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Ethno-Medico-Biology of Bān-Aālu (*Dioscorea* species): A neglected tuber crops of Odisha, India

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Abstract

Dioscorea – a genus of wild tuber crops is one of the major underground medicinal food sources among rural and tribal populace of Odisha. Twelve species of *Dioscorea* are reported in Odisha of which all except *Dioscorea alata* are wild while the latter is a cultivated one. The species are unique for their medicinal, food and economic values. The details in the terms of ethnobotanical values, bioactive compounds, pharmacological potentials, diversity in selected districts of Odisha and their therapeutic uses in maintaining health care have been documented through field survey using passport data and from literature. The richness of these valuable tuber crops is declining due to various anthropogenic activities. Therefore, an attempt was made to document the therapeutic values, diversity and food potentials of these species. The implications of this study in terms of sustainable use of these tuber crops by the rural and tribal communities and their conservation have been discussed along highlights the medicinal potential of the *Dioscorea* species found in Odisha.

Key-Words: Biochemical constituents, *Dioscorea* species, Medicinal values

Introduction

The WHO reports that 80 % of the world's populations rely chiefly on traditional medicines. Plant extracts are valuable sources of natural products for maintaining human health. Since ancient times the aboriginals have been using plant parts against different diseases. In this modern era, synthetic drugs are being used extensively in an improper way thus creating a problem of increased resistance of pathogens against particulars drugs. It creates zero values of the particular allopathic agent and indicates the need of screening new plant or animal sources. This screening is based on ethnobotanical survey followed by investigation of pharmacological activity and clinical trials. In the last few years a number of such studies have been conducted in Odisha with different plants and their extracts (Kumar *et al*., 2012; Sahu *et al.*, 2010). The sources of ethnobotanical values are forests and their dwellers such as tribal and rural communities. They are the real treasure of this unexplored knowledge that transmits from generation to generation. Odisha, the most picturesque state in Eastern India, occupies a unique place in the tribal map of India.

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It has largest number of tribal communities i.e., 62 including 13 primitive tribes which constitute 22.3 % of the state's population. Kharia, a primitive tribe of Simlipal Biosphere Reserve, is one of them which famous for its ethnobotanical knowledge. They use different types of plant extracts for various purposes (Kumar *et al.*, 2012; Behera, 2006). For new drugs formulation some unexplored plants are required having sound medicinal values. Such plant species are inhabitants of Odisha among which tuberous plants particularly *Dioscorea* species are very common. Aboriginals use them in various ways. They use their tubers as food as well as medicine. There are 12 species of *Dioscorea* found in Odisha including 11 wild and one cultivated. All are highly acrid in nature causing irritation in throat and mouth. Still, the tribal people use these tubers frequently after preparation as food and also as traditional medicine. Keeping this in mind, an attempt has been made for conservation of these plants in Odisha through documentation of their diversity and therapeutic medicinal values through field as well as literature survey.

Taxonomy and distribution of *Dioscorea* species

The genus *Dioscorea* is a member of *Dioscoreaceae* or Yam (Bān Aālu) family under the order Liliales of the class Liliopsida which is under the division

Magnoliophyta. Taxonomically it is a climber monocot, rarely erect, herbs or shrubs; rootstock tuberous or with a hard rhizome and tuberous roots. Leaves are opposite or alternate, sometimes both on the same plants (*Dioscorea alata* L., Fig-5), simple, lobed or digitally 3-9 foliolate (*Dioscorea hispida a*nd *Dioscerea pentaphylla*) (Fig- 6 & 7), palminerved and reticulately veined; petiole often angular and twisted at the base. Flowers regular, small or minute, usually monoecious or dioeccious, rarely bisexual in spikes, racemes or panicles. Perianth tubular, urceolate or rotate, 6-cleft, often shortly connate below. Male flowers: stamens 3 or 6, or 3 perfect with 3 alternating staminodes inserted at the base of the perianth or on its lobes; anthers small, pistillate sometimes present. Female flowers: staminodes 6, 3 or 0, Ovary inferior, trimerous, usually 3 celled; ovules 2, superposed per cell; style-3, short; stigma entire or 2 – fid, recurved. Fruit berry or 3 valved capsule. Seeds flat or subglobose, winged or not (Haines, 1925; Saxena and Brahmam, 1995). The vine *Dioscorea* has about 600 species (Asokan *et al.*, 1983). The major yam growing regions of the world are Asia, South America and West Africa (Behera *et al.*, 2008). In Odisha, it is found throughout the state (Fig-1) and abundantly present in the regions of Similipal Biosphere Reserve (SBR) forest, Karlapat Sancutuary (Kalahandi), Gajpati, Ganjam etc. *Dioscorea puber* (Fig-2) is most abundant in Bangriposi valley and Gurguria region of the SBR (Fig-1). *Dioscorea wallichii* is abundant in Ghatkumari region of the SBR. *Dioscorea pentaphylla* (Fig-7) and *Dioscorea hispida* (Fig-6) is frequently available in Keonjhar.

Table 1: Local name and distribution frequency of *Dioscorea* spp. in Odisha

Dioscorea spp.	Local Name	Frequency
D. alata L.	Khambo aālu	+ + + + +
D. bulbifera L.	Pita Kanda	+ + +
D. glabra Roxb.	Konta aālu	+ +
D. belophylla Voigt. Ex Haines	Kunda aālu	+
D. hamiltonii Hook.	Meram tua Sānga	+ + +
D. hispida Dennst.	Banya aālu	+ +
D. oppositifolia L.	Pani aālu	+ + +
D. pentaphylla L.	Mundi aālu	+ +
D. puber Bl. Enum.	Kosa aālu	+ + + +
D. wallichii Hook. f.	Suta aālu	+ +

(+ + + + +: Most frequent, + + + +: Frequent, + + +: Less frequent, ++: Occasional, +: Rare)

Ethnobotany of *Dioscorea* species in different parts of Odisha

Dioscorea species play a vital role among the tribal communities by serving as a food in their daily diet and as a traditional medicine to cure different types of diseases during critical period. Literature survey reveals the importance of the tubers of many *Dioscorea* species in fulfilling the dietary and medicinal requirements. Many South Asians use syrup of the root to get relief from labour pain and also physicians recommend it to patients with colic pain, asthma, hiccough, rheumatism and gastric problem related to alcoholism. Powdered tubers were used as an ingredient of medicines for cholera and constipation and plant juice was used in sores, in treatment of piles, skin diseases, intestinal worms and obesity (Foster and Duke, 2000; Natraj *et. al.*, 2009). Uadia, (2003) reported that some *Dioscorea* species are used to treat diabetes. *Dioscorea* species are sometime also used as an herbal tonic. Therefore, it is recommended for the treatment for poor appetite. *Dioscorea* species are used for the treatment of leprosy and tumors in Bangladesh (Mbiantcha *et al.*, 2011). In Zimbabwe, *Dioscorea* species are used as an infusion apply on cuts and sores, both for humans and animals, while in Cameron and Madagascar, the pounded bulbs are applied to abscesses, boil and wound infections (Mbiantcha *et al.*, 2011). Rout and Panda, (2010) reported that *Dioscorea wallichii* is used against stomach pain at Mayurbhanj district of Odisha. Behera, (2006) reported that 2 g of *Dioscorea bulbifera* paste along with 1 g root paste of *Costus specious* is used to cure piles among tribal groups of Simlipal Biosphere Reserve forest. Sahu *et al.*, (2010) reported that 2 g of tuber paste is mixed with 4 g of young leaf paste of *Costus specious* is administered for 15 days against rheumatism. Kumar and Satpathy, (2011) report that *Dioscorea puber* (Fig-2) is eaten to remove weakness or as tonic. Nayak *et al.*, (2004) reported that root powder of *Dioscorea bulbifera* (Fig-4) is applied externally in cases of hernia and hydrocele and is also applied on scorpion bite wound. Mishra *et al.*, (2008) reported that some species of *Dioscorea* are used as stimulant, tonic, carminative and expectorant. In Jaypore tract, Odisha, about 250 g of *Dioscorea oppositifolia* (Fig-3) is boiled with 100-150 g of *Dolichos uniflorus* and is given to women one time a day for nearly a month after delivery to revive their strength. *Dioscorea glabra* is considered a general tonic. *Dioscorea hamiltonii* is consumed to get relief from piles and burnt and *Dioscorea bulbifera* enhances the appetite, respectively (Mishra *et al.*, 2008). The bulbils of *Dioscorea* species are also used to treat piles, syphilis and are applied to

ulcers and inflammation (Mbiantcha *et al.*, 2011). A few species of *Dioscorea* are used to make arrow poison and certain species contains small quantities of *diosgenin* that is used as a precursor in the commercial synthesis of sex-hormones and pills for birth control (Uadia, 2003; Crabbe, 1979).

Palatability and Biochemical constituents

Among available *Dioscorea* species, four species are major as per consumption rate (Fjg-). These are *Dioscorea alata, Dioscorea bulbifera, Dioscorea pentaphylla, Dioscorea puber*. The palatability of *Dioscorea alata* is high due to less bitterness. It is grown as tuber crop for economic values by rural and tribal farmers. *Dioscorea* species are acrid due to presence of Calcium oxalate. Still tribal people use them in their daily diet and in critical conditions like famine, off-agriculture periods and during shortage of food. A study conducted by NISWASS reveals that six *Dioscorea* species are edible in Tumudi Bandha area of Phulbani district (Behera *et al.*, (a) 2010). Coursey and Aido, (1966) reported that the ascorbic acid content is beneficial and many *Dioscorea* species are considered as good source of vitamin C. Behera *et al.*, (b) (2010) reported that in *Dioscorea belophylla* vitamin C content is higher than others. Holloway *et al.*, (1989) reported that presence of Oxalic acid; Citric acid, Malic acid and Succinic acid are considered to be the major organic acids in Yams. Martin *et al.*, (1974) reported that in *D. bulbiferra*, (Fig-4) a nutritionally useful pigment, β-Carotene related carotenoid is present. Recently Kumar *et al.*, (2012) reported that 11 edible wild *Dioscorea* species are available in the Simlipal Biosphere Reserve forest.

Bioactive compounds

Martin, (1969) reported a bioactive compound Diosgenin, is a sapogenin used in the synthesis of steroidal drugs. Diosgenin is the primary active ingredient in *Dioscorea* species. It is structurally similar to cholesterol after oral administration. It is metabolized in the liver and eliminated via bile. Estrogenic and anti-inflammatory effects of diosgenin have been hypothesized due to its structural similarity to estrogen precursors. Wild yam also contains an abundance of starch (Satija, 2011). Asha and Nair, (2005) reported that *Dioscorea deltoidea* Wall. is the major species exploited in India for diosgenin obtained from rhizomes, they also reported the maximum diosgenin yield was recorded in *Dioscorea puber* (1220 µg /g d. wt.) followed by *Dioscorea spicata* (305 µg/g d. wt.), *Dioscorea hispida* (57 µg/g d. wt) and *Dioscorea hamiltonii* (3 µg/g d. wt.). Ozo *et al.*, (1984) reported the phenolic compounds Cyanidin-3-glucoside and the procyanidin dimmers B-1 and B-3 from *Dioscorea alata*. Hou *et al.*, (2000) reported that dioscorins present in *Dioscorea* species have potential to exhibit carbonic anahydrase and trypsin inhibitors activities. Okunlola and Odeku, (2008) evaluated as disintegrants in chloroquine phosphate tablet formulation in comparison with official corn starch. Again Okunlola and Odeku, (2009) reported the compressional characteristics and tableting properties of starches of *D. dumetorum*, *D. alata*, *D. oppositifolia* and *D. rotundata*. Behera *et al.*, (2010) estimated the diosgenin content in *D. bulbifera* (1383 mg) and *D. hispida* (825 mg). Avula *et al.*, (2012) reported 20 different types of steroidal saponins from *Dioscorea* species using UHPLC-QTOF-MS. Franklin *et al.*, (1966) reported the sapogenin in different *Dioscorea* species. Martin and Cabanillas, (1963) reported a precursor of cortisone and related steroidal drugs derived from *Dioscorea* species. Poornima and Ravishankar, (2009) reported the bioactive compounds in *Dioscorea belophylla* as saponins (18.46 mg / 100 g), alkaloids (0.68 mg / 100 g), flavonoids (8.84 mg / 100 g), tannin and phenols. Lkediobi *et al.*, (1988) reported acid phosphatase in the tubers of *Dioscorea* species. Many phytochemical studies revealed that purine derivatives, saponins, starches and mucilage are present as active constituents in *Dioscorea* species and allantoin, one of the purine derivatives which is well known as a biologically active compound, plays an important role in nitrogen storage (Yoon *et al.*, 2008). Zhang *et al.*, (2007) reported that many water soluble compounds which are not saponins, such as cyclo (Leu-Tyr) and adenosine are also present in *Dioscorea* species.

Pharmacological properties

Dioscorea species attribute anti-microbial activities due to the presence of secondary metabolites like steroid-saponins exerting a large variety of biological functions such as, anti-fungal, anti-bacterial and anti-cancer (Sautour *et al.*, 2004; Li *et al.*, 2001). Quan *et al.*, (2006) reported efficient anti-bacterial activity against *Bacillus subtilis* and *Staphylococcus aureus*. Araghiniknam et al., (1996) reported the antioxidant activity of *Dioscorea* and dehydroepiandrosterone activity in older humans. Sonibare and Abegunde, (2012) reported the antioxidant activity and their bioactive metabolites of *Dioscorea* species of Nigeria. Panduranga *et al.*, (2011) reported anti-inflammatory activity of ethnolic leaf extract of *Dioscorea hispida*. Liu *et al.*, (2006) reported antioxidant activities of *Dioscorea* species using DPPH radical, Hydroxyl radical scavenging activity assay and anti-lipid peroxidation test. Gao *et al.*, 2007 reported the anti-tumor-promoting effect found in the 75% ethanol

extracts of the rhizomes of *Dioscorea bulbifera* L. using the neoplastic transformation assay of mouse epidermal JB6 cell lines. Parkash and Hosetti, (2012) reported the antibacterial and antifungal activity of *Dioscorea pentaphylla* of Midmist-Western Ghats against 27 bacterial strains and 5 fungal clinical strains. Panduranga *et al.,* (2011) reported analgesic activity of ethnolic leaf extract of *Dioscorea hispida.* Maithili *et al.,* (2011) reported the antidiabetic activity of ethanolic extract of *Dioscorea alata* tubers in alloxan induced diabetic rats. Ghosh *et al.,* (2012) reported the antidiabetic potential of tubers of *Dioscorea bulbifera* L.

***In Vitro* culture of *Dioscorea* species**

In vitro plantlet regeneration for vegetative propagation of some economically important *Dioscorea* species has been achieved using nodal cuttings (Chaturvedi, 1975; Lakshmisita *et al*., 1976; Mantell *et al*., 1978; Alizadeh *et al.,* 1998; Yan *et al.,* 2002); bulbils (Asokan *et al.,* 1983), meristem tips (Malaurie *et al.,* 1995), immature leaves (Kohmura *et al.,* 1995) and roots (Twyford and Mantell, 1996). Regeneration of plantlet of *Dioscorea oppositifolia* through *in vitro* culture from nodal segments using MS medium containing 2.0 mg / l KINETIN + 1.0 mg / l BAP + 0.5 mg / l NAA + 100 mg / l ascorbic acid (Behera *et al*., 2009). Behera *et al.* (2008) reported the effect of plant growth regulators on *in vitro* micropropagation of *Dioscorea hispida* Dennst. Asha and Nair, (2007) developed a protocol for in vitro bulbil induction from single nodal segments in six *Dioscorea* species. Mahesh *et al.,* (2010) reported in vitro propagation of wild yam, *Dioscorea wightii* through nodal cultures. In vitro propagation of two wild yams, *Dioscorea oppositifolia* (Fig-3) and *Dioscorea pentaphylla* (Fig-7) is reported that multiple shoots were initiated in nodal explants on Murashige and Skoog medium supplemented with 8.8 µM 6-benzylaminopurine and 0.3 % activated charcoal (Poornima and Ravishankar, 2007). Shoot and root were produced from nodal explants with Murashige and Skoog (MS) medium supplemented with 0.5 mg / l 6-benzylaminopurine (BAP) and 0.1 mg / l NAA. Callus was successfully produced from leaf explants on Murashige and Skoog (MS) medium supplemented with 0.5 mg / l indole-3-butyric acid (IBA).Multiple shoots were initiated from callus in Murashige and Skoog (MS) medium supplemented with-2.0 mg / l Naphthalene acetic acid (NAA) and 2.5 mg / l kinetin. Root induction was achieved from the base of the shoots in the same medium (Maheswari *et al.,* 2012).

Conclusion

Dioscorea species are important wild tuber crops consumed by many rural and tribal communities as a food and medicine in Odisha. The study revealed their nutritional potential particularly during famine. The survey indicates that the consumption rate is very good and after some scientific changes they can be used as vegetables. They are rich in starch and carbohydrate. They have sound ethnobotanical values. The extracts of tubers are used against various skin infections and diabetes. However, there is lack of scientific reports on the pharmacological activity and nutritional values of these tuber plants. Further research is highly needed for using these tuber crops by the tribal communities for getting benefit for treatment of bacterial and fungal infections on one hand and on the other, to fulfill their supplementary food demand. Conservation, mass cultivation and commercialization of the tubers will lead to a greater economic revolution in the future for eradication of poverty, malnutrition and sustainable development.

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(+ + + + +: Most frequent, + + + +: Frequent, + + +: Less frequent)

Fig. 1: Distribution of *Dioscorea* species in selected districts of Odisha

Fig. 2*: D. puber*

Fig. 3: *D. oppsitifolia*

Fig. 4: *D. bulbifera*

Fig. 5: *D. alata*

Fig. 6: *D. hispida*

Fig. 7: *D. pentaphylla*

Plate.1: Common *Dioscorea* species available in Odisha