YAM

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MESSAGE

The use of herbs as a medicine has a very long historical background corresponding to the Stone Age. In this modern era, the world's populations are facing many health issues, therefore they want to connect with mother nature which is a rich source of medicinal herbs. The high demand for plant-based medicine, food, and nutrition supplements are attracting many researchers to think about it. Here ethnobotany plays an important role in helping mankind to get familiar with the unexplored medicinal plant and helps many people economically sustainable. In this scene the book **YAM** is an exceptional documentation on tubers plant having different domains of its use as food, medicine and nutraceutical. I congratulate **Dr. Jaydeep Kumar Sahu,** Associate Professor**,** Sri Sri College of Ayurvedic Science & Research Hospital, Sri Sri University, **Dr. BL Manjula**, Associate Professor**,** SJR College, Bangalore, **Arvind Kumar**, Assistant Professor, LND College, Motihari, **SS Dash**, PhD Scholar, CUTM, Odisha and **Dr. S. Kumar**, CEO, APRF, Odisha and all the authors of the chapters of this book for their sincere efforts.

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This book is going to be a great contribution to humankind and scientific community. It will be helpful to bring attention on different yam species, their food values, medicinal values and ecological importance. It will be very helpful to focus on cultivation of tuberous crops and their use as a food supplement in our day-to-day life, to mitigate food scarcity and as well as a nutraceutical.

Ilarani Pradhan

The book YAM will be very helpful in developing the functional foods for the urban food basket.

Sanjeet Kumar

Yam is a lovely addition to ethnobotany.

Arvind Kumar

Eating Yam, a nutraceutical, as a snack instead of junk food avoids health issues among people.

B. L. Manjula

YAM will ignite new researchers to focus on tubers having potency of food, medicine and nutraceuticals

Jaydeep K Sahu

FOREWORD

Why we are facing malnutrition, infectious diseases and pandemics like COVID-19 ? We have advanced technologies to fight against diseases, disorders, pandemics, new lethal infectious diseases, and many other food & healthcare related problems. Even having such technologies as a panacea, most of the time, in most of the places of the world, we become silent in front of the above global problems. Solution is hidden in our rich culture, indigenous practices, ancient therapeutic systems, and medico-seasonal food of our ethnic communities. We must change ourselves as soon as possible and must readapt our ancient living styles, food behaviors in metallic cities. Still, we have time for the change but the problem is we have forgotten the indigenous practices and food behaviors. If we are not going to wake up now also, some edible & medicinal plants are going to extinct even from the rural and tribal kitchen and therapeutic practices respectively. The adaptation of our ancient behaviors is not only important for our health but it is very necessary for the sustainability of life on earth when we are facing climatic changes and other negative environmental actions. Therefore, the documentation of less known practices, medicinal plants, food plants, indigenous traditional knowledge on different aspects and hidden medico-food is very important to get life on track. Among the less known plant species, tuberous plants, particularly yam species (genus *Dioscorea*) play a vital role in providing food, medicine and in maintaining the ecological balance of the forest. The book – Yam brings attention on the importance of yam as underutilized tuberous plant and their uses in past, present and future. The chapters included in the book, give a clear

idea about their identification, ecology, distribution, food, medicinal, pharmacological, and economic values of 8 underutilized yam species. Among the discussed 8 yam species, *D. alata* is a commonly available and widely distributed species in India. It has a sound food and medicinal values along with sociocultural significance but not much known in urban areas and in city life. Palatability of this yam is good, useful as a cooling agent and good for diabetics. Rest 7 yam species discussed in different chapters grow in wild and have less palatability. They have some antinutritional factors but are widely used as a medico-food by the local communities of India. They follow traditional practices to remove the toxic components before consumption.

The information provided on the yam in 9 chapters of the book could be used as a baseline data for the future advance research in food biology and development of functional food. It also provides an idea for the formulation of therapeutic agents against diverse diseases and disorders. In addition to the food and medicinal values, the last chapter gives us an information about the plant-animal relationship and could be useful in wildlife management in Indian forest.

(Sanjeet Kumar)

PREFACE: FROM THE COORDINATING EDITOR

In this modern world people are forgetting the traditional food being used by our forefathers since ages, which were nutritionally more superior and healthy than processed food that are being widely consumed now a days, which are causing diseases.

This book- "**YAM**" is an attempt made by the editors & authors to explore the little-known perennial herbaceous vine of tropical and sub-tropical climate namely **Yam** (*Dioscorea sp*.). The different species of this plant that has been described here possess many nutritional and medicinal properties that make them a prospective nutraceutical plant.

This is a collaborative research book by Ambika Prasad Research Foundation in which various authors have tried to understand the morphological, nutritional, ethnobotanical, and medicinal characteristics of about eight species of the genus *Dioscorea* (Family-Dioscoreaceae).

This book will be helpful to the students, faculty and researchers interested in knowing about plants giving alternative food choices to the people. They will also become aware of the various tribal uses of Yam. This book has been written with the help of both previous literature as well as ethnobotanical field studies. Although further studies and research work is needed, this book will certainly raise an interest on this hitherto little known tuberous plant.

(Arvind Kumar)

INTRODUCTION

Cereals and vegetables are rich with primary metabolites & minerals. They provide abundant calories and nutrients. Many people, especially urban population subsist on monotonous cereal diets and even ignore seasonal foods and are therefore nutritionally deprived even if they eat sufficient calories. Increasing the use of chemical fertilizers & GMOs (Genetically modified organisms) in global and regional level are the major challenges for researchers along with frequent climatic changes in a landscape. Another global issue is effect of drug failure due to antimicrobial resistance. Therefore, for mitigating these problems, we should focus on underutilized species that have regional significance, food-medicinal values, scope of value addition & global marketing, especially for small scale farmers & communities which are neglected on global scale. The neglected wild food plants which could be future crops are often overlooked by researchers due to lack of knowledge, despite valuable traits that are promising for emerging markets. They have sound nutraceutical values which could improve and diversify our diets and improve immunity as well. Yam is such a food plant which comes under neglected wild & cultivated foods. The tubers of yam are highly nutritious and contain health promoting secondary metabolites which provide additional health benefits such as regulation of blood sugar, act as a tonic for getting good health, control cholesterol, reduce complications of diabetes, act against infectious diseases and many more. Yam has been used as a traditional food since a long time but it is almost unknown to the rural & urban world. Therefore, we started this project under entitled "YAM" and gathered the researchers from different states of India to document the yam (genus *Dioscorea*) species and their uses, significance & predication of future aspect along with identification keys. We have documented here selected yam species in Volume I. Photographs are also provided in the chapters for the easy identification in the field so that the researchers can collect the species for research and other purposes. The book will be helpful to mitigate the problems of food, medicine, and climatic changes. Details about the yam is provided in the chapters.

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Chapter 1
Dioscorea dumetorum (Dioscoreaceae)

Arvind Kumar, Sweta Mishra and Sanjeet Kumar

Abstract: Yams (*Dioscorea* spp.) constitute a staple food for over 300 million people in the humid and sub humid tropics. About 650 species of *Dioscorea* are described and widely distributed. *Dioscorea dumetorum* (Kunth) Pax., is one of the highest nutrient values containing yam species commonly found in India. The tuber of *D. dumetorum* is used as nutritional food and medicine among tribal communities. The information on *D. dumetorum* is scanty in literature. Therefore, an attempt has been made to document the taxonomic characteristic, habitat and uses for further research and development work. The chapter highlights the importance of an unexplored wild tuberous species.

Keywords: *Dioscorea*, Wild edible tuber, Ethnopharmacology, Unexplored plants

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Introduction: Survey and exploration of plant wealth and study on medicinal plants is conducted throughout the world, still there are number of unexplored medicinal plants available which need much detailed studies. However, with the huge availability of millions of plant species on the earth, there is always a possibility for the exploration of plants with tremendous beneficial effects. The correct identification,

isolation, identification of active principles and pharmacological studies of the active phytoconstituents of these unexplored plants may be considered and studied elaborately in order to be employed in the treatment of various diseases and disorders (Adhami et al. 2018). Exploration of wild edible plants is very crucial as they play an important role in the livelihood strategies of rural and tribal people in most of the developing countries. There are a large number of wild relatives of cultivated tuber crops available which are under exploited and known to tribals. These wild tuber crops are used as an alternative to staple food during food scarcity (Kumar et al. 2012). Wild tuberous plants contain their special storage organs like true bulb, corm, tuber, tuberous root or rhizome, which are the storehouse of carbohydrates (Sundarial and Sundarial 2001; Rana et al. 2007). They are also a source of some of the active ingredients in modern pharmaceuticals (Kumar et al. 2013a; Kumar et al. 2013b). However, the active compounds, proper methods of preparation, dosages, effectiveness, and side effects of medicines prepared from these tuberous plants have not yet been studied extensively (Christopher et al. 2002).

Most of the species belonging to the genus *Dioscorea* are unexplored from Dioscoreaceae family. It is also an important wild tuberous plant that serves as a staple food and medicine. These are herbaceous vines with twine. Approximately 650 *Dioscorea* species are reported from various parts of the world (Agbor-Egbe and Treche 1995). The tubers are highly rich in starch and show cultural, economic and nutritional importance in the tropical and subtropical regions of the world (Coursey, 1967). Wild species of *Dioscorea* have some toxic compounds which make them less palatable and sometimes cause health problems like vomiting and diarrhoea when a large amount is consumed without proper processing or if eaten raw (Webster et al. 1984; Anthony 2004; Kumar and Jena 2014; Kumar et al. 2015; Kumar 2015). The processed tubers contain a good proportion of essential amino acids and many dietary minerals that are good for health and also to boost immunity (Shanthakumari et al. 2008; Alozie et al. 2009; Arinathan et al. 2009; Shajeela et al. 2011). Among the unexplored species of Yam, *D. dumetorum* is native to tropical Africa and found in wild as well as in cultivated form (Siadjeu et al. 2015). It is commonly known as trifoliate yam and has not been widely studied as other species (Martin et al. 1983; Owuamanam et al. 2013; Mishra and Kumar 2021). Agronomically, *D. dumetorum* is a high-yielding climber under traditional farming. Farmers used to describe this plant that produces round or elongated, yellow-fleshy gray-skinned, and smooth tubers with a few rootlets at their head (Laly et al. 2019; Mishra and Kumar 2021).

Taxonomic characteristic of *D. dumetorum*

Habit & tuber: Large woody climber. Tubers are spheroid, and consist of 3 spheroid-shaped tubers, whitish with many fibrous roots, sometimes tubers are in cluster of 3-5 **(**Mishra & Kumar 2021; https://powo.science.kew.org; Plate 1-2).
Stem: Left twining stem up to 10 m, velvet, and beset sparsely or rather densely with prickles, up to 2 cm in diameter, prickles 1-3 mm long, towards gravity.

Leaves: Leaves alternate, 3-foliolate, 5 to 6 costae, large up to 25 cm, green, petiole up to 20 cm long, pubescent, usually with a few scattered prickles, leaflets with petiole up to 10 mm long, pubescent, glabrescent above, rarely sparsely hirsute beneath hairy and sometimes purple dotted structure observed, median leaflet obovoid, acutely acuminate, cuneate or rounded at the base and conspicuously 3-nerved from just above the base (Present study).
Inflorescence: Male inflorescence paniculate, the ultimate branches spreading in all directions forming dense subsessile cylindric spikelets up to 15 mm long, subsessile or on peduncles up to 5 mm long; bracts broadly ovate, adpressed to the perianth and partly concealing it, densely pubescent; perianth subglobose, glabrous, with the 3 inner segments ± 1 mm long and the 3 outers considerably smaller and thinner. Stamens 6. Female inflorescence pendulous, spicate, 5–10 cm long, with the flowers close together at first, the internodes elongating greatly in age; flowers directed downwards; perianth depressed sub-globose, ± 2 mm in diameter, pubescent; lobes subequal. Ovary ± 7 mm long and densely pubescent (Present study).
Fruit & seed: Capsule, long, rather sparsely pubescent. Seeds are long, with the wing on the basal side only.
Habitat: It is commonly found on the edges of lowland rainforests, dry evergreen forests, dry deciduous forest, moist deciduous forest, evergreen bushlands, near bamboo species and water bodies.
Distribution: India, Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Gulf of Guinea Island, Ivory Coast, Kenya, Malawi, Mali, Mozambique, Nigeria, Northern Provinces, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Togo, Uganda, Zambia, Zaire and Zimbabwe (https://powo.science.kew.org).

Food values: Tubers of *D. dumetorum* are used as a nutritional food by the tribal communities. They are rich with starch and other metabolites (Afoakwa and Dedeh 2001). Their storage under tropical conditions makes them susceptible to a hardening phenomenon characterized by loss of the ability to soften during cooking (Alozie et al. 2009; Siadjeu et al. 2015). In 1994, Lape and Treche studied the nutrient content of *D. dumetorum* flour and reported the digestibility of available carbohydrates. The carbohydrate of the raw *D. dumetorum* flour is as digestible as that of the instant flours from boiled or steamed tubers. Otegbayo et al. (2018) reported the iron content in *D. dumetorum* between 1.1 to 3.9 mg per 100 g. Otegbayo et al. (2014) reported the range between 15.1% and 27.0% for amylose content in *D. dumetorum* (Otegbayo et al. 2020). In 2016, Akinoso et al. reported that noodles are prepared from *D. dumetorum* flour and wheat flour are able to reduce the malnutrition in rural areas.

Plate 1: Habit, stem twining and habitat of *Dioscorea dumetorum*

Plate 2: Vegetative parts of *Dioscorea dumetorum* (Leaves, Seeds and Tubers)

Ethnobotanical values: *Dioscorea* species are used to cure many diseases and disorders globally. *D. dumetorum* leaves paste is used to cure skin infections in Odisha, India (Present study). In West Africa, the tubers are used in the treatment of diabetes and to make arrow poison (Corley et al. 1985). The tuber of *D. dumetorum* is also used in the treatment of jaundice (Ghosg et al. 2013; Mustafa et al. 2018).

Pharmacological values: *D. dumetorum* is not only used for human consumption but also for various pharmaceutical purposes (Kumar and Jena 2017; Kumar 2017; Kumar et al. 2017b; Kumar et al. 2017c). Kumar et al. (2017a) reported that tubers are possible sources of antimicrobial & antioxidant agents due to richness of phenolic contents (Swain et al. 2020). Another Nigerian study also reported flavonoid content as well as the associated antioxidant activity in *D. dumetorum* (Ukom et al. 2014). Some novel bioactive compounds like dioscorine, dioscoretine has been detected from *D. dumetorum* (Iwu et al. 1990; Price at al. 2016), which can be used advantageously as a hypoglycaemic agent to reduce the blood sugar level in situations of acute stress (Sonibare et al. 2010). Due to its hypoglycemic effect, *D. dumetorum*, plays an active role in the treatment of diabetes. It is also reported that the aqueous extract of *D. dumetorum* tuber, known for its alkaloid (dioscoretine) content which could control hypercholesterolemia, hyperlipidemia and hyperketonemia (Malviya et al. 2010). Onuegbu et al. (2011) discussed on its industrial applications as a source of pharmaceutical agent.

Conclusion: Trifoliate yam or bitter yam (*D. dumetorum*) is an under-exploited but high yielding and nutritious yam species. From the present study, it was noted that though having rich primary & secondary metabolites, it is an unexplored tuberous plant of the genus *Dioscorea*. Therefore, there is an urgent need to do exploration works on its traditional uses as food and medicines and experimental works on the food chemistry and pharmacological values. Cultivation should be encouraged as it also provides a high yield.

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Chapter 2
Dioscorea pentaphylla (Dioscoreaceae): A pharmacological agent

BL Manjula, Sweta Mishra, Meenu E Benny and Sanjeet Kumar

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, slender 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 panicled, or the axillary racemes are sometimes branched. The Spike of the female flower is long and solitary or rarely panicled. 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, South Central & South East China, 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 the treatment of skin infections by the Santhal community. They apply the macerated tuber paste externally on lesions to treat the infections. They 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). 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).

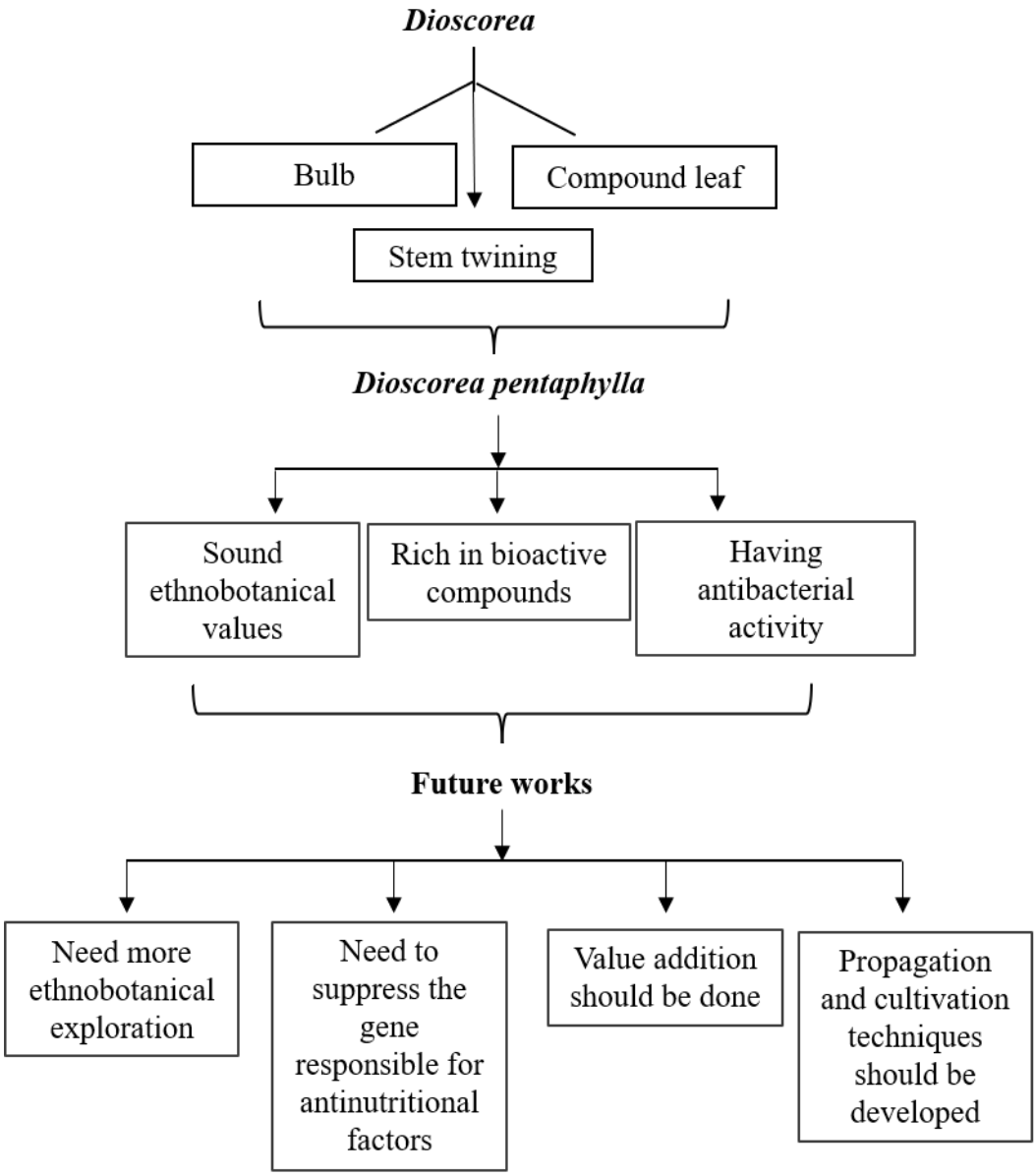

Illustration 1: Identification, uses and future aspects of *D. pentaphylla*

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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Chapter 3
Dioscorea pubera (Dioscoreaceae): an economically important wild nutraceutical

Bhagwati Prashad Sharma, Madhu Bala, Sweta Mishra and Sanjeet Kumar

Abstract: Food and medicine are considered as the most imperative aspects that are essential for the survival of human beings. These basic needs of an individual create a link between "nutrition" and "health", and thus the concept of "nutraceuticals" evolved. Several species of the genus *Dioscorea* available throughout the world are used as food and medicines for various diseases and disorders. Among them, *Dioscorea pubera,* a common tuberous wild species is used as food and medicine which also indicate the elevation of the landscapes. It shows diverse bioactive compounds. Keeping this in mind, an attempt has been made to gather information on *D. pubera*, its food, economic and nutraceutical values. Morphological description, and the photographs are provided for identification which could open new avenues in the finding of capable nutraceuticals.

Keywords: Starch, Secondary metabolites, Tuberous plants, Tribal food

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Introduction: Adequate is the primary requirements for the normal functioning of the body which help to maintain health, improve immunity and also reduce the risk of various diseases. It needs of the population create a link between "nutrition" and "health", and thus the concept of "nutraceuticals" evolved (Rama et al. 2006; Verma and Mishra 2016). Nutraceuticals are essential food that is more than food but less than pharmaceuticals. This means, it provides nutritional as well as medicinal benefits. In many countries, nutraceuticals are included in dietary supplements due to the presence of active compounds such as carotenoids, collagen hydrolysate, and dietary fibres. They are considered to be healthy sources for the prevention of many life-threatening diseases like diabetes, renal and gastrointestinal disorders, as well as diverse microbial infections (Telessy 2019; Ali et al. 2021). Various nutraceuticals have been playing a vital role in immune status and vulnerability to certain diseases. They also help to prevent disease related to oxidative stress including allergy, Alzheimer's disease, cardiovascular diseases, cancer, eye conditions, Parkinson's disease, obesity etc (Pandey et al. 2010; Nwosu and Ubaoji 2020). Many different terms, definitions, and meanings used for nutraceuticals vary from country to country. They have also been called medical foods, designer foods, functional foods, herbal products, processed products or nutritional supplements (Pise et al. 2012). Countries like United Kingdom, Germany and France were the first countries which considered that diet is a more important factor than exercise or hereditary factors in achieving sound health and immunity. Canada defined nutraceuticals as a product isolated or purified from foods but sold in pills, powders and other medicinal forms not generally associated with food and demonstrated to have a physiological benefit. It also provides benefits against chronic diseases. In Britain, nutraceuticals are defined as "a food that has a component incorporated into it to give it a specific medical or physiological benefit, other than purely nutritional benefit". In India, nutraceuticals are food components made from herbal or botanical raw materials, which are used for preventing or treating different types of acute and chronic maladies (Cockbill 1994; Pandey et al. 2010). Worldwide, the local or tribal people near the forest areas use various wild edible roots and tuber crops as food resources. These are free and easily collected by the local people as a good source of nutrients and are rich in energy, minerals, vitamins, antioxidants and dietary fibres (Aigal et al. 2017; Suwardi et al. 2018) could be termed as nutraceuticals. *Dioscorea*, one such tuberous plant, popularly known as Yam, belonging to the family Dioscoreaceae, is a prime staple medicinal-food substitute for the majority of rural and local people of the state of India, having excellent medicinal and nutritional properties (Kumar et al. 2017). *Dioscorea pubera* is one of the efficient tuberous species with food, medicinal and pharmacological values along with nutraceutical importance (Ummalyma et al. 2018).

Taxonomical features of *D. pubera*

Dioscorea pubera Bl. Enum. Pl. Javae 1:21. 1827; Prain & BurkillAnn Roy. Bot. Gard. (Cutcutta) c14(2):402. tt. 138 & 143. 1938; Burkil in Steenis. Fl. Males. I.4:333. 1951.

Description: Stem twining to the right, densely pubescent. Rootstock woody, directly producing cylindrical tuber; tubers are 35-50 cm long, 1.6 cm in diameter at the neck, and 3.5-3.9 cm in the middle. Bulbils axillary, potato-like, 1.3-2.6 cm across, with greenish skin. Leaves are alternate at base and then opposite, entire, broadly ovate or suborbicular, 7.8-25 x 5-22 cm, acuminate or cuspidate, pubescent on the nerves beneath, base cordate, leaf surface have brown hairs, 2 most exterior lateral veins terminating halfway to margin, the 3 inner-most veins terminating at the apex. Petiole half to as long as the blade, slender, pubescent, 7.0 × 0.2–0.4 cm, brown hairs at base. Male inflorescence is composed of many cymose arranged in racemes, slender, axillary, flowers 1.5 mm long, stamen 6 perfect, small, adnate to the inner perianth lobes. Female spikes are densely pubescent, 6-11 cm long, solitary, axillary or mostly in short axillary panicles, 9-11 cm long. Perianth 1.1 mm long, thickened at the base with age, outer perianth lobes ovate rounded, inner rather smaller. Ovary densely pubescent or tomentose, not beaked. Capsule 1.2-2.3 cm long and 2.1-3.2 cm broad, sub cordate at top and bottom, the margin of wings thickened. Seeds winged at the periphery. Flowering: September to November; Fruiting: December to January (Ummalyma et al. 2019; Kumar and Dimri 2022; Present study, Plate 1-3).

Synonyms: *Dioscorea anguina* Roxb., *Dioscorea combilium* Buch. -Ham. ex Wall., D*ioscorea cornifolia* Kunth.

Ecology: *D. pubera* grows in hilly regions with moderate temperatures (Present study).

Distribution: *Dioscorea pubera* is native to the Indo-China region and distributed throughout the temperate, tropical regions of Bangladesh, Eastern Himalaya of India, Jawa, Myanmar, Bhutan, Nepal and Sumatra (Kumar et al. 2017; Kumar and Dimri 2022).

Food values: Yams have been considered to have a considerable amount of various dietary nutrients in comparison to other tropical tuber crops. The tubers of yams are reported to have a good source of essential nutritional components such as starch, proteins, lipids, vitamins, and minerals, etc**.** The food value of *Dioscorea pubera* is least explored throughout the globe. In some places, tubers are boiled, mixed with rice, salt, and eaten as famine food. Many tribal communities of the Indo-Burma Biodiversity hotspot of the country use the tubers of *D. pubera* to get instant energy (Present study). In Odisha, tribal communities use the tubers as, vegetables, main meal with rice, in salad, as chips. The tubers contain good amounts of carbohydrates, low-level fats, fibers, and other nutrients, which makes them a good dietary source. It is used widely as traditional leafy and tuber food in many parts of Karbi Anglong district in Assam. Consumption of this tuber is well known among the tribe till today and many of the households now grow this plant in their homestead garden; consumed mostly as breakfast and evening tea item (Terangpi et al. 2015; Dutta 2015; Ummalyma et al. 2019).

Plate 1: Habitat of *Dioscorea pubera*

Plate 2: Tuber of *Dioscorea pubera*

Plate 3: Vegetative parts of *Dioscorea pubera* and discussion with local people

Nutraceutical values: The tuber of *D. pubera* is used as food and other vegetative parts of this climber are used to treat skin infections. Tribal people use the tuber to get instant energy. The tubers as well as bulbils have nutraceutical values. Cooked bulbils are used to relive colic pain. They use tubers as food and medicine. Tubers are taken to reduce weakness. The tuber pastes and Karanja oil (*Millettia pinnata*) is applied twice a day to recover from wounds and other skin infections. Dried tubers of *D. pubera* are chopped in water overnight and boiled with rhizome of Haldi (*Curcuma officinalis*) and the water is taken during delivery to reduce labour pain. Ethnobotanical studies revealed that the tubers are used in single or multiple formulations against various common and lethal diseases (Ummalyma et al. 2018; Ummalyma et al. 2019; Kumar et al. 2017; Figure 1).

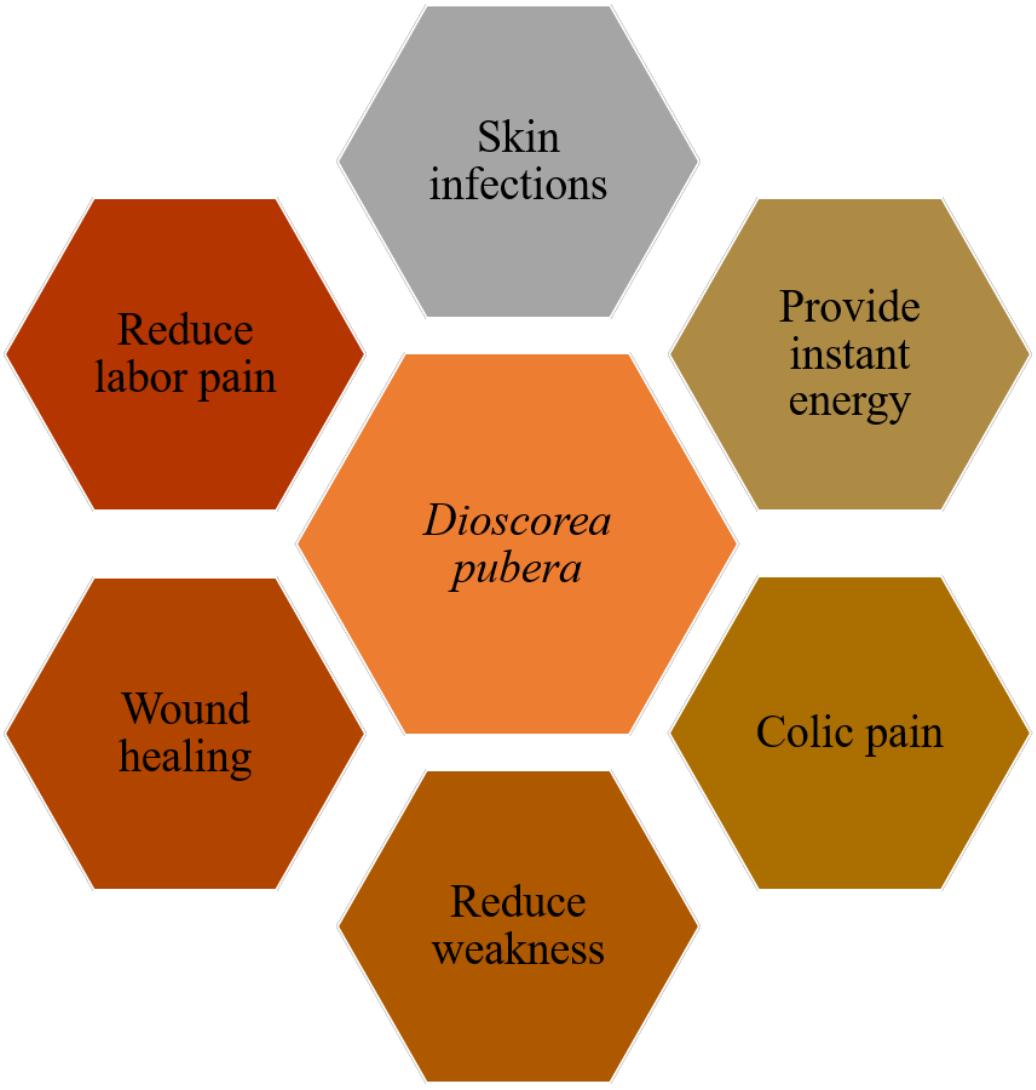

Figure 1: Medicinal values of *Dioscorea pubera*

Economic values: Many yam species are widely cultivated in Africa, Asia, and South America. This traditional staple crop is very important for regional food security and also to get financial support. Tubers of *Dioscorea pubera* are sold in local markets. Tubers are collected from the forest, for food and medicine by tribal people of Odisha, India. The boiled tubers of *D. pubera* are also sold in the local markets of Odisha state (Plate 4).

Future aspects as an economically important nutraceutical: It is well known that many fruits and vegetables are nutraceuticals which are responsible for our health benefits. Due to these health benefits, they should be regularly taken to get cured or reduce the risk factors such as high cholesterol, high blood pressure, diabetes etc (Nasri et al. 2014).

More nutraceuticals are being explored day by day and the list is changing continually and reflects ongoing market developments, research, and consumer interest. These developments require a multidimensional approach in the form of product development by incorporating the whole food which contains the desired property into the product during processing or by active component separation.

This technique involves isolation or purification of the active compound from the food and it is incorporated in other food to have a physiological benefit or provide protection against diseases (Kumari 2015). With rapidly increasing interest in nutraceutical consumption, substantial researches are absolutely necessary to warrant that nutraceuticals usage is safe and effective. There are several factors influencing the growth of the Nutraceutical Ingredients market and its economic status. COVID-19 pandemic is one of the key influencing factors in both positive and negative manner in the Nutraceutical Ingredients market. Several foods are available which are used to help in fighting against or reduce the risk of cardiovascular diseases, obesity, diabetes, hypertension dyslipidemia, and many other fatal diseases. Nowadays, nutraceuticals have received great attention as they have potential in nutrition and safety profile as well as therapeutic capability. Pharmaceutical and nutritional companies are aware of the changing trends because of to the advantages of these compounds (Alissa and Ferns 2012).

In this scenario, *Dioscorea pubera* is one of the best suggestions to enlist in the nutraceuticals. The tubers are very much crucial for the diet of women and and children and also for the economy of marginal farmers. It contains biologically active components which have the potential to optimize physical and mental wellbeing and which may also reduce the risk of disease**.** So that they can be used as novel sources for developing modern nutraceuticals and functional foods. Nowadays, people are more conscious about their food habits, health, and lifestyle. Encouraging these types of wild tuberous plants may lead to a healthy diet both in nutritional and economical aspects (Kumar 2017; Kumar et al. 2017).

Plate 4: Tubers of *D. pubera* in local markets of Odisha, India

Conclusion: The world is becoming more sophisticated and interesting. Healthy foods are becoming more crucial, appealing and fortified to meet the increasing demand for our nutrition. In the present scenario, nutraceuticals are the major source of health benefits and potential for disease prevention, which should be taken according to their acceptable recommended intake. From the above studies, *D. pubera* has proven its health benefits and disease prevention capabilities. Diosgenin is the most important compound from *Dioscorea* members, used in the synthesis of steroidal drugs, however other potential uses of this compound and related compounds such as estrogenic, anti-inflammatory, and anticancer potential need to be studied extensively. The secondary metabolites from *D. pubera* like alkaloids, saponins, flavonoids, tannins and phenols make it more potent in disease prevention. Bioprospecting of this plant will open new avenues in finding of capable nutraceuticals. New phytochemicals, from this plant, will provide lead molecules for pharmaceutical industries. Exploration and research should be encouraged in this field.

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

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Abstract: *Dioscorea bulbifera* is a wild edible tuberous twiner belonging to the family Dioscoreaceae. *D. bulbifera* is a supplement wild food crop, widely distributed around the world. It contains a significant amount of carbohydrates, starch, sugar, proteins, lipids, vitamins, minerals, fibers, 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 crisis.

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

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Introduction: Dioscoreaceae is a family of monocotyledonous flowering plants, comprising of nine genera with about 715 species. It is considered as one of the earliest families of the plant kingdom (Adomenien and Venskutonis 2022). Species of this family have mostly a 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 segregated 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 stocks 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 (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; Present study).

Dioscorea, the true yam, includes several economically important species, which are very important food sources in many tropical regions. It comprises of about 650 species (Mishra and Kumar 2021) found throughout the tropics and subtropics, especially in West Africa, parts of Central America, 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 and 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 (Present study).

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, diabetes, 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 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 diarrhea 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. 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 diarrhea and dysentery (Gairola et al. 2013). The roasted and 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). 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. 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.

Food values: World population continues growing at higher rate 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. 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 crisis, 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.

Figure 2: Consumption of *Discorea bulbifera* tubers

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, fibers etc. It was reported that *D. bulbifera* contains the highest percentage of crude fibers 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 nutrient 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 renaturalize the plant in its own habitat with more purpose.

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Chapter 5
Dioscorea hispida (Dioscoreaceae): an unexplored medico-food of India

Binod Saradar, Sushma Tilak Mehra, Paramita Ray, Rekha Maggirwar, Jeline Rani, Sweta Mishra and Sanjeet Kumar

Abstract: People are facing food problems even though many organisations in nook and corner of the world are working on food security. Inside our forest, a number of food plants are available yet, many more are to be discovered and explored. Yam species are such unexplored food plants abundantly available in forests. They have food and medicinal values. Keeping the importance of the yam species in mind, authors have discussed here the utilization of *Dioscorea hispida* in day-to-day life by the tribal communities and the future aspects to mitigate the challenges regarding the lack of food and medicines.

Keywords: Food problems, Yam, Future food, Health problems

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Introduction: Human beings from time immemorial have been using about 5538 crop species for consumption purposes, among which 12 crop species share the major

percentage of food security globally. Now throughout the globe, it is estimated that more than 1000 neglected and underutilized crops rich in nutrition and stress-bearing species will be utilized in future food security (Hossain et al. 2021). Many indigenous crops which are available in the culture of local and tribal people referred to as neglected and underutilized, are sources of valuable nutrients, income, therapeutic properties, and possess the potential in fighting hidden hunger (Mondo et al. 2021). Among the indigenous food, roots and tubers play an important nutritional source after grains. Yam, the edible tuberous plants, supplement staple food with micronutrients throughout the world through preserved and starchy stored foodstuff (Faugiah and Masudah 2015; Kumar 2016). Tubers of many species from the genus *Dioscorea* (family Dioscoreaceae), are a valuable source of nutrition like carbohydrates, fibers, and low levels of fats, which makes them a good dietary source (Osman 1990; Faugiah and Masudah 2015). The genus is composed of about 715 species, thrive in tropical and temperate (Adomenien and Venskutonis 2022). Across different ethnic communities and geographic regions, diverse species of *Dioscorea* have been adopted within different habitation as a food source due to the high nutritional benefits and therapeutic values towards the treatment and cure of certain health problems which play a significant role in food security, medicine and economy in the developing countries (Obidiegwu et al. 2020). Approximately 50 species of yam are consumed as wild harvested staples or famine food. Among them, *Dioscorea hispida* is a staple subsistence food source in some tropical regions of the world. This yam is used as medicine too. *D. hispida*, also known as intoxicating yam, grows wild in India, South East Asia, Indonesia and extends to Papua New Guinea and the Philippines (Nashriyah et al. 2012). It is a staple food in some parts of the Philippines such as Palawan, Cavite, and Batangas (Murthy 2013).

Morphological features of *D. hispida*: Strong geophytic twiner; stem twining to the left, prickly, tomentose when young; tubers subglobose or irregular, up to 38 cm in diam., covered with many fibrous roots. Leaves 3-foliolate; petioles 6 – 35cm long, prickly, glabrous or finely pubescent; leaflets- the terminal one elliptic, entire, caudate-acuminate, 3 – 5-costate, base tapering lateral leaflets much oblique, shortly 2-lobed, gibbous, broader than long; petiolules 2 – 19mm long. Male flowers in dense, short, narrowly oblong axillary spikes, 6 – 8 mm long; panicles pubescent, prickly; rachis pubescent or villous; bracts of flowers small, orbicular, concave, pubescent; inner perianth lobes oblong-obovate; anthers 6, perfect, minute; female spikes 2-nate, simple, pubescent or tomentose. Capsules are quadrate, oblong, truncately rounded, and smooth. Seeds winged at the base (Plate 1-2). Flowering: June – August; Fruiting: August – September (Ummalyma et al. 2018; Saxena and Brahmam 1995).

Ecology and associated plant species: *D. hispida* is found in regions where temperature is moderate and found to be grown in association with *Dioscorea bulbifera*

L., *Cissampelos pareira* L., *Celastrus paniculatus* Willd., *Lygodium flexuosum* (L.) Sw., *Dioscorea pubera* Blume, *Elephantopus scaber* L.,etc.

Ethno-medicinal values: Previous studies indicate that *D. hispida* can be used as a source of medicine & food. Ethnomedicinally this yam can used to reduce the blood sugar level. Boiled tuber is used in preventing vomiting and in treating indigestion. Sap of the tuber is applied around the affected parts and covered with clothes for one night to treat wounds and injury. Temuan tribe use the pounded leaves from intoxicating yam for treating sores (Nashriyah et al. 2012). Tuber is used in reducing the risk of obesity, diabetes and other related health problems (Aprianita et al. 2009). Water of the soaked tuber is used in eye problems. Crushed tubers are used in fish poisoning. In the Philippines, folk stories in rural areas claimed that eating raw or improperly cooked tuber can result in a long deep sleep (Kumar et al. 2017; Murthy 2013). The tuber contains a water soluble toxicant, dioscorine, having insecticidal and antifeedant activities (Banaag et al. 1997; Nagata et al. 1999). Boiled tuber is traditionally been used to treat constipation too by Bhuian tribe (Present study).

Food values & methods to remove toxic constituents: Tubers of *D. hispida* are used as food sources in preparing traditional foods. Traditionally, the tuber can be detoxified by boiling, roasting or soaking in flowing water for 2-3 days. Detoxified *D. hispida* was used as a staple food in olden days by rural and tribal people where they made it into flour, cakes, pancakes, and porridge. In Odisha state, India, it was observed that tubers are mostly soaked overnight in water or left overnight in stream and subjected to successive boiling to remove the bitterness (Present study). Then tubers are boiled to remove the toxins and the thinly sliced tuber is used in making chips (Present study). In Malaysia, villagers eat intoxicating yam with glutinous rice and grated coconut, especially during breakfast or rainy season. People in New Guinea slice and boil the *D. hispida* tubers for two days to remove their toxin before cooking. Sakai people in Thailand also remove the toxin by prolonged boiling with wood ashes before eating the yam (Nashriyah et al. 2012; Kumar et al. 2017). Day by day this nutritious food has been forgotten because of the difficulties of the traditional detoxification process (Hudzarin et al. 2011; Ashri et al. 2014).

Pharmacological values: *D. hispida* is rich in primary and secondary metabolites. It shows the presence of carbohydrates, proteins, alkaloids, glycosides, saponins, tannins, phenolic compounds etc. Tubers of this yam are potentially active as an antimicrobial agent due to the high content of alkaloids and other bioactive compounds. Dioscorine is a type of toxic alkaloid, removed from the tuber prior consumption has pharmacological values (Hazrin-Chong et al. 2018). *D. hispida* also possesses high antioxidant and thrombolytic activities due to the presence of phenolic compounds (Miah *et al.* 2018). Previous studies have demonstrated that *D. hispida* shows insecticidal properties as well as free radical scavenging properties

Plate 1: Leaf of *D. hispida* in wild habitat

Plate 2: Plant parts of *D. hispida*

(Bhamarapravati et al. 2003; Otake et al. 1995). *D. hispida* has also been used as a coating material on rubber wood and demonstrated repelling activity against white-rot fungi and termites (Lazim et al. 2016). *D. hispida* possesses significant anticancer and antioxidant activity due to its higher saponins and phenolic content (Kumar et al. 2011). It has also hypoglycemic polysaccharides that are able to reduce blood glucose levels (Estiasih et al. 2012). Further investigation on different biological activities is needed.

Conclusion: Availability of adequate food and medicines are the contemporary problems in most of the nations. There are a number of medico-food plants available in our forest. Therefore, there is a need to explore the plants used as medicine & food by the ethnic communities. Present study concluded that, it has sound ethnomedicinal and food values. It could be used to formulate new drugs and to mitigate the food problems in its distributional areas of the world.

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Chapter 6
Dioscorea oppositifolia (Dioscoreaceae): a medico-food of tribal India

Santwana Samilita Dash, Arti Sharma, Anjali Arya, Sushma Tilak Mehra, Nithiyananthan Sinnadorai and Sanjeet Kumar

Abstract: About 650 species of the *Dioscorea* genus are reported throughout the world. Most of the species have starchy tubers with excellent food and medicinal values, but they are yet to be explored scientifically. *Dioscorea oppositifolia* is a medicinal yam, commonly known as Pani Alu, consumed by local communities as medico-food in India. There is a very little documentation on its medicinal-food values. Therefore, an attempt has been made to document their importance through the field and literature survey. The results revealed that tubers are consumed after different traditional practices to remove the toxic elements. The tuber is also consumed as a medicinal agent, particularly in women related problems. Further studies are required to evaluate the food and medicinal values to do the value addition for providing livelihood opportunities to the locals and to establish a sustainable health care system.

Keywords: Tuberous plants, Women health care, Medicinal food, Value addition

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Introduction: Yam represents the species of the *Dioscorea* genus of the Dioscoreaceae family under the order Dioscoreales. They are initially consumed by the communities of New Guinea and then slowly spread across Africa, Asia, Europe, The Caribbean and Oceania (Kumar and Jena 2017). It spread quickly due to the presence of starch in their tubers and rhizomes. They are popular but have less palatability due to the presence of anti-nutritional factors and some toxic elements. There are a number of traditional practices that are observed to remove these unpalatable factors (Present study). They play a significant role in food security, medicine, and the economy of the developing countries. Among the *Dioscorea* species, *Dioscorea oppositifolia* is very common, having a wide distribution in the world. *D. oppositifolia* is a deciduous perennial, twining vine, that may reach up to 16 feet in height, taking support from trees and shrubs. Terete stem, twinging spirally from left to right (clockwise: identification key) and glabrous. Underground, it has a deep, persistent, root-like tuber up to 1 metre long that resprouts annually. Leaves are opposite, although they may be alternate in the upper nodes, coriaceous, simple, pointed to long-pointed with a heart-shaped base, 5-7 nerved, 5.0 to 8.2 cm long and are typically ovate, hastate, or sagittate in shape. Petiole up to 3.5 cm long. Spike 2.0-6.5 cm long, slender, 3-6 together along the peduncle; peduncle 15-22 cm long; bracts lanceolate. Flowers are small, greenish-yellow in colour. The flowers are unisexual and arise from the leaf axils in spicate or paniculate inflorescences. Male flower tepals ovate, obtuse, stamens 6. Female flowers distant, tepals 1 mm long, orbicular, glabrous. Fruits are membranous, three-angled glabrous capsules (Present study; Plate 1-3; Kumar 2016; Kumar and Jena 2017). *D. oppositifolia* can grows in a number of different habitats and environmental conditions, but it is commonly found at the edges of forests, along stream banks, and water bodies (Present study). It is native to India, Bangladesh, East Himalaya, Myanmar, and Sri Lanka. Some of the food, medicinal and economic values are reported by some researchers, but detailed studies are needed. Therefore, an attempt has been made to gather information on the above aspects of *D. oppositifolia*. In this chapter, the authors discussed the utilisation of this tuberous plant (Present study).

Methodology: For the present study, literature and field surveys were carried out. For the field survey, from 2014 to 2022, the authors visited the selected areas of Odisha state under different projects and gathered information on *D. oppositifolia* using a random questionnaire method. The plant was identified by the authors.

Results and discussion: The observations and collected information from the field are presented under the following heads:

Food values: During the survey, the authors found that the tubers of *D. oppositifolia* are collected from December to February and are consumed as food. The authors observed a number of traditional processes that were carried out prior to consumption. The observed practises are as follows:

1. Tubers are cut into small pieces and boiled. Boiled tubers are cooked with tomatoes and tamarind water.

Plate 1: Habit and habitat of *D. oppositifolia*

Plate 2: Plant parts of *D. oppositifolia* (Leaves, Flowers and Fruits)

Plate 3: Mature fruits of *D. oppositifolia* in wild

2. The young tuber is washed and consumed raw by the children.
3. The mature tubers are collected and burned. The burned tubers are consumed as snacks.
4. The tuber is left in running water (24 hrs), then boiled and consumed as a salad with a meal or country liquor.

Medicinal values: Most of the yam species are used to cure different types of diseases and disorders. The most commonly observed therapeutic values of *D. oppositifolia* are:

1. The juice of rhizome is taken to reduce the complications related to menopause.
2. The tuber decoction is used for early menstruation.
3. The decoction of the tuber is used as a birth control agent and to reduce obesity.
4. The tuber is boiled and consumed as a snack to give strength to the mother after delivery.
5. The boiled tuber is consumed to enhance the appetite.

Economic values: Most of the yams are cultivated for economic purposes. The tuber of *D. oppositifolia* is not cultivated in the study areas, but the authors observed that the tribal people collect it from near forest areas and use it to sell in their local markets.

Propagation as a future food: *D. oppositifolia* can reproduce both sexually and asexually. Sexual reproduction in this plant is not documented even though it is capable of sexual reproduction. Female plants have not been observed in the wild. Asexual reproduction takes place through tubers.

Discussion: Many researchers have reported the food and medicinal values of this yam species. Felix et al. (2009) reported that the *D. oppositifolia* is traditionally used as antiseptics, in ulcers and abscesses. The root is chewed to cure toothache and aphthae. The whole plant extract is used in secondary syphilis and psoriasis. According to their work on phytochemical analysis, petroleum ether extract of *D. oppositifolia* showed the presence of steroids, triterpenes, sugars, tannins, and amino acids. Methanol extract showed the presence of sugars, alkaloids, phenolic groups, flavones, tannins, and amino acids. Benzene and chloroform extracts showed the presence of steroids, sugars, and steroids, triterpenes, and sugars respectively. The aqueous extract shows the presence of steroids, triterpene, sugar, and tannin. According to Shajeela et al. (2011) *D. oppositifolia* contained higher crude lipid compared to other *Dioscorea* species. Sheikh et al. (2013) reported that the *D. oppositifolia* shows the presence of saponin, terpenoid and cardiac glycosides which might be responsible for treating fungal and yeast infections, bacterial infections ad cardiac failure respectively. Kumar (2016) documented the uses of the tuber of *D. oppositifolia* in swelling, scorpion and snake bites due to the presence of flavonoids and alkaloids, tuber powder taken with honey orally increase the number of sperms due to the presence of diosgenin. Vivek and Prakash (2018), reported the presence of alkaloids, saponins, tannins, triterpenoids, steroids, phenols, flavonoids, glycosides, and reducing sugars in the tuber of *D. oppositifolia* and the nutritive evaluation showed that the tubers are a good source of

proteins, lipids, crude fibres, starch, vitamins, and minerals. Mustafa et al. (2018) reported that the tubers are used as nutrition tonic after pregnancy and also used as an antiseptic. Rani and Raju (2020) reported the presence of alkaloids, phenols, flavonoids, steroids, tannins, glycosides in *D. oppositifolia* and show significant antimicrobial and antiinflammatory activities. Gavad and Khade (2021) documented that the tubers of *D. oppositifolia* is given to women once a day for nearly a month after delivery to revive their strength. Leaf paste is used as an antiseptic for ulcers whereas powdered root mixed with cow urine is applied to a scorpion bite.

Conclusion: The study concluded that *D. oppositifolia* has sound therapeutic values against problems related to women. It has food value too and is popular among the tribal communities of India in general. Therefore, a medico-food can be developed to reduce the problems related to women as well as can do the value addition to provide livelihood opportunities to the locals. The present study indicates that there is a lack of scientific evaluation on food and medicinal values of *D. oppositifolia*. Hence, there is a need to evaluate all possible bioactivities of its plant parts.

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Chapter 7
Food and medicinal values of *Dioscorea alata* L.

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Abstract: Food and nutritional security are the major concerns in many countries of the world, and to address this concern, it's now time to transform food systems for food security, improved nutrition, and affordable healthy diets for all by searching for alternative foods. The underground edible tuber of *Dioscorea alata* L. (Dioscoreaceae) is a functional food with high nutritive value and therapeutic potential. It provides food and medicine to millions of people in the world, especially in the tropical and sub tropical regions. It is one of the oldest tuber crops cultivated from wild in tropical regions around the world, and it is a staple food for many rural and tribal groups. *D. alata* tubers have a high medicinal and economic values. These tubers are used for the treatment of different diseases and are also used as tonics. They have diuretic, aphrodisiac, anthelmintic, anti-inflammatory, and anti-diabetic properties. Tubers contain various phytochemicals such as diosgenin, saponins, flavonoids, dioscorine and other important constituents. These chemicals have vast activities like anticancer, antimicrobial and effects on cardiac diseases as well as CNS. Further research should be carried out to utilize the bioactive compounds present in these tubers for the formulation of new drugs to fight against different diseases.
Keywords: Nutraceutical, Cultivation, Yam, Tuberous plants

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Introduction: Globally, levels of hunger are now at a critical juncture. According to the Global Report on Food Crisis (GRFC) 2021, approximately 193 million people are suffering from acute food insecurity and are in need of urgent assistance across 53 countries. It clearly indicates that the meaning of food security has changed as hunger and malnutrition are now larger underlying problems (Magdoff and Tokar 2009; Kwasek 2012). On the other hand, global food security is an economic phenomenon and essence. In the Middle East and Africa, the poorest spend about 50% of their income on food, which means that the increase in the prices of major food products has an incredibly high impact on household spending (Abdulkadyrovaa et al. 2016). The income levels of the population affect food access at a greater rate. More people should be able to afford adequate diets and should have access to healthcare (Leathers and Foster 2016). Coincidentally in the last two years, we faced a pandemic situation due to COVID-19, impacting the world's economy, triggering an unprecedented recession, and the food security and nutrition status of millions of people, including children. We need an appropriate immune boosting plants in our diet and thus a need to cultivate them. It's time now to transform food systems for food security, improved nutrition, and affordable healthy diets for all. In these circumstances, tuberous plants are the best solution in every aspect. They produce starchy roots, tuber, rhizomes, corms that play an important role in nutrition and health. From time immemorial, these starchy tubers have been a part of the food choices in the human diet. Roots and tuber crops are also important cultivated staple energy sources, followed by cereals, generally in the tropical regions of the globe (Thompson and Hirschi 2016; Chandrasekara and Kumar 2016).

Wild edible tuberous plants are important in the livelihood strategies of local or tribal people and forest dwellers in many developing countries. There are a number of roots and tubers belonging to several species which creates extensive biodiversity even within the same geographical location. India is rich in the plant diversity with roots and tubers, which includes a large number of wild relatives of cultivated tuber crops as well as many under-exploited tuber crops known to the tribals (Kumar and Shiddamallayya 2014). Except for some common potatoes, sweet potatoes, and cassava, other starchy tuber crops are yet to be fully explored for their nutritional and health benefits for use in the human diet. Unexplored tuberous plants may include yam species and aroids belonging to different botanical families but are grouped together. In addition, variations in the growth pattern and adopting indigenous practices make roots and tubers specific use systems. However, roots and tuber crops are bulky in nature with a high moisture content of 60–90%, leading them to be associated with high transportation costs, short shelf life, and limited market margin in developing countries, even where they are mainly cultivated (Chandrasekara and Kumar 2016). Some edible tubers are used for traditional and alternative medicinal sources. Tubers and roots are potential nutraceuticals to manage a number of ailments and ensure general wellness. *Dioscorea,* the most primitive tuberous angiospermic genus of the family Dioscoreaceae, comprises of about 650 to 682 species distributed

across the world, with higher diversity in Southeast Asia, Africa, Australia, and tropical America (Waris et al. 2021). The tuber crop members of this genus constitute one of the major food items for many ethnic groups after cereals and are cultivated or harvested from the wild in tropical regions throughout the world (Dutta 2015). *Dioscorea* are either climbing herbs or shrubs with rhizomes and tubers, bear alternate leaves with reticulate venation and possess unisexual flowers. *Dioscorea* shows a number of anatomical, morphological, and embryological characters which are reminiscent of dicotyledons. The nature of twinning and the occurrence of prickles in the plants are the key characteristics of the genus, which can be used to distinguish and help to identify the species (Present study). The occurrence of dicotyledonous characters like reticulate venation in leaves, simultaneous type of development in pollen grains, the arrangement of vascular bundles, and the presence of a second rudimentary cotyledon in some species create confusion that yams are dicot. The genus prefers a wet climate for flowering and fruiting, and in the dry season, tubers persist (Bouman 1995; Waris et al. 2021). Keeping the importance of Yam species, a study was carried out on *Dioscorea alata* through literature and field surveys under several project works in India.

Dioscorea alata: It is commonly known as purple yam or greater yam. The tubers of *D. alata* are irregular in shape and are usually violet-purple to bright lavender in color. Sometimes they are also cream to plain white in colour. Tubers are large in size. Purple yam is available at the edges or in the canopy gaps in moist deciduous as well as in evergreen forests of India. This climber is native and widespread in Asia and Africa and it has a dormancy period of at least two months, making this climber easy to transport. The greater yam has many medicinal and pharmacological values along with nutritional value. It is a vigorous, perennial, climbing plant, producing annual stems with tubers. These stems scramble over the ground, or twine into the surrounding vegetation. Stem twining to right, 4-5-winged or angled, up to 10m long, glabrous, wings sometimes reduced to ribs. Bulbils or aerial tubers globose, ovoid or obpyriform, occasionally with rootlets up to 12 cm long. Leaves are opposite or lower alternate, broadly ovate or deltoid-ovate, base cordate or sub sagittate, apex acuminate, 12-13 cm long and 8-10 cm broad, primary veins 7. Petiole up to 9-10 cm. winged. Inflorescences glabrous. Flowers 1.5 mm long, deltoid-ovate, tepals widely ovate, obtuse, stamens 6, free, pistillode conical. Female flower1 per leaf-axil, up to 21–35 cm. long, perianth triangular-sub globose, ± 5 mm. across. Ovary glabrous. Male flower ± 2 in the leaf-axils or forming axillary terminal panicles in the axils of bracts, spreading, axis zigzag, with the sessile, staminodes 6, very small. Perianth sub globose, not opening widely, ±1.5 mm. across. Capsule 2-2.5 mm long, broadly obcordate. Tubers one to several, annual, polymorphic, variously branched or lobed, normally cylindric, up to 6 cm. in diameter, descending vertically (Saxena and Brahmam 1995; Plate 1).

Distribution in World: It is originated in South-East Asia with the widest global distribution of all the yams found throughout the tropics. Apart from South-East Asia,

it is widely grown in the Caribbean, West Africa, and in Oceania. In South-East Asia, it is the most important species and is grown in virtually all countries of the region, especially in Indonesia, Malaysia, Papua New Guinea, the Philippines, and Vietnam. It is native to Bangladesh, Bismarck Archipelago, Borneo, Cambodia, Christmas, East Himalaya, India, Jawa, Lesser Sunda Islands, Malaya, Myanmar, Nepal, New Guinea, Philippines, Sulawesi, Sumatra, Thailand, Vietnam. Purple yam is introduced in regions like Alabama, Andaman Islands, Angola, Bahamas, Burundi, Cameroon, Colombia, Ethiopia, Fiji, Florida, French Guiana, Honduras, Jamaica, Japan, Madagascar, Maldives, Peru, Queensland, Taiwan, Tanzania, Togo, Venezuela, Zambia etc (https://www.ipni.org/).

Distribution in India: In India, greater yam is cultivated in the states of Andhra Pradesh, Madhya Pradesh, Kerala, West Bengal, Bihar, Odisha, North Eastern states, Uttar Pradesh, Kerala, Tamil Nadu, Gujarat and Maharashtra as a commercial crop (Patel et al. 2019; Rao et al. 2019; Present study)

Food values: Worldwide, *Dioscorea* has been cultivated for its tubers, which are considered as staple food in many regions. Tubers are primarily consumed for their carbohydrates in the form of dry matter and secondarily for protein, vitamins and other minerals. So, it is a crucial tuber crop containing essential nutrition as an alternative food source. *D. alata* is a major component of the diet in Africa, America and South-East Asia (Patel et al. 2019; Fauziah et al. 2020). The tuber is baked and eaten, as a sweetened dessert, or as a vegetable. The freshly cut tuber is also edible and is used as a staple food in Taiwan. In Philippines, it is most common and used as an ingredient in many desserts as well as to flavour some items. These tubers are used to cook creamy soup in Vietnam. In many parts of India, tubers are fried to make chips (Wanasundera and Ravindran 1994; Muimba-Kankolongo 2018; Present study). Water and fat content change, especially in chips and flours of *D. alata*. In chips, fat increases by up to 2.314%, and water goes down by 56.61%. In flour, there was a decrease in water up to 88.93%. The highest phenolic compound in steamed *D. alata* is 265.49% (Makiyah and Djati 2018).

Medicinal values: *Dioscorea* species are characterized by the presence of diosgenin, the basis for anti-infertility drugs such as contraceptive pills and sex hormones, such as testosterone, which are consumed by body builders as supplements to increase their testosterone levels and build muscle strength. The tubers of *D. alata* has the potential to treat a wide range of fatal diseases and disorders. Tubers are used in the treatment of various skin diseases, wounds, burns, etc. 2-3 g of paste of the tuber is tied to the infected part of the body to treat cancerous wounds, leprosy, gonorrhea, blood pressure, etc. Tubers are also used in gastrointestinal disorders, cardiovascular system disorders, central nervous system disorders, disease of bones and joints, metabolic disorders, immune deficiency and autoimmune diseases, dysfunctional changes in the female reproductive system, diarrhea, irritability, abdominal pain, and anemia. Besides it, tubers are extensively used in the treatment of dysentery, piles,

and chronic liver pain disease (Dutta 2014; Makiyah and Djati 2018; Mustafa et al. 2018).

Pharmacological values: The tuber of *D. alata* is well known for its traditional therapeutic uses as well as pharmacological values. It contains diosgenin which is a major aglycone of steroid saponin acting as an intermediate steroid in the pharmaceutical industry. Steroid saponin is the most important bioactive compound due to its several biological functions, such as anticarcinogenic, antithrombotic, antiviral, hemolytic, hypocholesterolemia, hypoglycemic, immunostimulatory, antitumorigenic, antimutagenic, immunomodulatory and anti-inflammatory depending on its structure (Dey et al. 2016; Makiyah and Djati 2018). In Indian traditional medicine, the tuber is extensively used as a diuretic, aphrodisiac, anthelmintic, antinflammatory and antidiabetic. Tuber is used as a tonic and health supplement in some states of India (Maithili et al. 2011; Kumar et al. 2017). In Chinese traditional medicine, tuber is used in the treatment of inflammatory diseases (Liu et al. 2012). *D. alata* was identified to have antifungal activities on *Botryodiploidia theobromae* (Eleazu et al. 2013). Tuber mucilage of *D. alata* stimulates antigen production and phagocytic activity. In addition, it enhances the cytotoxic activity of splenocytes (Shang et al. 2007). A bioactive hydro-methanol fraction of the tuber demonstrated stimulation of cell adhesion, phagocytic activity and plaque formation (Dey et al. 2014; Dey et al. 2016).

Economic values: The tubers of *D. alata* have high economic value due to their food, medicinal and pharmacological values. It is commercially produced in Nigeria and other countries, providing a livelihood for farmers. In the past few years, the growth in yam cultivation has not matched the growing demand, leading to a shortage and thus a price rise in Nigeria. As this climber continues to be cultivated in many parts of the world, infrastructure support is required to promote its production and sale. It becomes necessary to identify the sources of the product and the relative importance of the channels through which consumer satisfaction is met (Bekun 2017; Nwike et al. 2017; Plate 2). In many states of India, it is cultivated for commercial purposes and can also be seen in rural and tribal markets (Plate 2).

Cultivation techniques: *D. alata* is cultivated widely in tropical areas for its edible tuber. The plant is not self-fertile. It needs suitable light, climate, and soil for its proper growth. The most common method of propagation is by using the tubers. The tip of the tuber is mostly preferred for propagation. In tropical areas, the optimum temperature varies from 30-35°C with a great combination of adequate moisture and this climber prefers the subtropical warm humid climate. It requires well-drained sandy loam soil with pH ranges from 6-6.5. Greater yam comes to harvest 8-9 months after planting, large-scale leaf yellowing and drying of leaves is an indication that the yam is ready to harvest. The tubers are dug out without causing injury to them. The tuber yield of this crop would be 30-35 ton/ha (Sawiphak et al. 2021; Pouya et al. 2022). Bulbils are also used for the propagation (Present study).

Value addition: Throughout the world, people are searching for future food to feed the uncontrolled and growing population of the world. Tuberous plants provide food for a long time and even in the modern era, they are the choice of researchers. *D. alata*, a tuberous plant, is easy to propagate. It has a high concentration of starch and carbohydrates. Therefore, diverse food products can be developed from it, thus encouraging entrepreneurship for its cultivation.

Conclusion: From the above discussion, it was found that *D. alata* is a potential climber and provides food, medicine, and livelihood to millions of people in the world, especially in the tropical and subtropical regions. It contributes about 10 % of the total root and tuber production around the world and is recognized as the fourth most important tuber crop after potatoes, cassava, and sweet potatoes. *D. alata* plays a very crucial role in many aspects of the lives of tribals. The tubers are dug for various uses, and it also helps during food scarcity periods. As discussed above, the tubers are rich in many primary and secondary metabolites; hence further research should be carried out to utilize the bioactive compounds present in the tubers for the formulation of new drugs to fight against different diseases. Focus must be given on improving *D. alata* as a food source, its cultivation, as well as establishing a logistics chain.

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Plate 1: *Dioscorea alata* in home garden

Plate 2: *Dioscorea alata* tubers in a local market

Chapter 8
Dioscorea wallichii Hook. f. (Dioscoreaceae): a tribal medico-food of India

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Abstract: There are a number of neglected tuberous plants available in India. They have food and medicinal values along with scope in commercial cultivation. *Dioscorea wallichii* is one such tuberous plant having sound ethnomedicinal and food values but comes under neglected tuberous plant due to less documentation. Therefore, an attempt has been made to document its potential as medico-food agent. Authors have discussed their importance and scope in commercialization. The chapter brings attention towards the importance of neglected tuber crops.

Keywords: Neglected tuberous plants, communities, yam, future food

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Introduction: *Dioscorea* L. is an herbaceous monocotyledonous genus. It is the largest genus of the Dioscoreaceae family, distributed in tropical and subtropical regions of

the world. The species of this genus are important both taxonomically and economically (Paul et al. 2017; Present study). These plants are climbing herbs or shrubs; stems annual, twining either to right or to left, sometimes with axillary aerial bulbils, with underground tubers and rhizomes; leaves alternate, rarely opposite, simple and compound, often cordate with reticulate venation (Present study). *Dioscorea* tubers are renowned for their ethnobotanical, nutritive, antioxidant, and biological potentiality that ensure the quality of daily nourishment of the indigenous people (Paul et al. 2020). Due to the great nutritional value of its underground tubers, they are an important source of energy for human populations worldwide (Wilkin et al. 2005). These tuberous plants have maximum uses among the tribal people and are less documented in their food and medicinal values (Kumar et al. 2017). Most species contain steroid saponins and also sapogenins, such as diosgenin, which is the starting material for the synthesis of many steroidal hormones used as anti-inflammatory, androgenic estrogenic, and contraceptive agents. The members of the genus *Dioscorea* are one of the oldest tuber crops, cultivated or harvested from the wild throughout the world and constitute one of the major food items for many ethnic communities (Dutta 2015). It is also the most important ingredient in the cosmetics and pharmaceutical industries. They have the potential for curing different diseases and ailments like cough, cold, stomach ache, leprosy, burns, fungal infections, dysentery, skin diseases, rheumatism, arthritis, and are also used as a birth control agent (Kumar et al. 2017; Salehi et al. 2019). Yams are grown on 5.36 million hectares in about 47 countries, with Nigeria as the leading producer of these tuberous plants (Aihebhoria et al. 2016). There is still a huge need for more research and information on the food, nutraceutical, and medicinal value of *Dioscorea* species worldwide. Among the *Dioscorea* species, *D. wallichii* is very common showing wide distribution throughout the world. It is native to Southeast Asia, India, and China. Very less documentations are available on this yam. Therefore, an attempt has been made to document the food, ethnomedicinal, pharmacological, and economic values of *D. wallichii* through literature and field surveys. Field surveys were made under different projects in India during 2014-2022.

Morphological characters: The key morphological characters of *D. wallichii* are (Saxena and Brahmam 1995; Plate 1): Stem twining to the right, smooth or scarcely prickly towards the base. Leaves are orbicular, bluntly acuminate, widely cordate at base; nerves 10-12 pairs from the base, glabrous, intercostae parallel; petiole up to 14 cm long. It has separate male and female plants. The female inflorescences (flowering structures) hang down from the vine, each one containing up to 22 flowers. Female flowers: perianth lobes fleshy, outer ones ovate, inner ones broadly ovate. Capsule (immature) not reflexed, drying blackish, oblate, glabrous, base truncate, apex emarginate to truncate; wings 1.7-2.2 cm wide. Tubers are palmately branched, cylindrical. Round capsules contain flat, brown seeds with a thin, marginal wing. Seeds inserted near the middle of the capsule in the flower and winged all round (Present study).

Plate 1: *D. wallichii* in wild habitat (fruits & leaves)

Habit & Habitat: It is a climber and grows on various large shrubs or trees in mixed deciduous, evergreen forests, on mountain slopes, occurs in disturbed areas along roadsides and margins of cultivated lands (Present study).

Global distribution: Bangladesh, China South-Central, East Himalaya, India, Malaya, Myanmar and Thailand (Paul et al. 2017).

Distribution in India: Andhra Pradesh, Kerala, Maharashtra, Odisha etc. (Present study)

Food values: During the rainy season, many tribal communities collect the tuber of *D. wallichii* and use it as a food supplement. It plays a vital role among the tribal communities by serving as food in their daily diet. It is commonly known as Suta aalu in Odisha (Guchhait et al. 2022; Present study). It serves as a main source of carbohydrates (Maneenoon et al. 2008). In Tripura, young aerial shoots and soft parts of tuber are used as a vegetable by most of the ethnic communities (Paul et al. 2017). Boiled and cooked tubers are also edible (Sheikh et al. 2017). Tubers are also roasted and used as a delicacy. After successive boiling, tubers are cooked as a curry. Tender leaves and shoots are boiled and cooked (Padhan and Panda 2016).

Ethnomedicinal values: The tuber of *D. wallichii* is commonly used as a fiber supplement. Powdered tuber is mixed with honey and taken orally for refreshment and to increase physical fitness. Janmatia and Reang communities of Tripura use the tuber against stomach pain (Paul et al. 2017). Boiled and cooked tubers are also used against stomach pain (Present study). The tuber juice of *D. wallichii* is used to treat stomach pain and jaundice (Gavad and Khade 2021). 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, rheumatism and gastric problem related to alcoholism. Powdered tubers were used as an ingredient of medicines for cholera and constipation. Tubers are also used as carminative (Kumar et al. 2013; Mustafa et al. 2018), flatulence and as a de-appetizer (Kumar et al. 2017).

Bioactive compounds: Phytochemical analysis of *D. wallichii* leaves showed the presence of alkaloids, flavonoids, coumarins, phenols, tannins, saponins, terpenoids, quinones and catechins (Irulandi et al. 2016). Diosgenin obtained from its rootstock which is one of the costliest and most important steroidal drugs is used worldwide. It has been used in the pharmaceutical industry as a chemical model in the development and complete synthesis of hormonal drugs. This metabolite is also reported to reduce oxidative stress damage, may protect the myocardium from ischemia-induced injury and modulates the intestinal microbiota. Dioscin and gracillin are also very important metabolites of this plant (Adomeniene and Venskutonis 2022).

Pharmacological values: Many researchers have documented the pharmacological values of *D. wallichii*. Irulandi et al. (2016) found the methanol extract of leaf of *D. wallichii* exhibited the highest radical scavenging activity. The results revealed significant free radical scavenging activity of methanolic leaf extracts of *D. wallichii*. According to their results, it was concluded that the plant extracts of *D. wallichii* have potent antioxidant activity. Padhan et al. (2020) reported that results of DPPH radical scavenging activities revealed that, most of the yam extracts showed higher

scavenging activity. The antimicrobial activity of methanol, ethyl acetate and acetone leaf extracts of *D. wallichii* leaves against Gram positive bacteria, Gram negative pathogenic bacteria and fungus are carried out by Irulandi et al. (2016). Results revealed that the methanol extract showed the potent inhibitory effect against *E. coli* and *S. aureus* compared to positive control. Methanol and ethyl acetate extract did not show any inhibitory effect against *C. albicans*. Acetone extract showed minimum antimicrobial activity against all the test microbial organisms with a zone of inhibition of 9.0-18.33 mm.

Economic values: *D. wallichii* is one of the potent medicinal tuberous plants against diverse diseases and disorders along with rich nutrition, but there is very less or no documentation available on its economic values. As the tubers have both food and medicinal values, it could be used as a source of livelihood as well.

Future aspects: The world population is growing day by day, indicating the urgent need to get sufficient food and medicine to get rid of food problems and fatal pandemics. Yam is one of the leading staple foods for millions of people in tropical and subtropical countries. They possess food, medicinal, pharmacological as well as economic values. Tubers are rich in starch, and are often incorporated into the human diet. The tuber not only stores food but also many of the plants' secondary metabolites, which are commonly referred to as antinutritional factors. *D. wallichii*, an unexplored species of Yam, plays a vital role in the rural and tribal communities of different regions throughout the world. The antioxidant, antimicrobial activities and rich content of tannins, saponins, and total phenols in *D. wallichii* make it a strong nutraceutical food vine. The presence of Diosgenin in the tuber makes it an important ingredient in many local formulations as well as a prime component in the pharmaceutical industry. There is a major need for research in this unexplored yam species, its cultivation and also marketing. As there are very less or no reports on the economic values of this yam species prior to this present study, there is a need to create awareness, document and explore this species further among the rural and tribal people. This vine could be a better nutraceutical in the future. There is still no clear classification and in-depth studies on the chemical components of *D. wallichii* and their activities, so the pharmacological mechanism has not been understood well. Further studies are needed to evaluate and explore more potent bioactive compounds present in different parts of *D. wallichii* which might be specifically pharmacology and clinical applications. Cultivation and utilization of this plant should be encouraged. In this pandemic period, as people are giving greater importance to their food and health, this chapter would be valuable for promoting the development of *D. wallichii* as a safe modern nutraceutical.

Conclusion

D. wallichii is one of the major sources of food and medicines, containing bioactive compounds like alkaloids, flavonoids, coumarins, phenols, tannins, saponins, terpenoids, quinones catechins etc. used in traditional therapeutic practices for treating stomach pain, jaundice etc. Despite their great importance in human life, they are enlisted in the neglected tuber crops till date. The present study gives a way for

additional scientific research and field survey exploration works to lead to the discovery of new sources of drugs from this unexplored tuberous plant.

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Chapter 9
Past, Present and Future of Yam: a concluding summary

Anita N Dharasurkar, Kevileto Rote, Nabendu Pal, Rakhee Dimri and Sanjeet Kumar

Abstract: Yam is a common name of the species belonging to the genus *Dioscorea*, and family Dioscoreaceae. Mostly they produce starchy tubers which are used as food and medicines from centuries. The early food habits of ancient civilizations show the utilization and at present people of different countries are using them as food and medicine. In contemporary situation, we are forgetting and removing them from our food leading to lack of diseases preventive agents in our diet. The global health issues indicate that we need nutraceutical agents to combat the health related problems. Keeping the old golden era of Yam and decline of their uses, the chapter is designed to document their past & present utilization and how they could be beneficial agents for our future generation. The chapter gives us a brief knowledge about the past, present and future uses of Yam species.

Keywords: *Dioscorea*, Lost food, Future nutraceutical, Sustainability

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Introduction: Human civilization started from the discoveries of fire and knowing about the food from the nature including how to do hunting. In the process of searching food from plant wealth, tubers were the first in the list of food discoveries and priority of choice (Zucoloto 2011). The major reason behind it can be getting high energy food, easy to store for long time and high yield. Among tubers, the yam species could be the first discovery of edible tubers from the soil. Early writings and evidences of oldest civilization also indicated the same. Might be the practices of the consumption of these tubers were developed in same time among the tribal communities and some species were introduced by the early travelers. They had an idea about the importance and nutraceutical values of some yam species like *Dioscorea alata* and they were brought to different regions while travelling from place to place leading to naturalization of those tuberous plants in many regions of the world. Slowly the yam species became a food of limited communities and during civilization the urban people forgot them and started consumption of other crops and their products. The tribal communities of the world kept using those plants with diverse consumption methods and practices under food & medicine. Still, they are using them as food, medicine and a means of livelihood. They used to collect them and used to sell at local markets. From past 1-2 decades, it is noticed that the new generation of tribal communities are not interested to use them because of availability of many easy foods which might come under junk food or not related to season & landscapes leading to new health issues. This creates a fear of losing the traditional knowledge on Yam species permanently. There is a need to conserve through proper documentation on the consumption patterns and their importance, so that, the knowledge can be restored for future generation through awareness programmes and development of diverse schemes. Keeping the need of proper documentation and restoration of traditional practices on yam species, this chapter has been designed. The chapter addresses the past, present, and future aspects of Yam species. The chapter is also summary of the last 8 chapters of the book Yam.

History and distribution of Yam: Yam species might have originated in the Laurasian Palaearctic between the late Cretaceous and the early Eocene. In these periods, yam expanded to the southern region by long distance dispersal. Now they are widely distributed having sound phylogenetic tree, but number of biogeographical speciation events seems to have decreased after the quaternary period began (Cauto et al. 2018). The various *Dioscorea* species apparently followed a divergent evolution in three continents separated by the formation of the Atlantic Ocean and desiccation of the Middle East. As a result, the major species of *Dioscorea* occur in three isolated centers. West Africa, Southeast Asia and Tropical America. These centers are also considered as areas for independent yam cultivation, and represent considerable diversity. *D. alata* originated in Southeast Asia, more specifically in Tropical Myanmar and Thailand but now it is the most diversified and extensively distributed species. *D. bulbifera* is another most popular and native to Asia, tropical Africa and Northern Australia. *D. hispida* is distributed in tropical and sub tropical regions, Philippines,

China, Taiwan, Malaysia, Vietnam, Africa etc. *D. pubera* is native to Indo-China regions and distributed in temperate, tropical America, Himalayas, Nepal, China, Bhutan etc. *D. pentaphylla* is native to tropical Asia and Eastern Polynesia and distributed in South East Asia, Hawaii, North America, Florida etc. In India about only 40 species of Yam is reported (Coursey 1967; Hahn 1995; Tamiru 2006; Couto 2018; Kumar et al. 2017a; Mishra and Kumar 2021; Present study). Hence, there is need to do taxonomic work.

Botany of Yam: They are climbing herbs. Flowers are unisexual, rarely abnormally bisexual. Male flowers have perianth with 6 short lobes. Stamens are 6 or 3 alternating with staminodes. Pistillode is thick and fleshy or absent. In female flowers, usually perianth has 6 free segments. Ovary is three celled. Fruits are loculicidal, flattened, 3-winged capsule. Seeds are compressed with wings. They are fleshy or hard (Present study). The stem twining is an important key for the identification of *Dioscorea* species. There is a lack of detailed description of Yam species. The present work indicates that there is a need of taxonomic revision works.

Traditional uses of Yam: Yam (*Dioscorea alata*) is used to prepare the Prasad (Food offering to God) in many temples. It signifies that our ancestors had an idea about the potential of Yam species. It also brings attention that there is a need of exploration work in different sacred grooves and have to document the uses of yam species in making traditional holy food (Prasad) in India (Devi et al. 2019; Present study).

Food and Medicinal values of Yam: Almost all known *Dioscorea* species are used to cure different types of diseases and disorders. The tuber of *D. alata* is used to reduce the body temperature. The tuber paste is also applied to cure gonorrhea with neem leaves whereas the boiled tuber of *D. esculenta* is consumed to reduce the body weight. The boiled tuber of *D. pentaphylla* is consumed to reduce abdominal pain after delivery while the tuber of *D. pubera* is consumed as a tonic for good health. Tuber pastes of *D. bulbifera* is used to treat skin infections. The tuber juice of *D. villosa* is used to reduce the complications of menopause. The tuber paste is used to cure skin infections caused by fungus. Tuber juice of *D. hamiltonii* is used to cure food poisoning. These reports are very scanty and need to explore more and more to get the knowledge about the food and medicinal values of Yam available in India (Kumar et al. 2017b, 2017c; Kumar et al. 2012, 2013a, 2013b, 2015; Kumar and Jena 2014, 2017; Kumar 2015; Kumar 2017).

Economic values of Yam: Yam is a staple crop in many tropical countries and play an important role in providing livelihood. Some yam species are cultivated and about 72.6 million tons of global yam production is observed in 2018. The major cultivated yam species are *D. alata, D. trifida, D. esculenta, D. rotundata* and *D. polystachya*. *D. alata* and *D. rotundata* having high economic values from rural to international markets (Sugihara et al. 2021). In India, *D. alata* can be seen easily in regional markets but *D. hispida, D. pubera, D. bulbifera, D. pentaphylla* can be observed only in rural and tribal Indian weekly markets (Present study). The observation again indicates that there is a lack of marketing knowledge on Yam which has led to ignorance of their cultivation.

In this aspect, researchers must do work and in near future, Yam species must be grown like horticultural crops in India.

Yam & wildlife conservation: Tiger conservation is water conservation. The population of tiger and higher animals in food chain mostly depend on prey population. Prey population depend on food plants. Therefore, the availability of food plants play a vital role in ecological balance. The yam species are the food of many prey species in India. The tubers and leaves are consumed by the Barking deer, Spotted deer, Mouse deer, Wild boar and Porcupine. These species are the food of many carnivores. The tubers of Yam species are also consumed by the Asian elephant and Sloth beer too (Present study). Therefore, the conservation and maintenance of the yam population is important for wildlife and ecological balance.

Value addition of Yam: The value addition of yam is available in African & other countries (Figure 1). We have discussed here about the Indian yam species and addressed that there is an urgent need of value addition for sustainable development of rural and tribal people. Many countries have developed yam chips, flour, pickles, ice-cream, candy etc., but in India there is no or less products are available. The present study concluded that there is a big scope in India for the development of food products from Yam species.

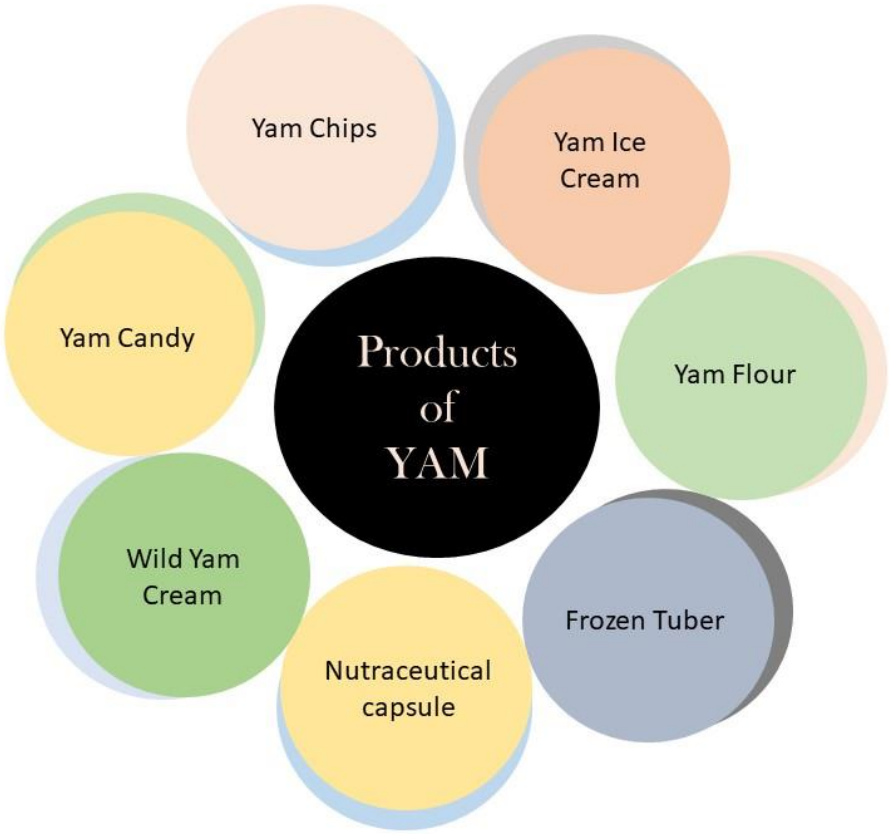

Figure 1: Products of Yam in different countries

Future aspects of Yam: The study and discussion on Yam among the authors and editors of the book Yam concluded that the following works could be carried out in future with yam species (Figure 2):

1. There is a need of exploration work in different states of India in general and particularly in Northeastern and Himalayan regions.
2. Documentation of traditional food and ethnomedicinal practices of Yam species among different communities of the country.
3. Documentation on relationship with wildlife and other floral species.
4. Evaluation of pharmacological values and characterization of active constituents followed by the formulation of future herbal drugs.
5. Development of functional food after reduction of toxic components from plant parts.
6. Research work needed to make them (selected species) horticultural crops.
7. There is a need to do value addition and with communities should develop food products like snacks, chips, pickles etc. to provide livelihood opportunity.

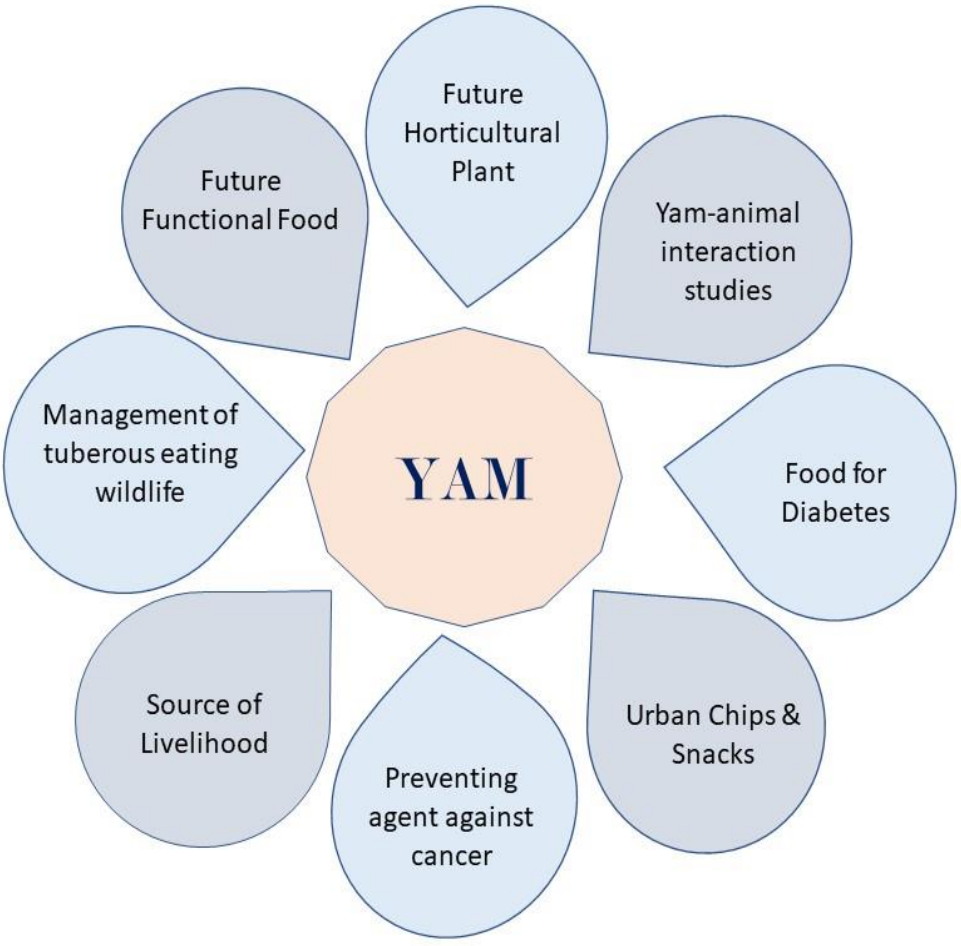

Figure 2: Future aspects of yam species available in India

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YAM

Since time immemorial, food and medicine are the basic needs of human beings. We are in the 21st century using all developed technologies in food and healthcare systems. Yet, we are facing the scarcity of these basic needs. At this juncture, addressing these problems and finding the best way to mitigate them has become the priority of almost all nations of the world. In this context, the book Yam is providing the basic knowledge of underutilized potent tuberous plants of India which can be nutraceuticals in high demand in future. The volume I of Yam discusses the problems, how to mitigate them and uses of locally available 8 yam species (*D. alata*, *D. bulbifera*, *D. pubera*, *D. hispida*, *D. pentaphylla*, *D. wallichii*, *D. oppositifolia* and *D. dumetorum*) of the country. It also highlights the importance of tribal communities and how they are interlinked to balance the sociocultural and socioecological bridges for sustenance of sound healthcare system and healthy environment with ecological security.

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