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Research Article

Pharmacological and Phytoconstituent Profile of Desmodium Gangeticum-An Update

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ABSTRACT

Several plants have been used and documented in the traditional and folklore system of medicine. The uniqueness of herbal medicines is their origin, which being nature itself, renders them compatible to human physiology. Another remarkable feature of the herbal plants is their composition. Plants constitute a variety of chemical compounds, which exert different actions and thereby exhibit surprising effects inside the human body. Unlike synthetic molecules, which work in a single-target centric manner to correct the physiological anomaly, phytoconstituents present in herbal medicines exert a multi-targeted mode of action, in a concerted fashion, thus regaining the physiological equilibrium. In this way, herbal plants heal a pathological state moderately, in a holistic fashion, without disturbing the cellular homeostasis. This review is on one of the plants, Desmodium gangeticum (DG), present in the popularly used Ayurvedic preparation, Dasamula kvatha, a dietary supplement. Among the ten constituent roots, which gives Dashmoola its name, one of the roots is from DG. DG, an indigenous plant, has been studied extensively by Indian researchers and the outcome is noteworthy as DG has established its potential in treating disorders originating in almost all the major organs, including brain, heart, liver and gastrointestinal tract. Owing to its antioxidant and anti-inflammatory properties, DG, also marks a potential role in treating wounds, nociception and arthritic inflammation. So varied are its uses, that it led researchers to explore its phytoconstituent profile, which imparts DG the special characters to cure variety of ailments. In this review, we have tried to consolidate the pharmacological studies on DG done so far, along with a detailed documentation of its phytoconstituents and their reported pharmacological actions.

Key Words: Desmodium gangeticum, Traditional use, Ethno-botanical claims, Pharmacological actions, Phytoconstituents, Extracts

INTRODUCTION

Desmodium gangeticum (DG), a traditional medicinal plant, identifies a well-established role in some of the Ayurvedic preparations that justifies its substantial potential in the modulation of several physiological anomalies. DG hails from the Leguminosae family and is synonymous with Hedyserum gangeticum. The roots of DG constitute as one of the components of the Ayurvedic medicine, Dashmoola, also called Dasamularishtam, a dietary supplement, which has marked its use in treating diseases like rheumatism, jaundice, paralysis, puerperal fever, filaria, edema and post-natal care1, 2. Popularly known as Prisniparni in Sanskrit, DG, an Indian medicinal plant has been widely used by many Ayurvedic and Unani physicians for curing fever, catarrh3, typhoid, piles, bronchitis, dysentery, asthma and various other inflammatory conditions arising from 'vata' disorder 4, 5. This perennial shrub grows 2-4 feet high and is slender, diffusely branched and irregularly angled6 (Fig.1).

Ethno-botanical information on DG in India and worldwide5 state,

- Known as Salvan in Satpura hills, India; Powdered root with honey – treatment of mouth ulcer7.
- Known as Shalparni in U.P., India; Leaf paste of DG and Aloe vera – applied externally to prevent hair fall8.
- Known as Biyanisaawata in Assam, India; Leaf paste – applied topically on infection to cure eczema9.
- Known as Salparni in Odhisha, India; Root decoction-treatment of dysentery10.
- Known as Da ye shan lu dou in China, Root consumed orally: treatment of diarrhea, root paste applied topically: treatment of toothache; leaf paste applied topically: treatment of headache11.
- Known as Kaganila akatono, Uganda, Africa; Root chewed to cure premature ejaculation12.

In this review, we have attempted to consolidate the pharmacological activities of DG, explored so far, and correlate those with the various aspects of this herbal plant, which include the plant part used, type of extract prepared, in vitro and in vivo screening and mechanisms proposed (Table 1). These points have been further collated with the

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Fig. 1: *Desmodium gangeticum*; A: Full View, B: Closer View

phytochemical profile of the plant, the constituents identified and their individual pharmacological potential.

From the above table, it is clear that the root has been studied the most for pharmacological activity. The reason behind selecting the root for detailed pharmacological screening could be the fact that the Ayurvedic Pharmacopoeia mentions the maximum therapeutic uses of the DG root. The root has been reported for its use in pyrexia, emesis, asthma, diabetes, intestinal worms, swelling, haemorrhoids, tuberculosis, ophthalmic diseases, hypertension, heart diseases, hemicrania30. Also, more number of phytoconstituents has been isolated from the roots compared to any other plant.

Phytoconstituent Profile: Pathological conditions such as pain31-33, cardiovascular diseases34, neurological disorders35, 36, diabetes37, cancer38, arthritis39 and gastrointestinal disorders40 have a strong correlation with inflammation, free radical damage and disrupted oxidative balance in the physiological system. It has been observed that most of the times it is the combination of the individual constituents (present in extract), which is more effective pharmacologically than a single constituent. However, some individual molecules, isolated from DG, have also exhibited pharmacological activity per se. To quote a few are,

- Gangetin (isolated from roots; 50, 100 mg/kg), a pterocarpanoid – anti-inflammatory and, analgesic8, 13, 41; anti-fertility (by modulating alkaline phosphatase activity in uterine fluids)42.
- Aminoglucosyl glycerolipid (glycolipids) and Glycosphingolipid (cerebroside) – in vitro antileishmanial and immunomodulatory activities43.
- Desmocarpin (isoflavanoid phytoalexin) – antifungal44.
- Tert-β-phenylethylamines and candicine (present in roots) – nicotine like effects on in situ dog intestine and carotid blood pressure45.
- Indole-3-alkyl-amines and β-carbolines (alkaloids isolated from aerial part) – anticholinesterase, CNS stimulant, smooth muscle stimulant and depressor response46.

From spectroscopic fingerprinting (HPLC, GC-MS/MS etc), a range of chemical moieties have been elucidated, majority of which are depicted in Table 2. Apart from that, spectroscopic analysis of the various extracts of DG has yielded the following findings.

1. Ethyl acetate root extract subjected to gas chromatography-mass spectrometry analysis revealed 38 compounds, of which major 71% comprised of phenol, 2,4-bis(1-phenylethyl) phenol, di isooctyl ester, n-hexadecanoic acid, 1,2-benzenedicarboxylic acid, octadecanoic acid, 2,5-bis(1,1-dimethyl ethyl)-9-octadecenoic acid(z)-methyl ester. Minor compounds were 1,4-dimethyl-7-(1-methyl ethyl)-1 tridecanol, 1,2-benzenedicarboxylic acid, cyclohexane, didodecyl phthalate, butyloctyl ester, isocyanato azulene, oleic acid, hexadecanoic acid methyl ester, and 1-hexadecanol.21

2. GC–MS analysis of methanolic root extract revealed 64 compounds, of which major compounds were 4-[2-(dimethylamino)ethyl] phenol (cactine), trans-Z-a–bisabolene epoxide, 2,5-bis (1,1-dimethylethyl)phenol, glycerine, asarone, sucrose, trans-2-methyl-4-n-pentylthiane S,S-dioxide, (−)- ortrachelogenin, decahydro-1,1-dimethylnaphthalene, 4,5 dihydro-2-(phenylmethyl) 1-H-imidazole, 2-methyl-9,10-anthracene dione and piperine, representing about 33%. Minor compounds were 2, 5 dihydro-1-H-pyrrole, 3-methyl-2-(2-oxo propyl) furan, conhydrin, thymol, oxirane, eugenol, eicosane, apiol, and 1-methoxy-10-H-phenothiazine22.

3. Gangetial, a new pterocarpan - isolated from the chloroform root extract of DG47.

It has been observed that the root mainly contains alkaloids viz., candicine, hordenine, hypaphorine, N-methyl

tyramine, N, N-di-methyl-tryptamine and its N-oxide and a β-phenylethylamine base. Also present in DG roots are pterocarpanoids viz., gangetin, gangetinin and desmodin, β-alkylamine derivatives, a pterocarpan and several carboxylated and decarboxylated tryptamines. Aerial parts also contain five tryptamine derivatives in addition to Nb-Me-tetrahydroharman and 6-O-Me-2-Me-β-carbolinium cation. β-carboline alkaloid, indole-3-alkylamine, carbolines and five phospholipids along with some sugars, fatty oil and alkaloids are present in seeds55, 56.

Table 1. Detailed pharmacological profile of *Desmodium gangeticum*

Plant part	Extract type	Pharmacological Activity	Treatment schedule	Findings/ Activity trend/ Effective dose	Mechanisms Proposed
-Aerial Parts -Roots	Water decoction	Anti-inflammatory and anti-nociceptive[13]	5, 10 and 20 mg/kg; p.o. (anti-inflammatory) & i.p. (anti-nociceptive) in rats	Models of Anti-inflammatory activity *Acetic acid-induced writhing* Aerial & root extract (10 and 20 mg/kg): 22–74% *Carrageenin-induced paw oedema in rats* Aerial extract: 20 mg/kg (42%); Root extract: (all doses), 15–51% protection *Cotton pellet granuloma* Aerial extract: No activity; Root extract: 14–39% protection Models of Anti-nociceptive activity *Analgesy-meter-induced pain* Aerial and root extract: 6.56–67.66% protection (all doses)	Inhibition of inflammatory mediators. Modulation of stimulation threshold of opioid receptor subtypes, neurotransmitters and secondary messengers.
Aerial parts and Roots	Aqueous extract	Antiamnesic[14]	50, 100 and 200 mg/kg; p.o. for 7 days in mice	100 and 200 mg/kg improved memory of both younger and older mice in interoceptive and exteroceptive behavioral models.	By improving learning and memory. By reversing scopolamine-induced amnesia. By reducing acetyl cholinesterase activity (due to indol-3-alkyl-amines and □□carbolines) in brain.
Aerial parts	Hydro-alcoholic extract	Antidiabetic[15]	200 mg/kg; p.o. in rats	Oral glucose tolerance test Reduced plasma glucose level, 30 min post glucose overload. Diabetogenic model On 7th day and 14th day elevated blood glucose levels dropped by 20 and 40% respectively. Plasma lipid profile Reduced triglycerides and total cholesterol by 44% and 32% respectively. Improved high density lipoprotein levels by 62%. *In vitro* studies in mouse insulinoma cells (MIN6-β cell line) At 2mM (sub-stimulatory glucose concentration), a rapid but momentary and reversible stimulation of insulin secretion was induced.	By increasing insulin secretion from the existing beta cells, thus potentiating plasma's insulin effect. Presence of caffeic acid (0.09%) and chlorogenic acid (0.12%). Chlorogenic acid has an established lipid lowering potential[16].

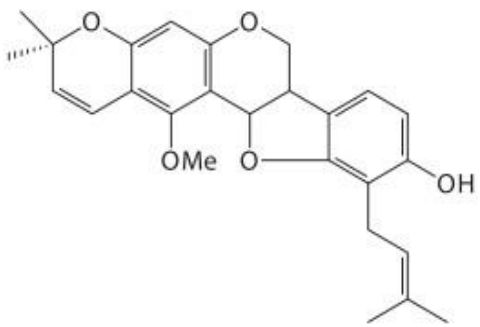
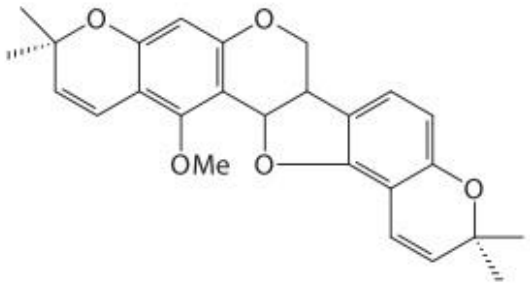
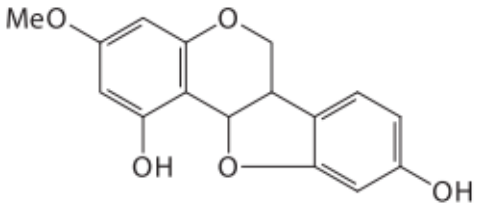
				At 20 mM (stimulatory glucose concentration), a biphasic and constant insulin secretory response was induced, which was enhanced by the extract.	
Aerial parts	Flavonoid and alkaloid fractions	Antioxidant and anti-inflammatory[17]	10 mg/kg, i.p. in rats	Flavonoid fraction exhibited anti-inflammatory activity better than alkaloid fraction and indomethacin. Flavonoid fraction exhibited better superoxide dismutase, glutathione peroxidase and catalase activity - superior antioxidant activity.	Presence of polyphenols such as caffeic acid and chlorogenic acid, which are reported antioxidants[18], in the flavonoid fraction.
Aerial parts	Ethanolic extract	Anti-inflammatory/ anti edematous Antinociceptive [19]	50, 100, 200 mg/kg; p.o. in rats	Dose dependent action. 200 mg/kg inhibited acetic acid-induced writhing by 68%, - increased the latency period by 37.65% in Eddy's hot-plate and 28.26%. - inhibited neurogenic pain by 29% and late inflammatory phase by 43% in formalin-induced nociceptive pain. - 45% inhibition in carrageenan induced paw model after 6 h, equipotent as indomethacin after 24 h.	Attributed to PG synthesis inhibition. Central and peripheral analgesic activity exerted by the secondary metabolites like flavonoids, pterocarpinoids, alkaloids and their N- oxides.
Leaves	Ethanolic	Analgesic and anti-inflammatory	50, 100 and 200 mg/kg; p.o. in rats	<u>Models of Anti-inflammatory activity</u> *Carrageenin-induced paw oedema* Dose dependent activity; 200 mg/kg maximally inhibited paw edema by 68% and 98%, upto 3 h and 5 h respectively. <u>Models of Analgesic activity</u> *Hot plate test* All doses raised the threshold of heat tolerance, as observed from the increased reaction time (rt); 200 mg/kg increased rt by 3.8 seconds in a span of 1 h. *Formalin-induced paw licking tests* Only 100 and 200 mg/kg were effective, of which 200 mg/kg was most effective. Reduced licking time (time spent on licking) by 52% and 47% in early and late phase, better than standard drug indomethacin (32% and 29%). <u>Antioxidant activity</u> Dose dependent inhibition of nitric oxide and superoxide radicals.	
		Free radical scavenging potential[2]	250-1000 µg/ml		
Roots	Aqueous extract	Cardioprotective effect [20]	3 ml/100 g b.w.; p.o. for 30 days in isoproter enol-	Extract prevented increase in enzyme creatinine phospho kinase (CK) level during peak infarction in the heart and liver tissues. Other cardio specific enzyme markers such as lactate dehydrogenase (LDH), alkaline phosphatase (ALP) and serum glutamic oxaloacetic	By hypocholesterolemic and antioxidant mechanisms. By preventing myofibrils degeneration and

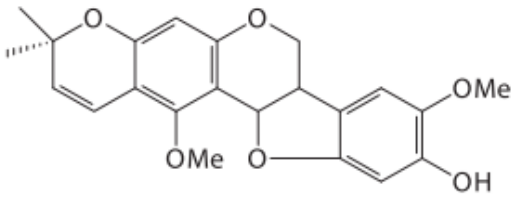
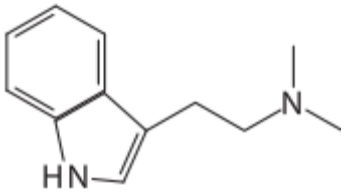
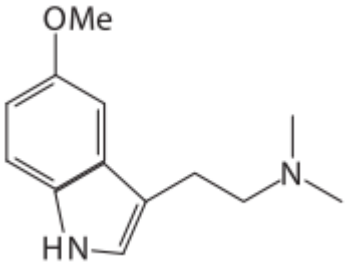
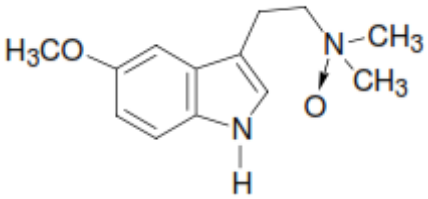
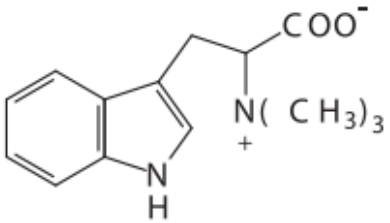
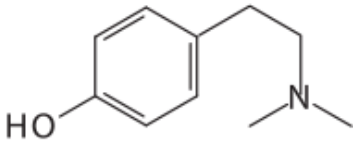
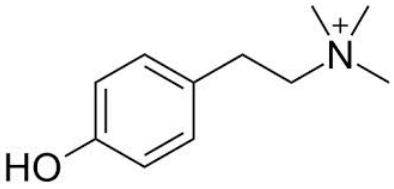
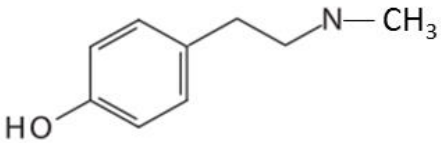
			induced myocardial infraction (MI) in rats	transaminase (SGOT) in the serum also reduced in activity. Decreased LDL, total cholesterol and triglycerides in the rat heart. Lowered thiobarbituric acid reactive substances (TBARS) and improved activity of myocardial catalase and glutathione reductase indicating free radical scavenging activity.	myocyte necrosis during MI.
Roots	Ethyl acetate extract	Antioxidant against revascularization injury[21]	100 mg/kg; p.o. for 30 days in rats	*In vitro* anti-oxidant activity (2-1000 µg/ml) Concentration dependent free radical scavenging. Half maximum inhibitory concentration (IC_{50}) scavenging DPPH (36.3 µg/ml), superoxide (55.3 µg/ml), hydroxide (43.7 µg/ml), nitric oxide (39.4 µg/ml) and lipid peroxidation (248 µg/ml). *In vivo* anti-oxidant activity (100 mg/kg) Levels of cardiac enzymes such as CK, LDH, SGOT and SGPT improved by 50%.	Improvement of cardiac function. -By improving the level of these cardiac enzymes like CK, LDH, SGOT and serum glutamic pyruvic transaminase (SGPT). -By decreasing the release of LDH in coronary effluent. -By decreasing the level of malondialdehyde in myocardial tissues.
Roots	Methanolic extract	Cardioprotective effect against ischemia reperfusion (IR) injury[22]	50 and 100 mg/kg; p.o. for 30 days in rats	*In vitro* anti-oxidant activity (5-50 µg/ml) IC_{50} for superoxide radical scavenging: 21 µg/ml and hydroxyl radical scavenging: 50 µg/ml. *In vivo* models Both doses are active. However, 50 mg/kg found better.	By improving the antioxidant function of mitochondria (present in myocardium and cardiac tissues) against IR-mediated oxidative stress. By decreasing TBARS in mitochondrial extracts and tissue homogenates. By recovering activity of mitochondrial respiratory enzymes viz., MDH (malate dehydrogenase), ICDH (isocitrate dehydrogenase), SDH (succinate dehydrogenase), NADH dH (NADH dehydrogenase) and cytochrome c oxidase.

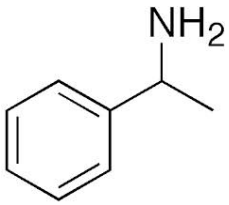
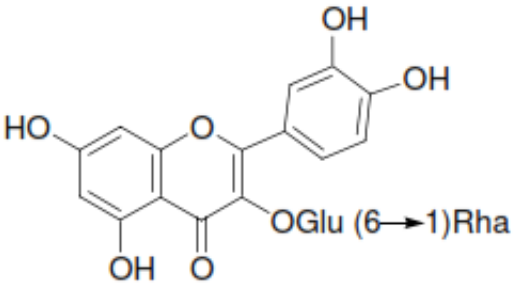
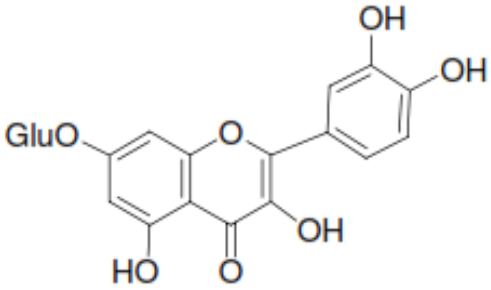
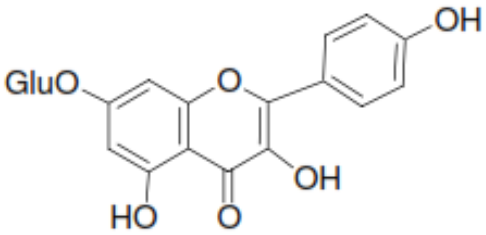
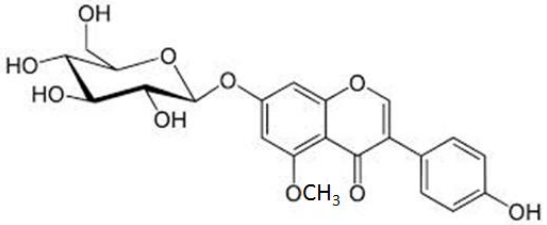
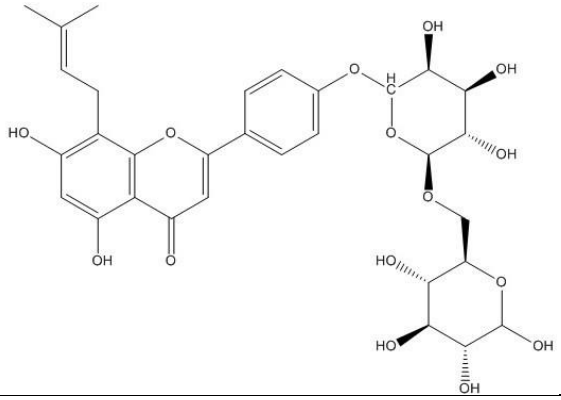
					Presence of two specific compounds (around 5% of volatile composition) namely p-[2(dimethylamino)ethyl]phenol and (E)-2,4,5-trimethoxypropenyl benzene (asaron)--- reported action on cardiac tissue[23].
Roots	Ethanolic extract	Gastroprotective[24]	50, 100 and 150 mg/kg; p.o. daily for 7 days in mice	Ethanol-induced gastric ulcer model in mice 150 mg/kg inhibited lesion index and lesion number by 85 and 74% respectively. Comparable to omeprazole. Pylorus ligated gastric ulcer model in mice 100 mg/kg reduced total acid output and gastric acid accumulation by 38% and 35% respectively. 150 mg/kg reduced total acid output and gastric acid accumulation by 66% and 67% respectively.	Increasing regeneration of damaged gastric mucosa.
Roots	Chloroform	Hepatoprotective[25]	-	Reduced the elevated levels of total and direct bilirubin by 58%. Reduced SGOT and SGPT by 31% and 48% respectively. Increased serum protein levels by 45%.	Improved hepatic function -By restoring the structural integrity of hepatocyte cell membrane. -By regenerating liver cells. -By increasing protein levels.
Whole plant	Ethanolic extract	Antiulcer[26]	200 mg/kg; p.o. in rats and guinea pigs	Alcohol-induced ulcer: 89% protection. Cold restraint stress-induced ulcer: 68% protection. Histamine induced duodenal ulcer: 63% protection. Pylorus ligation-induced ulcer: 40% protection. Aspirin-induced ulcer: 38% protection. Reduced acid secretion by 42%. Increased mucin secretion by 57%, which was better compared to omeprazole (12%).	Cytoprotective, anti-secretory and mucin secretion enhancement.
Whole plant	Ethanolic extract and fractions (chloroform, n-butanol	Antileishmanial[27]	250 mg/kg ×2 on day −7 and +7	Inhibited parasite multiplication. Ethanolic extract: 41% inhibition. n-butanol fraction: 66.7% inhibition.	n-butanol fraction imparted non-specific resistance against Leishmania infection to

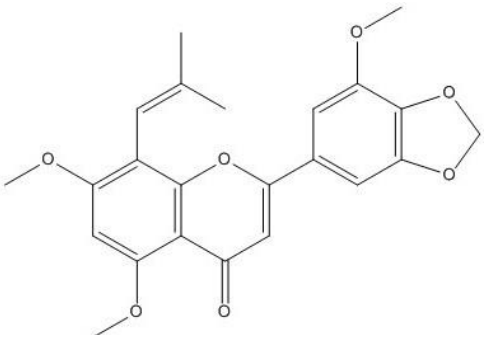
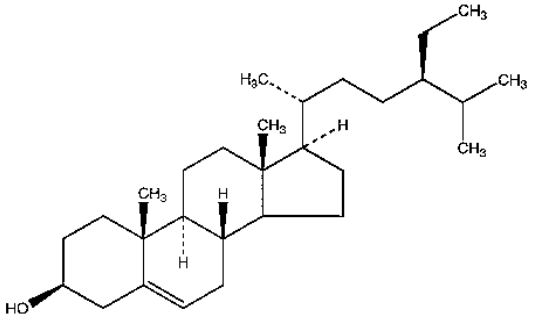
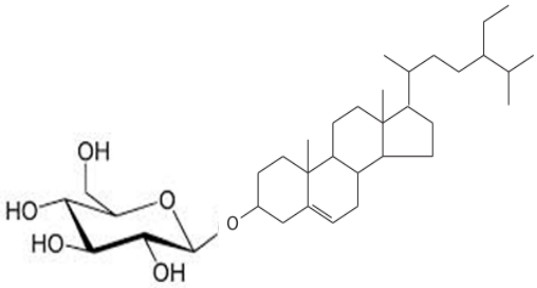
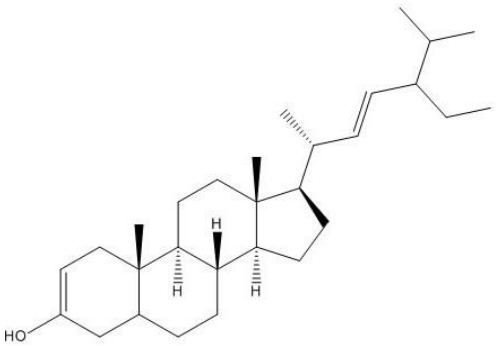
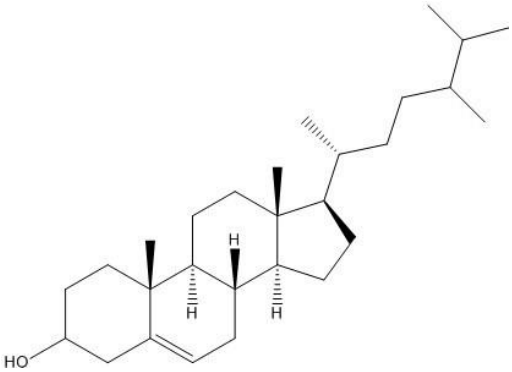
	and aqueous)				peritoneal macrophages.
Whole plant	Aqueous, Ethanolic, Chloroform and Methanolic	Antibacterial[28]	2 g/ml	Methanolic extract exhibited maximum antibacterial potential, followed by ethanol, chloroform and aqueous extracts. Bacteria Zone of Inhibition(mm) *S. mutans* 24 *K. pneumonieae* 23 *E.coli* 22 *S. typhi* 20 *P. aeruginosa* 18	Nature of biological active components, which may be enhanced by methanol extraction. Maximum active constituents are extracted in methanol, rendering this extract highly potent against different types of bacteria.
Whole plant	Aqueous extract	Antiviral in vero cell lines[29]		Lowest effective concentration : 10 ng/ml	Moderate antiviral activity against Peste des Petits Ruminants (PPR) virus.

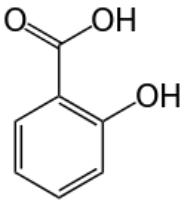
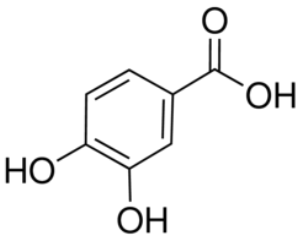
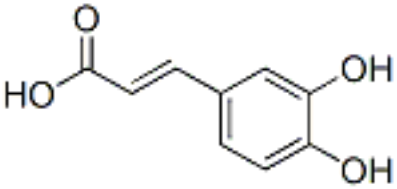
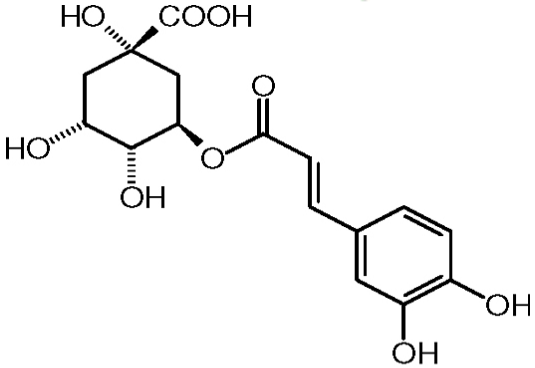
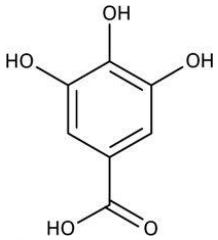
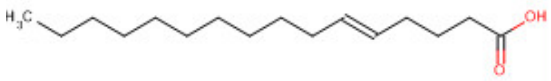
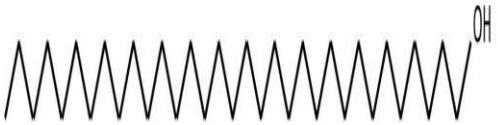
Table 2: Constituents isolated and identified from *DG*

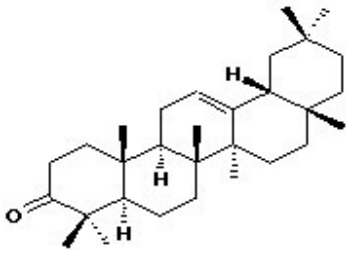
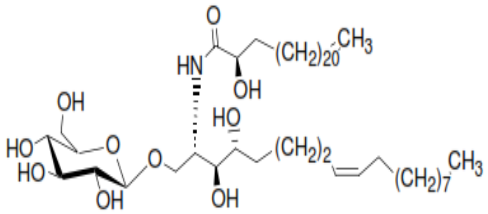
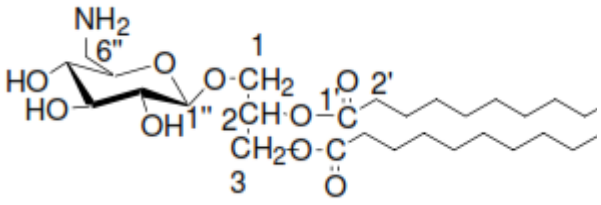
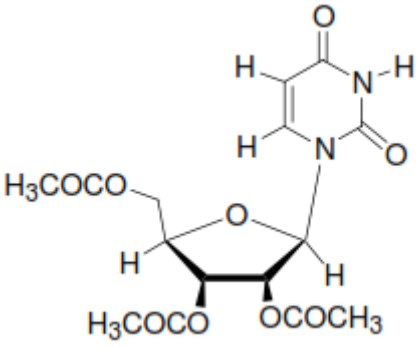
Chemical class	Name	Isolated from	Structure
Pterocarpans	Gangetin[45, 48] 7α,12α-dihydro-13-methoxy-3,3-dimethyl-11-(3-methyl-2-butenyl)-3H,7H-benzofuro[3,2-C]pyrano[3,2-g]benzopyran-10-ol	Roots	
	Gangetinin[45, 49]	Roots	
	Desmocarpin[44]		

	Desmodin[45, 49]	Roots	
Alkaloids	N,N-dimethyl tryptamine[5, 50]	Aerial parts	
	5-methoxy- N,N-dimethyl tryptamine[5, 50]	Aerial parts	
	5-methoxy N,N-dimethyl tryptamine N_b -oxide[5, 43]	Aerial parts	
	Hypaphorine[6, 46]		
	Hordenine[6, 46]		
	Candicine[6, 46]		
	N-methyl tyramine[5]		

	β-Phenylethylamine[6, 46]		
Flavonoid Glycosides[5]	Rutin		
	Quercetin-7-*O*-β-D-glucopyranoside		
	Kaempferol-7-*O*-β-D-glucopyranoside		
	5-O-methyl genistein-7-*O*-β-D-glucopyranoside		
	4’,5,7-trihydroxy-8-prenyl-flavone 4’-*O*-□-L-rhamnopyranosyl-(1□6)-□-D-glucopyranoside[51]*	Stem	

	8-C-prenyl-5,7,5'-trimethoxy 3',4'-methylene dioxy flavone[43, 51]*	
Sterols[5, 43]	β-sitosterol	
	β-sitosterol-3-*O*-β-D-glucopyranoside	
	24-ethylcholesta-5,22-dien-3β-ol,24-ethylcholest-5-en-3β-ol[52]*	
	24-methylcholest-5-en-3β-ol[52]*	

Phenolic acids	Salicylic acid[53]		
	3,4-dihydroxy benzoic acid(Protocatechuic acid)[5, 43, 53]	Roots and Aerial parts	
	Caffeic acid[53]		
	Chlorogenic acid[53]		
	Gallic acid[53]		
Trans-5-hexadecenoic acid[43, 54]			
1-tritriacontanol[43]		Whole plant	
1-heptadecanol[43]			

β-amyrone[43]		
Glycosphingolipid[43]	Whole plant	
Aminoglucosyl glycerolipid [pentadecanoic acid-3-(6-aminomethyl-3,4, 5-trihydroxy-tetrahydro-pyran-2-yloxy)-2-pentadecanoyl oxy-propyl ester][43]		
Uridine triacetate[43]		

Please Note: The structures of compounds marked an asterisk (*) *have been drawn using ChemDraw software*.

CONCLUSION AND COMMENTARY

From the pharmacological activities reported so far, it is quite clear that DG primarily possesses good antioxidant properties, which facilitates its action as an anti-inflammatory, analgesic, anti-nociceptive, cardioprotective, antiamnesic, antidiabetic, gastroprotective and antimicrobial. A consolidation of the information collected on the ethno-botanical claims and the pharmacological actions tested in the laboratory, direct our focus to the wide scope of use of DG in curing various plethora of diseases. From the traditional roles established, it is quite evident that among all the parts of the plant, the root is the one, which is used the most. Be it curing piles, or hemicrania or being identified as an anthelmintic, the roots find their use in a wide range of ailments. That could be the reason why majority of the pharmacological studies have been conducted on root extract, followed by aerial parts, whole plant and lastly the leaves. Also, to note here is the fact that most of the pharmacological activities have been an outcome of the oral route of dosing, which suggests the convenience of administration to patients. The potential of DG as an antibacterial and antiviral has also been tried; however, the mechanism of combating microbial and viral infections is yet not explored substantially, which paves the way for research in this direction

The question that intrigues the mind is that despite so many pharmacological activities exhibited by this plant and its proclaimed use in Ayurveda, why this plant or its constituents have not been developed into a suitable

formulation for the treatment of the wide range of lifestyle diseases. Is there a lack in the implementation of the rich Indian heritage and knowledge about the traditional medicinal plants? Perhaps, it is the unsurmountable hurdles in the drug development path from medicinal plants that, irrespective of the technology in hand, researchers are unable to make herbal medicines reach the masses. If research could be fast tracked to gather information required for validating the effectiveness of the medicinal plants in curing pathologies, probably then, more and more drugs from herbal sources can be obtained and drug development process can witness significant leaps. Overall, the patient population will be benefitted as many diseases take a toll on human lives, just because either there are too many side effects associated with the current therapy or there is a severe dearth of the right attitude and approach to take the herbal medicines to a level at par with their synthetic counterparts.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Kritikar KR, Basu BD. Indian medicinal plants with illustrations. Edn 2, Oriental Enterprises, Dehra Dun 2001, 1061.
2. Sagar MK, Upadhyay K. Evaluation of in vitro anti-oxidant, antinociceptive and anti-inflammatory properties of Desmodium gangeticum (L.) in experimental animal models. American Journal of Phytomedicine and Clinical Therapeutics 2013; 1(3): 256-265.
3. Avasthi BK, Tewari JD. Chemical investigation of Desmodium gangeticum II. Chemical constitution of the lactone. Journal of American Pharmacists Association 1955; 44(10): 628-629.
4. Kirtikar KR, Basu BD. Desmodium Desv, in Indian medicinal plants, International Book Distributors, Dehradun, India, 1987, 756.
5. Rastogi S, Pandey MM, Rawat AK. An ethnomedicinal, phytochemical and pharmacological profile of Desmodium gangeticum (L.) DC. and Desmodium adscendens (Sw.) DC. J Ethnopharmacol 2011; 136(2): 283-296.
6. Kirubha TSV, Jegadeesan M, Kavimani S. Studies on Desmodium gangeticum: A review. Journal of Chemical and Pharmaceutical Research 2011; 3(6): 850-855.
7. Kosalge SB, Fursule RA. Investigation of ethnomedicinal claims of some plants used by tribals of Satpuda Hills in India. J Ethnopharmacol 2009; 121(3): 456-461.
8. Singh A, Singh PK. An ethnobotanical study of medicinal plants in Chandauli District of Uttar Pradesh, India. J Ethnopharmacol 2009; 121(2): 324-329.
9. Saikia AP, Ryakala VK, Sharma P, Goswami P, Bora U. Ethnobotany of medicinal plants used by Assamese people for various skin ailments and cosmetics. J Ethnopharmacol 2006; 106(2): 149-157.
10. Panda SK. Ethno-medicinal uses and screening of plants for antibacterial activity from Similipal Biosphere Reserve, Odisha, India. J Ethnopharmacol 2014; 151(1): 158-175.
11. Ma X, Zheng C, Hu C, Rahman K, Qin L. The genus Desmodium (Fabaceae)-traditional uses in Chinese medicine, phytochemistry and pharmacology. J Ethnopharmacol 2011; 138(2): 314-332.
12. Tabuti JR, Lye KA, Dhillion SS. Traditional herbal drugs of Bulamogi, Uganda: plants, use and administration. J Ethnopharmacol 2003; 88(1): 19-44.
13. Rathi A, Rao Ch V, Ravishankar B, De S, Mehrotra S. Anti-inflammatory and anti-nociceptive activity of the water decoction Desmodium gangeticum. J Ethnopharmacol 2004; 95(2-3): 259-263.
14. Joshi H, Parle M. Antiamnesic effects of Desmodium gangeticum in mice. Yakugaku Zasshi 2006; 126(9): 795-804.
15. Govindarajan R, Asare-Anane H, Persaud S, Jones P, Houghton PJ. Effect of Desmodium gangeticum extract on blood glucose in rats and on insulin secretion in vitro. Planta Med 2007; 73(5): 427-432.
16. Rodriguez de Sotillo DV, Hadley M. Chlorogenic acid modifies plasma and liver concentrations of: cholesterol, triacylglycerol, and minerals in (fa/fa) Zucker rats. J Nutr Biochem 2002; 13(12): 717-726.
17. Govindarajan R, Vijayakumar M, Rao Ch V, Shirwaikar A, Kumar S, Rawat AK, et al. Antiinflammatory and antioxidant activities of Desmodium gangeticum fractions in carrageenan-induced inflamed rats. Phytotherapy Research 2007; 21(10): 975-979.
18. Foley S, Navaratnam S, McGarvey DJ, Land EJ, Truscott TG, Rice-Evans CA. Singlet oxygen quenching and the redox properties of hydroxycinnamic acids. Free Radic Biol Med 1999; 26(9-10): 1202-1208.
19. Sagar MK, Upadhyay A, Kalpana, Upadhyay K. Evaluation of antinociceptive and anti-inflammatory properties of Desmodium gangeticum (L.) in experimental animal models. Archives of Applied Science Research 2010; 2(4): 33-43.
20. Kurian GA, Philip S, Varghese T. Effect of aqueous extract of the Desmodium gangeticum DC root in the severity of myocardial infarction. J Ethnopharmacol 2005; 97(3): 457-461.
21. Kurian GA, Suryanarayanan S, Raman A, Padikkala J. Antioxidant effects of ethyl acetate extract of Desmodium gangeticum root on myocardial ischemia reperfusion injury in rat hearts. Chin Med 2010; 5: 3.
22. Kurian GA, Yagnesh N, Kishan RS, Paddikkala J. Methanol extract of Desmodium gangeticum roots preserves mitochondrial respiratory enzymes, protecting rat heart against oxidative stress induced by

reperfusion injury. Journal of Pharmacy and Pharmacology 2008; 60(4): 523-530.
23. Percot A, Yalçin A, Erdugan H, Güven KC. Hordenine amount in Phyllophora nervosa (D. C. Grev) (Marine Alga) collected from Sile (the Black Sea) and Dardanelle. Acta Pharmaceutica Sciencia 2007; 49: 127-132.
24. Mahesh A, Jeyachandran R, Rao DM, Thangadurai D. Gastroprotective effect of Desmodium gangeticum roots on gastric ulcer mouse models. Brazilian Journal of Pharmacognosy 2012; 22(5): 1085-1091.
25. Prasad MVV. Hepatoprotective activity of roots of Desmodium gangeticum (Linn.) DC. Asian Journal of Chemistry 2005; 17(4): 2847-2849.
26. Dharmani P, Mishra PK, Maurya R, Chauhan VS, Palit G. Desmodium gangeticum: a potent anti-ulcer agent. Indian J Exp Biol 2005; 43(6): 517-521.
27. Singh N, Mishra PK, Kapil A, Arya KR, Maurya R, Dube A. Efficacy of Desmodium gangeticum extract and its fractions against experimental visceral leishmaniasis. J Ethnopharmacol 2005; 98(1-2): 83-88.
28. Karthikeyan K, Selvam GS, Srinivasan R, Chandran C, Kuolothungan S. In vitro antibacterial activity of Desmodium gangeticum (L.) DG. Asian Pacific Journal of Tropical Disease 2012: S421-S424.
29. Jabbar S, Khan MT, Choudhuri MS, Sil BK. Bioactivity studies of the individual ingredients of the Dashamularishta. Pak J Pharm Sci 2004; 17(1): 9-17.
30. Reviews on Indian Medicinal Plants (Da-Dy). In: Tandon N, Sharma M, editors. Reviews on Indian Medicinal Plants, Indian Council of Medical Research, Delhi, 2009.
31. Wang ZQ, Porreca F, Cuzzocrea S, Galen K, Lightfoot R, Masini E, et al. A newly identified role for superoxide in inflammatory pain. Journal of Pharmacology and Experimental Therapeutics 2004; 309(3): 869-878.
32. Ndengele MM, Cuzzocrea S, Esposito E, Mazzon E, Di Paola R, Matuschak GM, et al. Cyclooxygenases 1 and 2 contribute to peroxynitrite-mediated inflammatory pain hypersensitivity. The FASEB Journal 2008; 22(9): 3154-3164.
33. Keeble JE, Bodkin JV, Liang L, Wodarski R, Davies M, Fernandes ES, et al. Hydrogen peroxide is a novel mediator of inflammatory hyperalgesia, acting via transient receptor potential vanilloid 1-dependent and independent mechanisms. Pain 2009; 141(1-2): 135-142.
34. Pashkow FJ. Oxidative Stress and Inflammation in Heart Disease: Do Antioxidants Have a Role in Treatment and/or Prevention? Int J Inflam 2011; 2011: 514623.
35. Shukla V, Mishra SK, Pant HC. Oxidative stress in neurodegeneration. Adv Pharmacol Sci 2011; 2011: 572634.
36. Farooqui AA. Inflammation and Oxidative Stress in Neurological Disorders, Springer International Publishing, 2014.
37. Wellen KE, Hotamisligil GS. Inflammation, stress, and diabetes. J Clin Invest 2005; 115(5): 1111-1119.
38. Reuter S, Gupta SC, Chaturvedi MM, Aggarwal BB. Oxidative stress, inflammation, and cancer: how are they linked? Free Radic Biol Med 2010; 49(11): 1603-1616.
39. Ramos VA, Ramos PA, Dominguez MC. Role of oxidative stress in the maintenance of inflamation in patients with juvenile rheumatoid arthritis. J Pediatr (Rio J) 2000; 76(2): 125-132.
40. Hartman KG, Bortner JD, Falk GW, Yu J, Martin MG, Rustgi AK, et al. Modeling inflammation and oxidative stress in gastrointestinal disease development using novel organotypic culture systems. Stem Cell Res Ther 2013; 4 Suppl 1: S5.
41. Ghosh D, Anandakumar A. Anti-inflammatory and analgesic activities of gangetin-a pterocarpanoid from Desmodium gangeticum. Indian Journal of Pharmacology 1983; 15: 391-402.
42. Muzaffer A, Pillai NR, Purushothaman AK. Examination of biochemical parameter after administration of gangetin in female albino rats. Journal of Research in Ayurveda and Sidha 1982; 2: 172-175.
43. Mishra PK, Singh N, Ahmad G, Dube A, Maurya R. Glycolipids and other constituents from Desmodium gangeticum with antileishmanial and immunomodulatory activities. Bioorg Med Chem Lett 2005; 15(20): 4543-4546.
44. Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal Plants, PID New Delhi., 1980-1984, 243.
45. Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal Plants, PID New Delhi, 1970-1979, 262-263.
46. Ghosal S, Banerjee PK. Alkaloids of the roots of Desmodium gangeticum. Aust J Chem 1969; 22
1. 2029-2031.
47. Varaprasad MV, Balakrishna K, Sukumar E, Patra A. Gangetial, a newpterocarpan from the roots of Desmodium gangeticum. Journal of the Indian Chemical Society 2009; 86: 654-656.
48. Purushothaman KK, Kishore VM, Narayanaswami V, Connolly JD. The structure and stereochemistry of gangetin, a new pterocarpan from Desmodium gangeticum (Leguminosae). Journal of the Chemical Society C: Organic 1971; (0): 2420-2422.
49. Purushothaman KK, Chandrashekharan S, Balakrishna K, Conolly JD. Gangetinin and desmodin, two minor pterocarpanoids of Desmodium gangeticum. Phytochemistry 1975; 14: 1129-1130.
50. Behari M, Varshney A. Sterols from Desmodium species. Indian Drugs 1986; 23: 434-435.
51. Yadav RN, Tripathi P. A novel glucoside from the stem of Desmodium gangeticum. Fitoterapia 1998; 69(5): 443-444.
52. Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal Plants, PID, New Delhi, 1985-1989, 267.
53. Niranjan A, Tewari SK. Phytochemical composition and antioxidant potential of Desmodium gangeticum

(Linn.) DC. Natural Product Radiance 2008; 7(1): 35-39.

54. Bhatty MK, Craig BM. Useful procedures for the determination of complex fatty acid composition. Occurrence of trans-5-hexadecenoic and trans-5,cis-9-octadecadienoic acids in the oil from Thalictrum venulosum. Can J Biochem 1966; 44(3): 311-318.
55. Ghani A. Medicinal Plants of Bangladesh with chemical constituents and uses. Edn 2, Asiatic Society of Bangladesh, 5 old Secretariate road, Nimtali, Dhaka, Bangladesh., 2003.
56. Rastogi RM, Mehrotra BN. Compendium Indian Medicinal Plants. , CDRI, Lucknow and Publication and Information Directorate, New Delhi, 1993, 91.