

Chapter 2

Dioscorea pentaphylla: A pharmacological agent

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Abstract: *Dioscorea* species are not fully explored. It is the most important genus of the family Dioscoreaceae having excellent medicinal and nutritional properties. Authors have made an attempt to explore *D. pentaphylla* in various aspects (food, medicinal, economic & pharmacological). The bioactivities and health benefits of *D. pentaphylla* extracts have been related to the presence of phytochemicals, which possess antioxidant, antitumor, antifeedant, antigenotoxicity, antimutagenic, anticancer activity etc. In Ayurveda, whole plant juice is used to treat boils. As we are now living in an era where people around the globe are suffering from untreatable infectious diseases because of the emergence and spread of antimicrobial resistance, the ethnobotanical properties of this tuberous plant have generated further interest in studying on *D. pentaphylla* plant parts for validating the efficacy as a nutraceutical.

Keywords: Microbial resistance, *Dioscorea*, Ethnobotany, Pharmacological activities

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Introduction: Antimicrobial resistance (AMR) - a process in which microbes (bacteria, parasites, viruses, and fungi) develop the capacity of resistance against antimicrobial drugs, commonly used to treat infections (UNICEF 2019; CDC 2019). Antibiotics are one of the most powerful tools for fighting life threatening infections and without effective antibiotics or antimicrobial drugs, common infectious diseases are more difficult to treat, leading the individual sick for a longer period and also leading to death (Cesur and Demiroz 2013). Resistant organisms thrive globally and are transmitted to and from healthy humans, animals and the environment. In addition, antimicrobial resistance often occurs through the inhibition of specific pathways such as cell wall synthesis, nucleic acid synthesis, ribosome function, protein synthesis, folate metabolism, and cell membrane functions (Ayukekbong et al. 2017; Fluit et al. 2001. Kohanski et al. 2010). Common diseases, such as urinary tract infections, respiratory tract infections, and sexually transmitted diseases are becoming untreatable. Lifesaving medical procedures are becoming more dangerous due to the risk of infections caused by drug resistant pathogens. Unfortunately, the antimicrobial resistance (AMR) is expanding at an alarming rate and the situation is perhaps aggravated in developing countries due to gross abuse in the use of antimicrobials. The magnitude of the problem worldwide and the impact of AMR on human health, on costs for the healthcare sector, and the wider societal impact, are still largely unknown (CDC 2019; Ikhimiukor et al. 2022). The extensive, inappropriate, irregular, and indiscriminate uses of antibiotics have resulted in the emergence of antimicrobial resistance, failing medical sciences (Davies and Davies 2010; Baym et al. 2015). Therefore, WHO started isolating and identifying new bioactive compounds from the plants which act against microbial resistance, capable of decreasing the use of antibiotics, and face resistance development (WHO 2014; WHO 2021). There are about 1340 plants available with defined antimicrobial properties and over 30,000 antimicrobial compounds have been isolated from plants (Tajkarimi et al. 2010; Vaou et al. 2021) among which 74% of compounds are derived from the plant based which show ethnomedicinal uses (Pandey and Kumar 2013; Vaou et al. 2021). Many wild plant species have been reported to have antimicrobial properties but still, number of plants are unexplored and need more research and exploration work. It includes many tuberous plant species, especially the Yam or *Dioscorea* species, used by the tribal and rural communities for the preparation of various drugs against healthcare problems (Tabassum and Hamdani 2014; Kumar et al. 2017; Kumar et al. 2022). These are the tuber crops used as a food item among the tribal groups which are cultivated in their home gardens or harvested from wild. *Dioscorea* produces rhizomes or bulbils, which are rich with food, medicinal and economic values. They contain various bioactive compounds like saponins, alkaloids, flavonoids, tannins, phenols, diosgenin, corticosterone, stigmasterol etc. which make it potential against various ailments and of great market value as well (Mustafa et al. 2018). Among the *Dioscorea* species, *D. pentaphylla* is one of the easily available tuberous plants, used by many tribal communities as food and also as medicine (Kumar et al. 2012). Tubers of *D. pentaphylla* attribute antioxidant activity and antimicrobial activities due to the expression of

browning properties and the presence of secondary metabolites in them (Kumar et al. 2017; Kumar 2017; Kumar and Jena 2017).

Morphological characters of *D. pentaphylla*: *D. pentaphylla* (Dioscoreaceae; common name- five leaf yam, Kanta alu, Phal alu, Panja sanga) is a tuberous monocot prickly vine bearing aerial bulbils. It may reach up to 10 m in length. It is left twining, slenderer climber, more or less prickly below, 3-5 foliate leaves up to 10 cm long. Leaves are glabrous/ pubescent beneath, alternately arranged. Leaflets of lower leaves are rarely larger, center ones are obovate or elliptic, suddenly cuspidate or acuminate, cuneate towards the base. The plant produces horseshoe-shaped bulbils. Axillary racemes and sometimes terminally paniced, or the axillary racemes are sometimes branched. The Spike of the female flower is long and solitary or rarely paniced. Capsule is large, oblong and deflexed. Bulbils are elongate obpyriform. Tubers are oblong or clavate, proceeding directly from the base of the aerial stem and thickening downwards (Gucker 2009; Kumar et al. 2013; Plate 1). It is native to Bangladesh, Borneo, Cambodia, Caroline Island, China South-Central, China Southeast, East Himalayas, Hainan, India, Jawa, Laos, Lesser Sunda Island, Malaya, Maldives, Maluku, Myanmar, Nepal, New Guinea, Philippines, Queensland, Sri Lanka, Sulawesi, Sumatera, Taiwan, Thailand, Tibet, Vietnam and West Himalayas (Kumar 2017).

Food values: The tribal communities of Odisha state collect the tubers from the forest and leave overnight in running water like stream and then boil it. The boiled tuber is consumed raw or cooked as a vegetable (Present study).

Ethnomedicinal uses: Tribal and rural people use the tuber and leaves of *D. pentaphylla* to treat diverse diseases and disorders. Tuber of *D. pentaphylla* is used in skin infections by the Santhal community. They apply the macerated tuber paste externally on lesions to treat the infections. They used to eat the boiled tuber as a vegetable to reduce poor appetite twice a week. The fresh tuber is crushed with water and the paste is applied externally to cure cuts and wounds. In Mankidia community they boil the tuber (Approx 250 g) with about 1 lit of water and prepare the juice. One cup of juice with salt is taken thrice a day to get cured from cold and cough. Ho community use boiled tubers as chips to cure stomach pain and constipation problems. Leaves paste is made with Karanja oil (*Millettia pinnata*) and is rubbed on joints to reduce joint pain by Munda community (Present study; Kumar et al. 2013). Santhal, Bathudi, Munda, Mankadia, and Ho communities of Mayurbhanj district of Odisha state also use the boiled tubers as vegetables.



Plate 1: Habit and habitat of *Dioscorea pentaphylla*

Uses in Indian Ayurveda: *D. pentaphylla* is also used in Indian Ayurveda in various compositions to cure diverse diseases and disorders. Whole plant juice is used to treat the boils and decoction of the whole plant is used to cure swelling. Modern herbalists use wild yam to treat intestinal colic, biliary colic, flatulence, menstrual cramps, and rheumatoid arthritis (Prakash and Hosetti 2012). Herbalists combine *D. pentaphylla* with black cohosh (and sometimes burdock root and motherwort) for rheumatic complaints. Some herbalists use *D. pentaphylla* as a tonic (Prakash et al. 2014). The decoction of the tuber of *D. pentaphylla* is given to animals for early recovery of fractured bones (Horrocks and Bedford 2010). *D. pentaphylla* is also used for curing skin infections, abdominal pain, and birth control (Kumar et al. 2017). Powder of the whole plant of *D. pentaphylla* is given orally to cure abdominal pain after delivery (Islam et al. 2018). Paste of tuber is applied to swelling of joints. Tuber paste is given to cattle when they become sick (Present study). Inflorescence is used as vegetables for body weakness (Gavad and Khade 2021).

Phytochemicals present

Phytochemical screening of *D. pentaphylla* reveals that it contains alkaloids, carbohydrates, tannins, gum proteins, steroids, glycosides, flavonoids, phenols, saponins, diosgenin etc (Islam et al. 2018). Reports are showing the presence of tannins and saponins in *D. pentaphylla* which are responsible to cure skin infections. Alkaloids and flavonoids present in this plant are responsible for antifungal activities and responsible to cure cuts, wounds, and joint pain. Diosgenyl saponins are one of the most abundant steroid saponins reported from the tuber of *D. pentaphylla*. Diosgenin is also reported from its tuber having diverse pharmacological values (Li et al. 2001; Prakash and Hosetti 2010; Kumar et al. 2013).

Antibacterial activities of *D. pentaphylla*: Species of *Dioscorea* genus are rich with diverse bioactive compounds which might be responsible for the antibacterial activities. Prakash and Hosetti (2010) reported antibacterial activities of *D. pentaphylla* using petroleum ether, chloroform and ethanol extracts. The petroleum ether extract demonstrated good antibacterial activity against all the clinical strains of bacteria. It showed maximum activity against *S. aureus* (16.13 mm) followed by *P. aeruginosa* (12.30 mm), *K. pneumoniae* (12.23 mm). Chloroform extract showed the least inhibition activity against all the strains of bacteria. Ethanol extract showed a significant inhibition zone as similar to standard. Ethanol extract illustrated the inhibition zone against *S. aureus* (20.63 mm), *P. aeruginosa* (20.50 mm) and *K. pneumoniae* (19.26 mm). In 2013, Kumar et al. studied the antimicrobial activity of *D. pentaphylla* tuber and reported that the acetone, methanol and aqueous extracts of tuber showed a significant zone of inhibition (cm) against *Vibrio cholerae* (MTCC 3906), *Shigella flexneri* (MTCC 1457), *Salmonella enterica typhi* (MTCC 1252), *Streptococcus pyogenes* (MTCC 1926) and *Streptococcus mutans* (MTCC 497). It has been observed that methanol and acetone extract was found to be active against Gram negative bacteria *Vibrio cholerae* (MTCC 3906). According to Kumar et al. (2017), the results of disc diffusion assay of

D. pentaphylla revealed that the methanol extract showed the highest zone of inhibition followed by acetone and aqueous extracts. It was also noted that the highest inhibition was exhibited by methanol extract of *D. pentaphylla* tuber against *S. pyogenes*. All three extracts were having excellent inhibitory effect, so the tuber extracts might be quite effective in controlling the diseases caused by *V. cholerae*, *S. typhi*, *S. flexnerii*, *S. mutans* and *S. pyogenes* (Kumar et al. 2017).

Antifungal: Antibacterial activities of *D. pentaphylla* tubers showed that the tubers might have antifungal activities too. In 2012, Prakash and Hosetti studied the antifungal activity of *D. pentaphylla* and reported that the petroleum ether extract showed maximum activity against *M. audouini* (14.42 mm) when compared to standard. Chloroform extract showed the least inhibition activity against all the strains of fungi that is 16.23 mm against the fungal strain *T. tonsurans*. Whereas, the ethanol extract showed a significant inhibition zone similar to standard. Ethanol extract illustrated an inhibition zone against the fungal strains of *M. gypseum* (20.37 mm) and *C. albicans* (18.13 mm).

Other pharmacological activities: Along with the antibacterial and antifungal activity, *D. pentaphylla* also possesses various pharmacological activities due to the presence of diverse phytochemicals or bioactive compounds. They are known to possess antitumor, antifeedant, antigenotoxicity, antimutagenic, antioxidant and anticancer activity (Prakash et al. 2014; Kumar et al. 2017).

Future aspects: As the *D. pentaphylla* mentioned above has so many ethnomedicinal, ayurvedic, pharmacological as well as food values, it needs to be validated and detailed investigations on the composition and pharmacological significance of this medicinal wild tuberous plant with the standardization of the formulations should be undertaken extensively. The plant is found to be rich in alkaloids, carbohydrates, tannins, gum proteins, steroids, glycosides, flavonoids, phenols, saponins and diosgenin etc. Need authentication of all the secondary metabolites by advanced analytical techniques to validate their quality and for conforming their biological potentials. As it contains diosgenin, it could be used in the synthesis of steroidal drugs, however other potential uses of these compounds and related compounds as antitumor, antifeedant, antigenotoxicity, antimutagenic, antioxidant and anticancer potential need to be studied extensively. Further studies are also required to conduct against various issues regarding the composition of the extracts used, explicability of the preclinical experiments and lack of conversion of the preclinical results to clinical effectiveness. Attempts should also be made to conduct serious human trials to determine the mechanism of action, bioavailability, and physiological pathways for various types of bioactive compounds present in the plant for their potential applications in drug discovery and for curing various life-threatening diseases. Studies should also be carried out to utilize the bioactive compounds present in the tuber of *D. pentaphylla* for the formulation of new drugs to fight against pathogenic multidrug resistant microorganisms (Illustration 1).

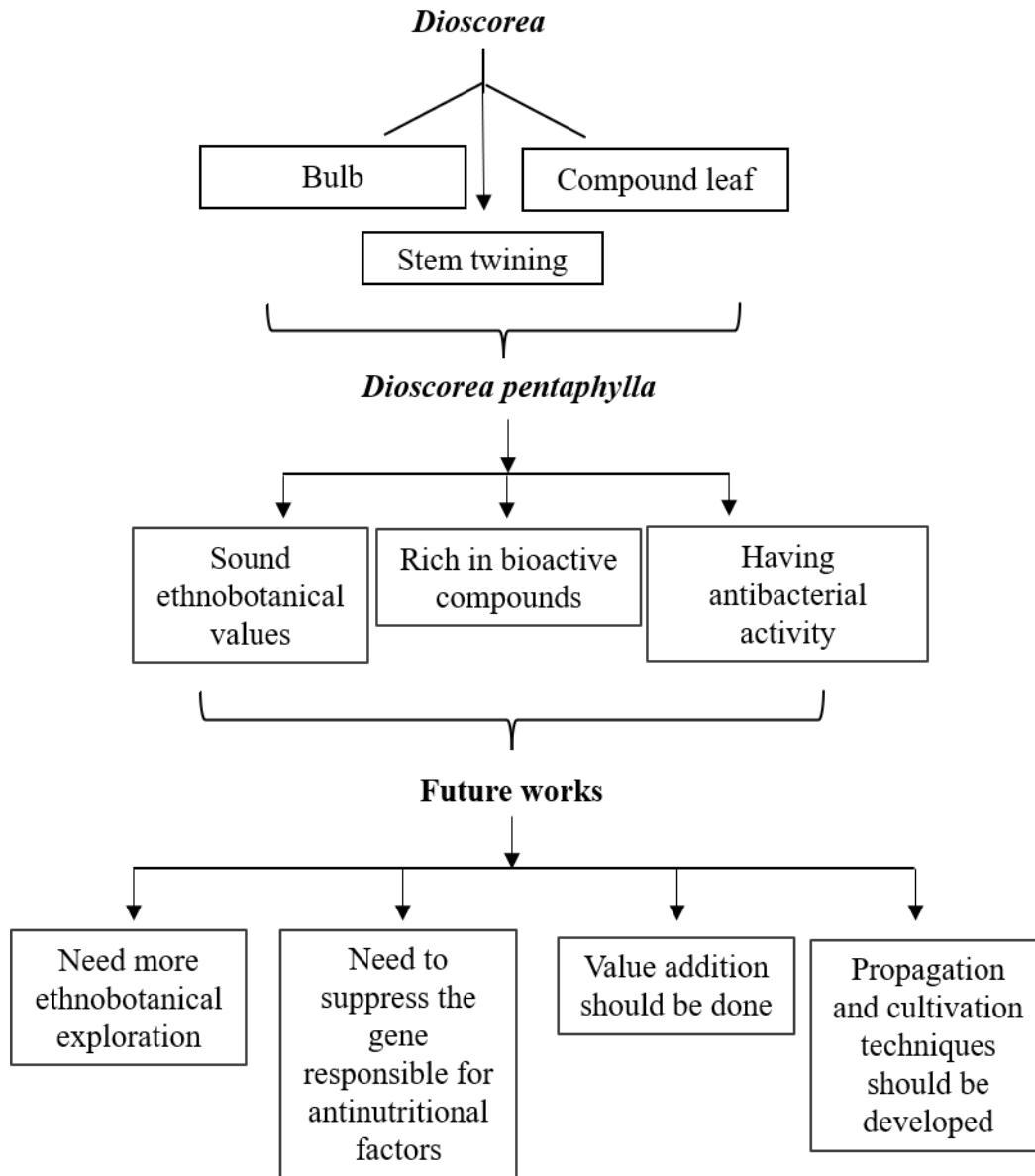


Illustration 1: Identification, uses and future aspects of *D. pentaphylla*

Conclusion: Plants as dietary sources are known to have several chemoprotective agents. *D. pentaphylla*, a wild tuber crop is one of them often used as edible food with various ethnomedicinal uses among rural and tribal communities. The presence of bioactive compounds has shown the potential as antibacterial, antioxidant, anticancer and other pharmacological actions of this wild tuber. The consumption of these tuber crops might play a vital role in preventing human diseases in which free radicals are involved, such as cancer, cardiovascular diseases and ageing. For follow up research, it is needed to determine the active components in each extract and confirm their mechanism of action.

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