Chapter 4
Food, medicinal and ecological significance of *Dioscorea bulbifera* (Dioscoreaceae)

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Abstract: *Dioscorea bulbifera* is a is a wild edible tuberous twiner belonging to the family Dioscoreaceae. Tuber of *D. bulbifera* is supplement wild food crop, widely distributed around the world. It contains a significant amount of carbohydrates, starch, sugar, proteins, lipids, vitamins, minerals, fiber, etc. It is extensively used to treat diverse diseases and disorders. The tribal communities use the tubers of *D. bulbifera* as a source of nutrition. Considering its importance, an attempt has been made to document the morphological characters, ethnomedicinal, and food values of *D. bulbifera* to explore its nutraceutical values, which will be helpful during food crises.

Keywords: Dioscoreaceae**,** Food problem, Tuber, Ethnomedicine

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Introduction: Dioscoreaceae is a family of monocotyledonous flowering plants, comprising about nine genera with about 715 species, considered one of the earliest families of the plant kingdom (Adomenien and Venskutonis 2022). Species of this family have a mostly Pantropical distribution. The family as most recently described contains 4 genera: *Dioscorea, Stenomeris, Tacca* (previously classified in Taccaceae), and

Trichopus (sometimes classified in Trichopodaceae), which form a strongly supported monophyletic group. Several segregate genera have been merged into *Dioscorea* (Cardiak et al. 2002; Simpson 2010). The Dioscoreaceae consist of twining herbs or woody vines, rarely erect, small herbs. Root stock are rhizomatous or tuberous. Stem twining to left or right, pubescent or glabrous, sometimes prickly. Leaves are alternate or opposite, petiolate, simple or palmately compound, basal veins 3-13, interstitial veins reticulate; leaflets of palmately compound leaves are often ovate or lanceolate. The inflorescence is an axillary panicle, raceme, umbel, or spike of monochasial units (reduced to single flowers), with prominent involucral bracts in *Tacca*. Flowers are usually unisexual (when plants are dioecious, rarely monoecious), sometimes bisexual, solitary, clustered, or in cymules, these in a spike, raceme, or thyrse, these are sometimes grouped into panicles. The fruit is a capsule or berry, often winged, 1-3 locular at maturity. Seeds with a membranous wing or not (Chih-tsun et al. 1985; Simson 2010).

Dioscorea, the true yam, includes several economically important species, which are very important food sources in many tropical regions. It comprises about 650 species (Mishra and Kumar 2021) found throughout the Tropics and Subtropics, especially in West Africa, parts of Central America and the Caribbean, the Pacific Islands, and Southeast Asia with comparatively few taxa found in temperate regions (Maneenoon et al. 2008; Maurin et al. 2016). It has been a major food source for many tribal communities worldwide due to the presence of essential dietary nutrients. It is known for its association with low-cost food culture, traditional medicine, modern medicine and the pharmaceutical industries (Adomenien and Venskutonis 2022). They are the source of carbohydrates, fats, fibres, and proteins and also possess a rich amount of mineral nutrients including sodium, potassium, phosphorus, calcium, copper, magnesium, iron, and manganese. It shows diverse medicinal properties due to the presence of various secondary metabolites including alkaloids, carotenoids, flavonoids, glycosides, phenolics, steroidal saponins, sapogenins, tannins, terpenoids, diosgenin, etc (Waris et al. 2021; Kumar et al. 2017).

Among them, *D. bulbifera* is the most common species. It is also known as Air yam, Aerial yam, Bitter yam, Cheeky yam, Potato yam, Pita alu, Gosh alu, Mas alu, Tikor alu, Thaphumiyung-wablai, and Ruipan. It is a major staple food crop widely distributed around the world, native to Asia, Northern Australia, America and tropical Africa (Dutta 2015; Coursey 1967; Suriyavath & Indupriya 2011; Kumar et al. 2017). The tubers of *D. bulbifera* are bitter in taste and have a faint odour. It contains the highest levels of calcium, magnesium, sodium and zinc. Therefore, it is taken as the most preferred yam for the diet in comparison to other yam members (Anona et al. 2018).

Morphological characters of *D. bulbifera*: It is a climbing vine. The stem is glabrous and smooth and twins to the left. Leaves are alternate, simple; petiole 2.5-5.5 cm; leaf blade broadly cordate, 8-15 (-26) x 2-14 (-26) cm, glabrous, margin entire or slightly

undulate, apex caudate-acuminate. Bulbils are purplish brown with orbicular spots, globose or ovoid, variable in size.

Plate 1: Seedlings of *Dioscorea bulbifera*

Plate 2: Morphological variations in the leaf of *D. bulbifera*

Plate 3: Plant parts of *D. bulbifera*

Plate 4: Morphological characterization of flower and tuber of *D. bulbifera*

Figure 1: Bulbils of *D. bulbifera*, an edible part (Photo Credit: Nithiyananthan Sinnadorai)

Tubers are usually solitary, ovoid or pear-shaped, 4 -10 cm thick; cork black; roots fibrous. Male spikes are usually clustered in leaf axils or along leafless, axillary shoots, drooping, sometimes branched. Male flowers: solitary, ± contiguous along rachis; bract and bracteole ovate; perianth purple, lobes lanceolate; stamens 6, inserted at base of the perianth, filaments nearly as long as anthers. Female spikes often have 2 or more together, similar to male ones, 20-30 cm. Female flowers: staminodes 6, 1/4 as long as perianth lobes. Capsule reflexed or drooping, straw-coloured, densely purplish dotted, oblong-globose, 1.5-3 cm, glabrous, base and apex rounded; wings 0.25-0.7 cm wide. Seeds inserted near the apex of the capsule, dark brown; wing pointing toward capsule base, oblong, 1.2-1.6 x 0.5 cm. Flowering & fruiting: Jul- Nov (Chih-tsun et al. 1985; Kumar and Jena 2017; Plate 1-4; Figure 1).

Ethnobotanical and pharmacological values of *D. bulbifera*: It is extensively used to treat diverse diseases and disorders. The tuber of *D. bulbifera* is reported to have therapeutic benefits as purgative, anthelmintic, diuretic, rejuvenating tonic, aphrodisiac and can also be used for the treatment in hematological disorders, diabetic, worm infestations, hemorrhoids, skin disorders, general debility as well as polyurea. It is used to treat cough, epistaxis, goiter, hemoptysis, pharyngitis, skin infections, piles, throat infections and to remove dandruff (Guan et al. 2017; Kumar et al. 2017). In the Indian traditional medicine system, the leaves are used to treat various skin diseases and also used against diarrhoea, dysentery, throat infection, and

tuberculosis (Sharma and Bastakoti 2009; Panduraju et al. 2010; Lim 2016). The Bhoxa community in Dehradun, Uttarakhand uses the tuber against diarrhoea and dysentery (Gairola et al. 2013). The roasted and crushed tuber with salt is used for cough, piles, ulcers and syphilis. Crushed twigs and tender shoots are applied to hair to remove dandruff (Dutta 2015). In Bangladesh, it is extensively used to treat diverse diseases and disorders. The tuber of *D. bulbifera* is reported to have therapeutic benefits as purgative, anthelmintic, diuretic, rejuvenating tonic, aphrodisiac and can also be used for the treatment in hematological disorders, diabetic disorders, worm infestations, hemorrhoids, skin disorders, general debility as well as polyurea. It is used to treat cough, epistaxis, goiter, hemoptysis, pharyngitis, skin infections, piles, throat infections and to remove dandruff (Guan et al. 2017; Kumar et al. 2017). In the Indian traditional medicine system, the leaves are used to treat various skin diseases and also used against diarrhoea, dysentery, throat infection, and tuberculosis (Sharma and Bastakoti 2009; Panduraju et al. 2010; Lim 2016). Bhoxa community in Dehradun, Uttarakhand uses the tuber against diarrhoea and dysentery (Gairola et al. 2013). The roastedand crushed tuber with salt is used in cough, piles, ulcers and syphilis. Crushed twigs and tender shoots are applied to hair to remove dandruff (Dutta 2015). In Bangladesh, *D. bulbifera* is used in the treatment of tumors and leprosy (Murray et al. 1984). *D. bulbifera* is used in the treatment of tumors and leprosy (Murray et al. 1984). In Zimbabwe, *D. bulbifera* is used in wound healing (Mbiantcha et al. 2011). In Brazil and Java, it is considered as remedy against dysentery and diarrhea in addition to syphilis, while for treatment of abscesses, boils, and wound infections in Cameroon and Madagascar (Cogne, 2002; Mbiantcha et al. 2011). Crushed tubers and decoction are emulsified into oil to treat infected ulcers and sinuses (Subasini et al. 2013; Tang et al. 2006). In Uganda, tubers are boiled and consumed by local people to treat HIV patients (Kundu et al. 2020). In the Republic of Congo, the raw bulbil of *D. bulbifera* is used and applied to cure ringworm (Terashima et al., 1985). In Chinese medicine, it is used as a remedy for sore throats, struma, gastric cancer, carcinoma of the rectum, goiter, food poisoning, and used against dog bites, and snake bites (Adeniran and Sonibare 2013; Ghosh et al. 2015). *D. bulbifera* exhibits variation in the phytochemical diversity depending upon its geographical location, parts of a plant and the extraction solvents used. It shows the presence of saponins, tannins, flavonoids, sterols, polyphenols, glycosides etc. (Ikiriza 2019). These bioactive compounds might be responsible for the above therapeutic claims. alarming

Food values: World population continues growing at rate and creating food problems throughout the world. So now, food security is an important aspect of every developing nation in the process of achieving sustainable development. Yam (*Dioscorea* species) are important species, distributed globally and has contributed enormously to food security especially in Sub-Saharan Africa because of its role in providing nutritional along with economic benefits (Obidiegwu et al. 2020). *D. bulbifera* is the most preferred yam for its nutritional content.

Figure 2: Consumption of *Discorea bulbifera* tubers

It is not a popular yam among the edible yam species. Tribal communities near forests use this yam as a food source but it is yet unexplored in urban areas. It is consumed by a small number of communities and is generally underutilized both at subsistence and commercial levels (Igyor et al. 2004). The tribal communities use the tubers of *D. bulbifera* as a source of nutrition, especially in food crises, and as a nutritional aid to a regular diet. These tubers are also found in the local markets for sale during the early summer season (Ojinnaka et al. 2017). In many parts of India, these tubers are also eaten raw or after successive boiling to enhance the appetite. Tubers are roasted and also cooked as a vegetable (Dutta 2015; Kumar 2015; Kumar 2017; Figure 2). The bioactive compounds present here, offer numerous health benefits ranging from prevention to treatment of degenerative diseases. It contains a high level of primary metabolites including carbohydrates, starch, sugar, proteins, lipids, vitamins, minerals, fiber etc. it was reported that *D. bulbifera* contains the highest percentage of crude fiber and highest amounts of cellulose and hemicellulose (Abara et al. 2011). A study was carried out to investigate the cell wall carbohydrates of 43 genotypes from five yam species *(D. rotundata, D. alata, D. bulbifera, D. cayenensis* and *D. dumetorum*) using detergent system analysis and recorded the highest cell wall carbohydrate in *D. bulbifera* at 2.1%, 3.2% and 1.1% for hemicelluloses, cellulose, and lignin, respectively (Otegbayo et al. 2018). The tuber of *D. bulbifera* is a good source of essential amino acids like phenylalanine and threonine along with necessary minerals (Ezeocha et al. 2014; Shajeela et al. 2011; Soto et al. 2014; Obidiegwu et al. 2020). In the case of iron

content, *D. bulbifera* also stands as a good source of iron (Otegbayo et al. 2018). *D. bulbifera* is more potential for diabetic patients and people with other health conditions like obesity, since they are more nutritious and less sweet. The leaves are used as a staple food for hunter-gatherers living in the forest such as Pygmies in Central Africa and Abayanda in Uganda, leading to the near extinction of this climber (Okeke et al. 2008; Ikiriza 2019).

Conclusion: Food is a basic human right. A sustainable and secure food chain is required to solve the world's food problems. If more poor people and farmers are engaged in all aspects of the effort to gain food security, the more they are energized in the process, the greater the chance of attaining lasting food security. The above discussion indicates that the tuber of *D. bulbifera* has significant proximate content with a good amino acid profile, a significant amount of minerals plus vitamins, and also has a richness in phytoconstituents. It could be a better option for our dietary system and for economic purposes as well. To encourage this crop, there is a need to enlighten the local inhabitants on its food, clinical and commercial importance and uses. Also, for the sustainable growth of this crop, the Government and Non-Governmental organizations should have to distribute the bulbils to the farmers for planting and also encourage its planting back into the wild. In addition to this, micropropagation of the *D. bulbifera* will be the perfect course of action to re-naturalize the plant in its own habitat with more purpose.

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