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A BRIEF REVIEW ON *DIOSCOREA BULBIFERA* LINN: CONSTITUENTS AND PHARMACOLOGICAL EFFECTS

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ABSTRACT

Dioscorea bulbifera is a monocot, herbaceous, tuber-yielding climber invasive, wild plant belonging to the family Dioscoreaceae and has about 600 species. *Dioscorea bulbifera* contains basic nutritional components like starch, low fat, fibers and minerals which provide it nutritional value; consequently, it is a staple food of tribal and non-tribal populations throughout the world. This plant has great ethnomedicinal value in the local regions of the world. Due to the presence of various type of secondary metabolites (saponins, sapogenins, carotenoids, tannins, alkaloids and flavanoids) it is commercially useful in the pharmaceutical industries for production of modern drugs. This plant is also source of a very important commercially viable phytosteroid i.e. "diosgenin" (A sapogenin). It possess other biofunctional compounds like catechin, kaempferol, catechuic acid, cortisones, bafoudiosbulbins, diosbulbins, xanthins, dioscin and dioscrine etc. and other various phytoconstituents along with diosgenin. Due to this reasons, this plant has healing property and can be used to treat diabetes, cancer, microbial infections, cardiac problems, digestive abnormalities, syphilis, typhoid, goiter and throat infections. The plant extracts also shows antioxidant, anti-inflammatory, antihyperlipidemic, antihelminthic and antileprosy activity.

KEYWORDS: *Dioscorea bulbifera*, Herbal medicine, Ethnomedicinal, Diosgenin, Antihyperglycemic.

INTRODUCTION

World Health Organization (WHO) states that the dream "Health for All" can never come true without herbal plant, because raw materials are the source for all drugs and medicnal formulations.[1] According to WHO, about 80% of world population believes in traditional medicine to improve their health.[2] Different tribal groups of the world use *Dioscorea bulbifera* (DB) as a source of food with high caloric and medicinal value along with wide range of adaptations.[3] This plant is known worldwide for its edible tubers. This plant is mostly distributed in hot, humid and tropical regions. Geographically, it is native of Asia and Africa continent and also distributed in some regions of central and South America.[4] This plant is not found in western hemisphere. In India, it is distributed all over the country in wild, but in North-East region of country, it is also cultivated for their edible tubers.[5] In India, it has different vernacular names in different area.

Local names

Hindi – Ratalu, Pahadi Alu, Ban alu
English- Air Potato, Aerial Yam
Sanskrit- Varahikanda
Marathi- Varahi, Dukarkand
Assamese- Bon Alu
Oriya- Pit Alu
Bengali- Ban alu

This plant is abundantly reported in Assam, Arunachal Pradesh, Mizoram, Karnataka, Maharashtra, and Uttar Pradesh in wild. In wild conditions, tuber is very bitter due to accumulation of various types of secondary metabolites. These secondary metabolites are raw materials for synthesis of various types of drugs for human and animals. In rural area these tubers are boiled and cooked to make it edible.[6] In tribal regions, it is the source of food as well as medicine. In Folk Medicine System, it is used for various kinds of illness and thus this plant has ethnomedicinal value as well as used in modern pharmaceutical industries.

Dioscorea sp. (having about 600 species) is a genus of Monocot Dioscoreaceae family and *Dioscorea bulbifera* is most common species of this genus.[7] It is twinning herb (about 25-30m) with smooth stem and simple, alternate, 5-11 veined, smooth and chordate shaped leaves. Flowers are spike and unisexual, white in color, perianth is tubular. Bulbils are spherical and dark brown and abundant. Tubers are random shaped and sometimes hairy.[8] Due to dioecious nature of plant, pollination and fertilization potency and rate of seed setting is very low. In this condition, bulbils and tubers are the only way to propagation of this plant. The propagation of this plant

through bulbils are easy than seed because seed germination rate is very low.[9]

Uses

Increasing population and demand of herbal medicine, the research on new plant are continuously going on in various research institutes and their immense properties are explored everyday in the treatment of new diseases, either physiological or microbial. DB is a wonderful source for food and as well as medicine as it have large amount of carbohydrates and protein as well as saponins, flavanoids tannins, alkaloid etc. (Table 1).[10,11] All parts of this plant have medicinal properties but tubers are main source of drugs due to storage properties. In quantitative test of tubers in two different extract (aqueous and ethanolic extract), the presence of valuable pharmaceuticals compounds are detected in appropriate amount.[12] (Table 2, Fig 1).

Table 1: Preliminary Constituents of Tubers and Leaves of DB.[10,11]

Sr. No.	Compounds	Tubers	Leaves	Uses of these compound
1.	Glucose & Fructose	+	+	Nutritional value
2.	Starch	+	+	Nutritional value
3.	Protein	+	+	Nutritional value
4.	Anthraquinone glycosides	-	+	Pharmaceutical Precursors
5.	Cardiac glycosides	+	+	Pharmaceutical Precursors
6.	Flavanoids	+	-	Pharmaceutical Precursors
7.	Alkaloids	+	-	Pharmaceutical Precursors
8.	Tannins	+	-	Pharmaceutical Precursors
9.	Phenolics compound	+	-	Pharmaceutical Precursors
10.	Saponins	+	-	Pharmaceutical Precursors

(+ = Present, - = Absent).

Table 2: Percentage of phytoconstituents of DB.[12]

Sr.no.	Constituents	% in Aqueous extract	% in Ethanolic extract
1.	Flavanoids	1.8%	1.7%
2.	Tannins	2.1%	1.5%
3.	Alkaloids	0.25%	0.5%
4.	Saponins	3.5%	4.5%

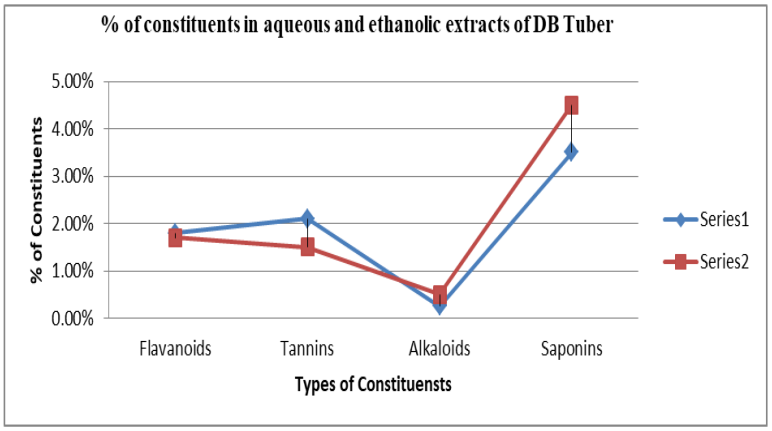

Fig 1: Phytochemical percentage composition of DB in two extracts. (Series 1= Aqueous extract, Series 2= Ethanolic extract).

Nutritional Roles of *Dioscorea bulbifera*

DB is an important climber plant which is staple food for big populations in Central and South America, South East Asia, West and South Africa, Carribean and India. It plays an important role in economy in the Tropical and Subtropical regions.[13,14] In India, in the hilly regions mostly North-East region, it is staple food for local and tribal people. The tuber is a rich diet having antioxidants and nutritional value. The tubers are consumed by local and tribal people for nutrition but they also stay healthy due to their medicinal value.[15] Cultivated bulbs are less bitter than wild and ideal for consumption as food. These cultivated bulbs are used after roasting by tribal population in India especially in north east regions, Madhya Pradesh, Chhattisgarh, Orissa and Jharkhand etc.[16,17] India enjoys a great generic diversity of crop and air potato, is one out of them, which contain carbohydrates, low amount of fat, fibers, calories and minerals such as iron, calcium and phosphorus etc. Due to this reason, it is nutrient rich option and it can also process into other kind of foods.[18] (Table 3).

Table 3: Nutritional constituents of DB tubers.

	Sr. no.	Starch	Proteins	Fibre	Lipids	Reference
Nutritional value on the basis of various studies	1.	27.5%	3.4%	7.5%	ND	[19]
	2.	78.34%	8.44%	2.28%	1.99%	[20]
	3.	70%	8%	3.5%	1.1%	[21]
	4.	38%	1.5%	1.8%	0.28%	[22]

ND=Not described

Pharmacological Roles of *Dioscorea bulbifera*

Traditional knowledge of any medicinal plant is the base of modern medication. DB has many ancient traditional uses and still valuable in all Indian medical system *viz*. Ayurveda, Homeopathy, Folk Medicine, Siddha, Unani etc. In wild condition, this species contains more amount of secondary metabolites than cultivated, hence wild species is more ideal for medicinal purposes. In recent studies, there are seven clerodane diterpenoids i.e. Bafoudiosbulbins-A to G,[23] sixteen Diosbulbins (A-P) and near about 150 types of medicinal extracts[24] are reported from bulbs, tubers, leaves and rhizomes of DB. It is a good source of diosgenin. Diosgenin-derived steroids are 1 out of 10 most recommended medicines of herbal medicines. The demand of steroids drugs are increasing day by day in pharmaceuticals.[25] Due to the presence of good quantity of various biofunctional chemicals, this plant is used in treatments of various types of physiological and microbial disorders (Table 4).

Table: 4 Important Medicinal Phytoconstituents of DB.

Sr.No.	Categories of phytoconstituents	Phytoconstituents	Medicinal Uses	References
1.	Steroidal saponins	Dioscoreanoside- A to –K.	Skin diseases, apoptotic effect.	[26]
		Dioscin	Anticancerous activity	[27]
		Spiroconazole-A	Antilarvicidal effect, Anticancerous, Antileismanial.	[28]
2.	Steroidal sapogenins	Diosgenin	Used in treatment of neurological disorders, cardiac problems, diabetes and Metabolic syndrome, Antioxidant, Birth control.	[29,30,31]
		Diosbulbisin-A to –D	Antiinflammatory,	[32]
		Diosbulbiside-A to –C	Hepatic cancer, cytotoxic activity	[33]
3.	Clerodane diterpenoids	Bafoudiosbulbin –A to –G	Antimicrobial activity	[23,34]
4.	Nonclerodane diterpenoids	Diosbulbin-A to –P	Antitumor, Hepatotoxic,	[24]
		8-Epidiosbulbins-E-acetate	Anticancerous agent	[24]
5.	alkaloids	Dioscrine	Birth control	[32]

Anticancerous Properties

Various studies are done to perform and observe the anti cancerous activity of DB plant. Bulbils of DB have mannose-binding lectins which shows its HIV and Cancer treating potential.[35] Alcoholic extract of this plant show aromatase inhibiting activity to reduce estrogen and progesterone level to treat breast cancer.[36] The ethyl acetate extract of DB can decrease the MTA-1 (Metastasis Associated Protein - 1) induced proliferation of MCF-7 (Human Breast Cancer Cell Line) cells.[37] Diosgenin can affect the cyclooxygenase-up regulation and Capsase activity to induce apoptosis in cancerous cells and *HeLa* cells respectively.[38] Diosgenin can be used in various carcinomas, lung cancer and human chronic myeloid leukemia.[29] · Anticancerous cytotoxic activity of DB is also assessed against four human cancer cell line i.e. HL-60, SMMC-7721, A-549 and SW-480.[39]

Antidiabetic properties

Flavonoids and saponins contents of DB bulbs have ability to inhibit α-amylase and α-glycosidase and due to this reason it is a good herbal drug to maintain blood sugar level.[40] Copper nanoparticles synthesized *Dioscorea bulbifera* explants show antidiabetic activity.[30] *Dioscorea bulbifera* possess gold, silver and platinum nanoparticles and thus it has immense activity for antidiabetic, antimicrobial and anticancerous properties.[41] Aqueous DB extract can decrease the blood glucose level of hyperglycemic and diabetic wister rat model.[42] In Alloxan induced diabetic rats, antidiabetic effects had been performed by using *Dioscorea bulbifera*.[43] This plant can offer a less costly medication to treat diabetes.

Antimicrobial Properties

The plant with sufficient amount of secondary metabolites (alkaloids, saponins, glycosides, phenols, flavanoids) has the ability to protect against various pathogens (bacteria, fungi and viruses).[44] Bafoudiosbulbins- A to –G (Clerodane Diterpenes) are potential drugs against multidrug resistant (MDR) bacteria.[34] The petroleum ether and chloroform extract of its bulb shows antifungal (against *Aspergillus niger*,

A. fumigatus, *A. nigricans*, *A. flavus* etc.) and antibacterial (against *E. coli*, *Bacilus aureus*, *Straphylococcus* etc.) activity.[45] (Table 5, Fig 2).[46] Minimum Inhibitory Concentration (MIC) of methanolic extracts of wild and cultivated plant of *Dioscorea bulbifera* had been tested on bacteria and this studies shows that, wild plant has more antibacterial potential.[12] (Table 6, Fig 3).[47] Butanol and ethyl acetate extraction of this plant can inhibit Coxsackie B I-VI virus and after inhibition of virus, cell can survive.[26] Extract of silver nanoparticles synthesized tuber have great potential to increase the antibacterial activity of various broad spectrum antimicrobial agent.[48]

Table 5:Antifungal activity (percent inhibition) of DB.[46]

Sr.no.	Test Organism (Fungus)	% Inhibition at 2 different extract	
		Aqueous extract	Ethanol extract
1.	*Botryodiplodia theobromae*	26.66%	13.04%
2.	*Sclerotium rolfsii*	35.48%	94.44%
3.	*Fusarium oxysporum*	16.66%	38.46%

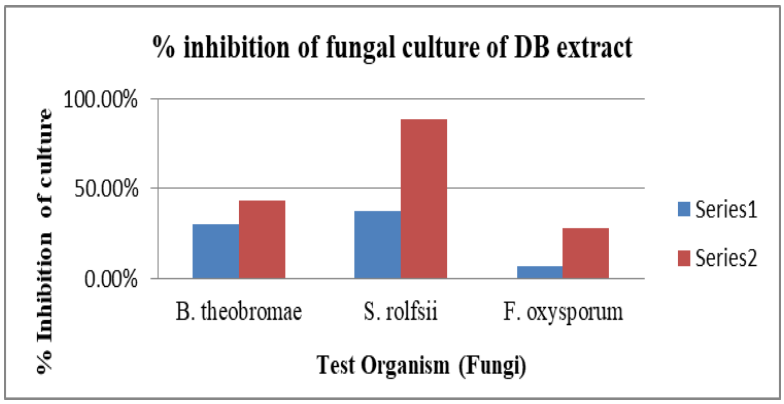

Fig 2: effect of DB on % inhibition on fungal culture (Series 1=aqueous extract, Series 2= ethanol extract)

Table 6: Antibacterial activity of tuber extract of DB.[47]

Sr. no.	Test Organism (Bacteria)	Zone of Inhibition (in mm) of three different extract of DB		
		Ethanol extract	Methanol Extract	Chloroform Extract
1.	*Bacillus subtilis*	11	13	11
2.	*Bacilus cereus*	13	15	9
3.	*Staphylococucus aureus*	14	17	8
4.	*Pseudomonas aeruginosa*	11	13	11
5.	*Salmonella typhi*	11	14	10
6.	*Escherichia coli*	13	17	13

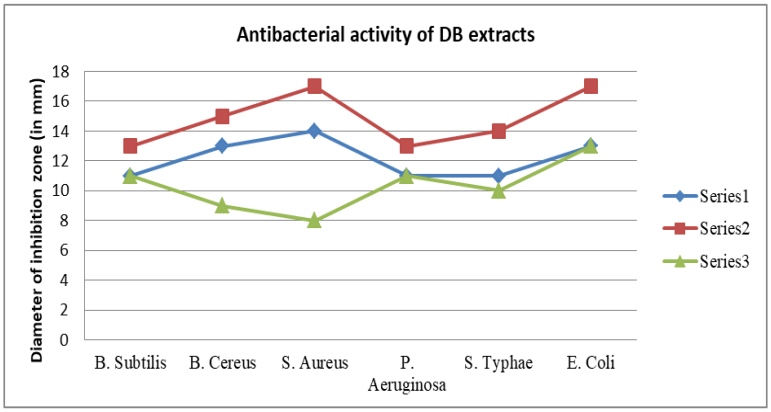

Fig 3: Effect of different DB extract on diameter of zone of inhibition on bacteria. (Series 1= Ethanol extract, Series 2 = Methanol extract and Series 3 = Chloroform extract).

Antioxidant and Scavenging Properties

In our body, metabolic processes go on continuously and consequently free radicals are generated, which exhibits harmful effect on nucleic acids, cell membranes, proteins etc. this destruction is responsible for aging, cardiac problems and cancer.[49] Thus antioxidants are useful in

keep us away from various kind of severe disorders. Antioxidant molecules can reduce these free radicals by chelating, reduction and scavenging mechanisms. DB contains excess antioxidants (phenols, carotenoids and vitamin C etc.).[50] A. D. Bholay[51] was using DPPH assay to reveal the percent scavenging action of DB extract of different parts at different concentration. (Table7).

Table 7: Percent scavenging of DB extracts from different plant parts at different concentrations.[51]

Sr.no.	Plant part	Percent scavenging action of DB extracts		
		200mg/ml	100mg/ml	50mg/ml
1.	Bulbs	36.66%	30.00%	20.00%
2.	Leaves	46.66%	43.33%	33.33%
3.	Stems	66.66%	53.33%	46.66%

Contraceptive Properties

Diosgenin is used in synthesis of cortisteroids, sex hormones and contraceptives drugs [52] and Dioscrine and Diosgenin are major constituents in synthesis of birth control pills.[32,53]

Cytotoxic Properties

In recent years, some poisoning cases of DB are reported in some patients. It has been seen that chronic and more doses of DB can cause liver injury *in vivo* and *in vitro* studies. It has been demonstrated that DB extract have hepatotoxicity potential.[54] Diosbulbin-D (nonclerodane diterpene) exhibits direct hepatocytes toxicity. It enhances the secretion of liver enzymes; alanine aminotransferase and aspartate aminotransferase and these properties determine the toxic effect of diosbulbin-D.[55]

Dyslipidemic Properties

Dyslipidemia is a metabolic disorder in which LDL Cholestrol and total cholesterols become high and HDL becomes low. Lowering the cholesterol in the raised serum LDL and HDL is a important property of diosgenin.[56,57] Diosgenin from *Dioscorea bulbifera* induces cholesterol degradation without interfering Neimann-Pick C1-Like 1 protein (a protein that regulate cholesterol absorption) of intestinal apical membrane of absorptive enterocytes.[58]

Others

In the presence of alcoholic extracts of *Dioscorea bulbifera*, stimulation of osteogenesis activity of osteoblastic cells has been seen *in vivo* condition on rat skeletons.[59] The extract of bulb is used in different indigenous system of medicines to cure cardiac and neurological disorders,[60] throat infection,[61] anti-inflammatory actions,[62] antihyperglycemic activity[63] and also used as antileishmanial,[64] diuretic,[65] analgesic,[66] antihelminthic,[67] Antitumor,[68] and Antihypertensive[69] agent.

DISCUSSION AND CONCLUSION

The need of situation and time is that, we should know medicinal and economical value of each and every flora around us to overcome huge demand of drugs i.e to be healthy in pandemic era and to support the 'Atamnirbhar Bharat Campaign of our country'. A plant which acts as food as well as valuable drugs source is like icing on the cake. *Dioscorea bulbifera* is such a type of plant, which overcomes our food demand and is a rich source of diosgenin and other kinds of drugs. Many local regions of our country, utilize this plant as a staple food, after cereals, as a nutrient source of carbohydrate, fiber, low fat, minerals. The carbohydrate content is also good for diabetic patient because of presence of other secondary metabolites. These secondary metabolites are unique in this plant and has enormous potency to cure various diseases either physiological (cancer, heart problem, tumor, diabetes, thyroids, hemorrhoids, arthritis, goiter, Pain, etc.) or microbial (leprosy, typhoid, syphilis, throat infection, malaria, measles, small pox, worm infection, immunity booster, digestive tract infection, UTI etc). It is good source of effective drugs against neurological disorders (such as Alzheimer's disease, Parkinson's disease, Nervous injury etc.),[35] cardiovascular diseases,[34] diabetes.[25] Cultivation of tubers and bulbils of air potato overcomes food scarcity in the tribal populations and ethno-medicinal knowledge of *Dioscorea bulbifera* will prove to be a blessing for human beings.

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