel containing 15 % aqueous extract exhibited satisfactory extrudability and spreadability. All the prepared gels were subjected to antibacterial study by determining zones of inhibition disc diffusion method. Herbal gels containing 15 % aqueous *P. acerifolium* seed extract exhibited better zones of inhibition against *E. coli*, *P. aeruginosa* and *S. aureus* in comparison with that of 5 % and 10 %. From the results of this study, it can be concluded that herbal gels containing 15 % aqueous *P. acerifolium* seed extract was found suitable for topical use against bacterial infections. It can be suggested that before its commercialization, the gel formulations should be subjected to detailed clinical studies using animals as well as human subjects. Also, extensive accelerated stability studies should be examined.

ACKNOWLEDGEMENT: We are very grateful to BPUT, Rourkela, Governing body SIPS for providing facilities and thankful to Dr. Sanmoy Karmakar, Prof. Jadavepur University, Kolkata and Dr. Amit Kumar Nayak, Asso Prof., SIPS, Jharpokharia for their suggestions.

CONFLICT OF INTEREST: None.

REFERENCES:

1. Nayak AK, Pal D and Santra K: Screening of polysaccharides from tamarind, fenugreek and jackfruit seeds as pharmaceutical excipients. International Journal of Biological Macromolecules 2015; 79:756-760.
2. Samal PK and Dangi JS: Isolation, preliminary characterization and hepatoprotective activity of polysaccharides from *Tamarindus indica* L. Carbohydrate Polymers 2014; 102:1– 7.
3. Sinha Mahapatra S, Mohanta S and Nayak AK: Preliminary investigation on angiogenic potential of *Ziziphus oenoplia* M. root ethanolic extract by chorioallantoic membrane model. Science Asia 2011; 37:72-74.
4. Nayak AK, Pal D, Pradhan J and Ghorai T: The potential of *Trigonella foenum-graecum* L. seed mucilage as suspending agent. Indian Journal of Pharmaceutical Education and Research 2012; 46:312-317.
5. Nayak AK, Pal D, Pany DR and Mohanty B: Evaluation of *Spinacia oleracea* L. leaves mucilage as innovative suspending agent. Journal of Advanced Pharmaceutical Technology and Research 2010; 1:338-341.
6. Bera H, Boddupalli S and Nayak AK: Mucoadhesive-floating zinc-pectinate-sterculia gum interpenetrating polymer network beads encapsulating ziprasidone HCl. Carbohydrate Polymers 2015; 131:108-118.
7. Sinha P, Ubaidulla U and Nayak AK: Okra (*Hibiscus esculentus*) gum-alginate blend mucoadhesive beads for controlled glibenclamide release. International Journal of Biological Macromolecules 2015; 72:1069-1075.
8. Das B, Nayak AK and Nanda U: Topical gels of lidocaine HCl using cashew gum and Carbopol 940: Preparation and *in vitro* skin permeation. International Journal of Biological Macromolecules 2013; 62:514-517.
9. Nayak AK and Pal D: Tamarind seed polysaccharide: An emerging excipient for pharmaceutical use. Indian Journal Pharmaceutical Education and Research 2017; 51:S136-S146.
10. Nayak AK, Pal D and Santra K: Swelling and drug release behavior of metformin HCl-loaded tamarind seed polysaccharide-alginate beads. International Journal of Biological Macromolecules 2016; 82:1023-1027.
11. Nayak AK and Pal D: *Trigonella foenum-graecum* L. seed mucilage-gellan mucoadhesive beads for controlled release of metformin HCl. Carbohydrate Polymers 2014; 107:31-40.
12. Hati M, Jena BK, Kar S and Nayak AK: Evaluation of anti-inflammatory and anti-pyretic activity of *Carissa carandas* L. leaf extract in rats. Journal of Pharmaceutical, Chemical and Biological Sciences 2014; 1:18-25.
13. Jena BK, Ratha B, Kar S, Mohanta S, Tripathy M and Nayak AK: Wound healing potential of *Ziziphus xylopyrus* Willd. (Rhamnaceae) stem bark ethanol extracts using *in vitro* and *in vivo* model. Journal of Drug Delivery and Therapeutics 2012; 2:41-46.
14. Chandra P, Sachan N and Pal D: Protective effect of *Dalbergia sissoo* Roxb. ex DC.(family: Fabaceae) leaves against experimentally induced diarrhoea and peristalsis in mice. Toxicology and Industrial Health 2015; 31:1229-1235.
15. Singh H, Mishra A and Mishra AK: Phytochemical screening, *in vivo* anthelmintic and anticonvulsant activity of *Cleome viscosa* Linn seeds extract. The Natural Products Journal 2016; 6:213-218.
16. Chen C, You LJ, Abbasi AM, Fu X and Liu RH: Optimization for ultrasound extraction of polysaccharides from mulberry fruits with antioxidant and hyperglycemic activity *in vitro*. Carbohydrate Polymers 2015; 130:122–132.
17. Wang P-C, Zhao S, Yang B-Y, Wang Q-H and Kuang H-X: Anti-diabetic polysaccharides from natural sources: A review. Carbohydrate Polymers 2016; 148:86–97
18. Zhang T, Gao J, Jin ZY, Xu XM and Chen HQ: Protective effects of polysaccharides from *Lilium lancifolium* on streptozotocin-induced diabetic mice. International Journal of Biological Macromolecules, 2014; 65:436–440.
19. Sheikh Y, Manral MS, Kathait V, Prasar B, Kumar R and Sahu RK: Computation of *Holarrhena antidysenterica* seeds extracts in streptozotocin-induced of *in vivo* antidiabetic activity diabetic rats. Iranian Journal of Pharmacology and Therapeutics 2016; 14:22-27
20. Polu PR, Nayanabhirama U and Khan S: Quality control assessment of *Tinospora cordifolia* (Willd.) Miers. (Menispermaceae) phyto-physicochemical and pharmacognostical profile. Advanced Science Letters 2017; 23:1798-1803.
21. Vijay JJ, Singh V and Mishra AK: Pharmacological and Phytochemical profile of *Cassia Occidentalis* L: A Review. Journal of Drug Delivery and Therapeutics 2016; 6:1-6.
22. Panda N, Patro VJ, Jena BK and Panda PK: Evaluation of phytochemical and anti-microbial activity of ethanolic extract of *Limonia acidissima* L. leaves. International Journal of Herbal Medicine 2013, 1:22-27

23. Jena BK, Ratha B, Kar S, Mohanta S and Nayak AK: Antibacterial activity of the ethanol extract of *Ziziphus xylopyrus* Willd. (Rhamnaceae). International Journal of Pharma Research and Review 2012; 1:46-50.
24. Ranjan D, Deogam A, Polu PR, Khan S and Rao JV: Preliminary studies on chemical constituents and antimicrobial activities of *Psidium guajava* Linn. Advanced Science Letters 2017; 23:1753-1757.
25. Khan S, Imran M, Imran M and Pindari N: Antimicrobial activity of various ethanolic plant extracts against pathogenic multi drug resistant Candida spp. Bioinformation 2017; 13:67-72.
26. Manna AK and Jena J: Anti inflammatory and analgesic activity of bark extract of *Pterospermum acerifolium*. International Journal of Current Pharmaceutical Research 2009; 1:32-37.
27. Mamun MIR, Nahar N, Mosihuzzaman M and Rolf A: Constituents of *Pterospermum acerifolium* Willd. leaves and bark. Journal of Bangladesh Chemical Society 2002; 15:91-95.
28. Mamun MIR, Rokeya B, Chowdhury NS, Muniruzzaman M, Nahar N, Ahmed MU, Mosihuzzaman M, Ali L, Azad Khan AK and Khan SH: Anti-hyperglycemic effect of *Pterospermum acerifolium* Willd. and *Pterospermum semisagittatum* Ham. Diabetes Research 2001; 35:163-170.
29. Manna AK, Jena J, Behera AK, Roy D, Manna S, Karmakar S and Kar S: Effect of *Pterospermum acerifolium* bark extract on oxidative damages in the gastric tissue during alcohol induced ulceration. International Journal of Pharmacy and Pharmaceutical Sciences 2009; 1:51-59.
30. Manna AK, Behera AK, Jena J, Karmakar S, Kar S, Panda BR and Maity S: The antiulcer activity of *Pterospermum acerifolium* bark extract in experimental animal. Journal of Pharmacy Research 2009; 2:785-788.
31. Manna AK, Bhunia SK and Nanda U: Wound healing properties of *Pterospermum acerifolium* Wild. Journal of Pharmacy Research 2010; 3:537-538.
32. Manna AK, Manna S, Behera AK and Kar S: *In vitro* antioxidant activity of P. *acerifolium* barks. Journal of Pharmacy Research 2009; 2:1042-1044.
33. Chatterjee P, Chakraborty B, Nandy S, Dwivedi A and Datta R: *Pterospermum acerifolium* Linn.: A comprehensive review with significant pharmacological activities. International Journal of Pharmacy and Life Sciences 2012; 3:1453-1458.
34. Sannigrahi S, Parida S, Patro VJ, Mishra US and Pathak A. Antioxidant and Anti-inflammatory potential of *Pterospermum acerifolium*, International Journal of Pharmaceutical Sciences Review and Research 2010; 2:1-5.
35. Wood JH, Catacalos G and Liberman SV: Adaptation of commercial viscometers for special applications in pharmaceutical rheology-II. Journal of Pharmaceutical Science 1993 52:375-378.
36. Malakar J, Basu A and Nayak AK: Candesartan cilexetil microemulsions for transdermal delivery: Formulation, *in-vitro* skin permeation and stability assessment. Current Drug Delivery 2014; 11: 313-321.
37. Malakar J, Sen SO, Nayak AK and Sen KK: Formulation, optimization and evaluation of transferosomal gel for transdermal insulin delivery. Saudi Pharmaceutical Journal 2012; 20:355-363.
38. Jana S, Ali SA, Nayak AK, Sen KK and Basu SK: Development and optimization of topical gel containing aceclofenac-crospovidone solid dispersion by "Quality by Design" approach. Chemical Engineering Research and Design 2014; 92:2095-2105.
39. Jana S, Manna S, Nayak AK, Sen KK and Basu SK: Carbopol gel containing chitosan-egg albumin nanoparticles for transdermal aceclofenac delivery. Colloids and Surfaces B: Biointerfaces 2014; 114;36-44.
40. Das B, Sen SO, Maji R, Nayak AK and Sen KK: Transferosomal gel for transdermal delivery of risperidone. Journal of Drug Delivery Science and Technology 2017; 38:59-71.

How to cite this article:
Manna AK, Nanda U and Kar S: Preparation and evaluation of antimicrobial herbal formulation of *Pterospermum acerifolium* willd. Int J Pharm Sci Res 2017; 8(12): 5308-14.doi: 10.13040/IJPSR.0975-8232.8(12).5308-14.