Cogent Biology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/oabi20

Dioscorea bulbifera, a highly threatened African medicinal plant, a review

Hilda Ikiriza, Patrick Engeu Ogwang, Emanuel L. Peter, Okella Hedmon, Casim Umba Tolo, Muwonge Abubaker & Ali Abdalla Mai Abdalla |

To cite this article: Hilda Ikiriza, Patrick Engeu Ogwang, Emanuel L. Peter, Okella Hedmon, Casim Umba Tolo, Muwonge Abubaker & Ali Abdalla Mai Abdalla | (2019) *Dioscorea bulbifera*, a highly threatened African medicinal plant, a review, Cogent Biology, 5:1, 1631561, DOI: 10.1080/23312025.2019.1631561

To link to this article: https://doi.org/10.1080/23312025.2019.1631561

© 2019 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

Published online: 28 Jun 2019.

Submit your article to this journal

Article views: 7110

View related articles

View Crossmark data

Citing articles: 5 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=oabi20

Ikiriza et al., *Cogent Biology* (2019), 5: 1631561
https://doi.org/10.1080/23312025.2019.1631561

cogent biology

PLANT SCIENCES | REVIEW ARTICLE

Dioscorea bulbifera, a highly threatened African medicinal plant, a review

Hilda Ikiriza[1]*, Patrick Engeu Ogwang[1,2], Emanuel L. Peter[1], Okella Hedmon[1], Casim Umba Tolo[1,3], Muwonge Abubaker[4] and Ali Abdalla Mai Abdalla[5]

Received: 13 November 2018
Accepted: 09 June 2019
First Published: 13 June 2019

*Corresponding author: Hilda ikiriza, Pharm Biotechnology and Traditional Medicine Centre of Excellence (ACE II), Mbarara University of Science & Technology, P.O Box 1410, Mbarara, Uganda.
E-mail: hilidaikiriza2@gmail.com

Reviewing editor:
David Popovich, Massey University, Palmerston North, New Zealand.

Additional information is available at the end of the article

Abstract: *Dioscorea bulbifera* bulbils are used in the treatment of Piles, dysentery, syphilis, ulcers, cough, leprosy, diabetes, asthma, and cancer. It is a raw material for contraceptives, and it is one of the most consumed yam species especially in West Africa. Unfortunately, this plant is at the verge of extinction because of increased harvest for medicinal purpose. This review aims at providing up-to-date information about its photochemistry, clinical benefits, conservation status and best possible way on how this plant can be conserved for future use. Literature database search was employed, and the findings indicate that much as *Dioscorea bulbifera* is of diverse clinical and ethnomedicinal benefits, it's vulnerable to extinction. In order to conserve *Dioscorea bulbifera*, there is a need to enlighten the local inhabitants on its clinical and commercial importance and uses. Also for the sustainable growth of the plant, the government and Non-governmental agencies have to distribute *Dioscorea* bulbils to the farmers for planting and also encourage its planting back into the wild. In addition, micropropagation of the *D. bulbifera* will be the perfect tool for re-establishing the plant in the natural habitat with more advantages of improving growth conditions of the plants.

ABOUT THE AUTHOR

Hilda Ikiriza is a Biotechnologist, and is currently a PhD student at Mbarara University of Science and Technology.
Casim Umba Tolo is a Senior lecturer Department of Biology, Faculty of Science and Centre Leader of Pharmbiotechnology and Traditional medicine centre (PHARMBIOTRAC) at Mbarara University of Science and Technology.
Patrick Engeu Ogwang is a senior lecturer Department of Pharmacy, Faculty of Medicine, Mbarara University of Science and Technology.
Abubaker Muwonge is a research scientist at National Crops Resources Research Institute, Namulonge.
Emanuel L. Peter is a research scientist with pharmacy background and a PhD student at Mbarara University of Science & Technology.
Okella Hedmon is a Biotechnologist and a PhD student at Mbarara University of Science & Technology.
Ali Abdalla Mai Abdalla is a Senior lecturer Department of Biochemistry and Molecular Biology, Faculty of science, Gezira University

PUBLIC INTEREST STATEMENT

Dioscorea bulbifera bulbil is a medicinal plant that treats diverse diseases and ailments. Its extract has been used as alternative contraceptive with the aim of reducing high population in the world. It is not clear how many varieties of this plant may be located in Uganda, but no documentation has been done and therefore this raises a need to characterize it. Also, a number of studies have indicated that this plant is slowly getting extinct; another reason to look for means of conserving it.

cogent oa

© 2019 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license..

Subjects: Management - Pharmaceutical Science; Biopharmaceutics; Natural Products

Keywords: Dioscorea bulbifera; medicinal; threatened

1. Introduction

The biggest percentage of the world's population (70%) depends on Traditional Health Care System to treat various diseases (World Health Organization [WHO], 2002). It is well proved that this kind of system of using herbal medicine offers minimal side effects (Firenzuoli & Gori, 2007) and is relatively of low cost as compared to other systems of conventional medicine thus becoming the preferred system by most patients in developing countries. This has led to overexploitation of medicinal plants for pharmaceuticals, herbal remedies, cosmetics and other natural products that have increased greatly in recent years (Batugal, Kanniah, Lee, & Oliver, 2004). This continuous harvesting practices and over-harvesting for production of medicines have led to degradation of genetic diversity of medicinal plants in the world to an alarming rates (Yadav, Singh, & Verma, 2012). Furthermore, extensive destruction of the plant-rich habitat as a result of forest degradation, agricultural encroachment and urbanization are other factors, that have challenged their existence (Bisht, Bhatt, & Dhar, 2006) and thus increasing the number of threatened plant species (Yadav et al., 2012).

Dioscorea bulbifera is one of the medicinal plants whose genetic resources in the world are getting into extinction due to habitat loss, climate change, overexploitation and poor natural regeneration since it is dioecious and chances of finding a fertile seed are automatically reduced (Otoo et al., 2015). *Dioscorea bulbifera* preparation has been used for memory enhancement, anti-aging, constipation and fever (Odugbemi, 2008), and has also been used as an infusion to apply to cuts and sores due to its high composition of the tannin that is used to hasten healing of wounds in a flamed membrane (Anona, Ezeabara, & Regina, 2018). In Cameroon and Madagascar, the pounded bulbils are applied to abscesses, boils and wound infections (Cogne, 2002). The bulbil of *D.bulbifera* has also been identified to contain saponin steroidal phytochemical called diosgenin that possess anti-fertility activity (Shajeela, Mohan, Louis Jesudas, & Tresina Soris, 2011) in addition to many other medicinal uses such as contraceptives, sexual vigour remedy and treatment of piles, dysentery, syphilis, ulcers, tuberculosis, leprosy, cough and diabetes (Table 1). The clinical significance varies greatly depending on the mode of preparations and the administration, hence the need for its conservation.

D.bulbifera has a faint odour and a bitter-salty taste. It contains a higher nutritional value compared to other *Dioscorea* species (Anona et al., 2018), with the highest levels of calcium, magnesium, sodium and zinc, highest values of vitamins B1, B3 and C and highest protein content. In spite of the great medicinal application and nutritional value of *D. bulbifera*, food preference is largely given to the flavour of other yam species. It has been left to the diabetic patients and people with other health conditions like obesity since they are more nutritious and less sweet (Okeke, Eneobong, Uzuegbunam, Ozioko, & Kuhnlein, 2008). This leaves it majorly as a staple food for hunters-gatherers living in the forest such as Pygmies in Central Africa and Abayanda in Uganda (Byarugaba, Ndemere, & Midgley., 2007). This has led to the near extinction status of this plant (Okeke et al., 2008) and therefore it is imperative to consider conserving this medicinally useful plant genetic resource.

2. Clinical benefits of dioscorea bulbifera

D. bulbifera (Family-Dioscoreacae) has been found to possess profound therapeutic potential. It is commonly used in traditional Indian, African and Chinese medicine in the treatment of sore throat (Sharma & Bastakoti, 2009), breast cancer (Anandpara & Tirgar, 2017), and type II diabetes mellitus (Ghosh et al., 2011, 2014, 2015,). Through clinical trials, it has been found that *D. bulbifera* has proved effective in the treatment of sub-acute thyroiditis (Nam, Cho, & Kim, 2006). Also, it has been proved that *D. bulbifera* could significantly induce apoptosis of HCT116 human colorectal carcinoma cells with ethyl acetate fraction (DBEAF) exhibiting the most compelling cytotoxicity on HCT116 cells with an IC50 of 37.91 ± 1.30 µg/mL (Hidayat, Fadhlurrahman, Chan, Mohamad, & Kadir, 2018), and it also has shown anti-helminthic activity against *Fasciola gigantica* and *Pheritima posthuma* at concentration of 100 mg/ml. (Adeniran & Sonibare, 2013).

Table 1. Ethnomedicinal uses of D.bulbifera

Plant part	Preparation	Mode of administration	Medicinal use	References
Bulbil	10 mg of dried bulbil powder is given in a day after menses for five days	oral	Contraceptive	(Das, Talukdar, Dutta Choudhury, & Talukdar, 2014; (Kamble et al., 2010); (Swarnkar & Katewa, 2008)
Bulbil	Bulbils are roasted, cooked as vegetable	topical application, oral	piles, dysentery, syphilis, and ulcers	(Dutta, 2015)
Bulbil	Bulbils are roasted, cooked as vegetable	oral	cough, leprosy, and diabetic	(Dutta, 2015)
Bulbil	Bulbils boiled 2–3 times with ash.	oral	tuberculosis	(Sharma & Bastakoti, 2009)
Bulbil	Bulbils boiled 2–3 times with ash.	oral	sore throat and struma	(Sharma & Bastakoti, 2009)
Bulbil	Bulbils are boiled	oral	sexual vigour food	(Subasini et al., 2013)
Bulbil	Bulbils are boiled	oral	wild food for HIV patients in Uganda	(Nabatanzi, 2016)

More so, *D. bulbifera* has proved to have Anti-HIV-1 integrase compounds. The ethyl acetate and water fractions (1–100 mg/mL) of *Dioscorea bulbifera* bulbils were isolated and tested for their anti-HIV-1 IN activity using the multiplate integration.

assay (MIA). The interactions of the active compounds with IN were investigated using a molecular docking method. Galloyl, catechol, and sugar moieties were found to be successful inhibitors for HIV-1 IN. (Chaniad, Wattanapiromsakul, & Pianwanit, 2016). *D. bulbifera* therefore stands a high chance as a candidate in the treatment of HIV. It's no wonder that it is one of the wild foods commonly eaten by the HIV patients as an accompaniment to staple foods (Nabatanzi, 2016). According to (Kuete et al., 2012), the methanol extract of *D. bulbifera* has an efficient anti-bacterial activity against multidrug resistant (MDR) bacteria like *Enterobacter aerogenes* EA289, CM64, *Klebsiella pneumoniae* KP63, *Pseudomonas aeruginosa* PA124, *Mycobacteria* strain and Staphylococcus aureus with the lowest MIC value for the methanol extract and fractions at 16 µg/mL. Their antioxidant and dehydroepiandrosterone activity in older humans has as well been reported by (Araghiniknam et al., 1996) whereby dioscorea supplementation increases serum dehydroepiandrosterone sulfate (DHEAS) in humans and modulate lipid levels in older people.

3. Phytochemistry D. bulbifera

Phytochemical analysis of *D. bulbifera* reveals the presence of saponins, tannins, flavonoids, sterols, polyphenols, glycosides (Ghosh, 2015) and steroidal saponins (Tapondjou, Jenett-Siems, Böttger, & Melzig, 2013). The phytochemicals present vary according to the geographical location, parts of a plant and the extraction solvents used. For example, extraction using Ethyl acetate soluble fraction of 75% ethanol extract of *Dioscorea bulbifera* from China has indicated the presence of flavonol aglycones, namely kaempferol-3, 5-dimethyl ether, caryatin, and catechin. It also contains flavonol glycosides, namely,quercetin-3-*O*-galactopyranoside,myricetin-3-*O*-galactopyranoside, and myricetin-3-*O*-glucopyranoside (Kuroyanagi et al., 2002). In addition, steroidal sapogenins named diosbulbisins A, B, C and D, spirostane glycosides named diosbulbisides A, B and cholestane glycoside named diosbulbiside C were found to be predominant in 95% ethanolic extract of rhizomes of China (Tapondjou et al., 2013). More so, the aqueous methanolic extract of bulbs of *Dioscorea bulbfera* from India contains 8-epidiosbulbin E acetate (EEA) (Shitole et al., 2008). Diosbulbin B is a demethyl diterpenoid found as

a main constituent of chloroform fraction (Kuroyanagi et al., 2002). Carotenoids such as lutein, zeaxanthin, neoxanthins are also prevalent in *D. bulbifera* (Ghosh, 2015). Methanolic extract of bulbils from Cameroon is found to be rich in clerodane diterpenoids, bafoudiosbulbins A, B, C, F and G (Kuete et al., 2012). Phytoalexin called demethylbatatasin IV and norditerpenoid diosbulbin D were isolated from bulbils from Nigeria and tubers from Bangladesh (Adesanya, Ogundana~, & Roberts~, 1989). Flowers of *D. bulbifera* from Cameroon has a wide range of steroidal saponins namely, dioscoreanosides A, B, C, D, E, F, G, H, I, J and K (Tapondjou et al., 2013).

4. Findings

Dioscorea bulbifera is made of diverse phytochemicals that contribute to its ethnomedicinal benefits and that these phytochemicals vary depending on the geographical location and the part of plant and type of solvent used in the extraction process.

Utilization of *Dioscorea bulbifera* greatly impacts on its conservation and sustainability. Its conservation can be done by promoting the utilization of *Dioscorea bulbifera* in order to encourage the farmers to cultivate them as in-situ/on-farm conservation in addition to conducting germplasm collection back up (Trimanto and Hapsari 2015). This is because characterization and proper evaluation of germplasm give reliable information that indicates a range of diversity in the collections, and this is of help to the breeders to select potential breeding stocks (Thomas & Mathur, 2003).

Finally, advanced Processing techniques need also to be explored and developed so that alternative products can be made from *Dioscorea bulbifera* bulbils which may be preferred by younger generation such as contraceptive capsules, and tablets to cure the mentioned ailments.

5. Conclusion

Dioscorea bulbifera has a wide spectrum of biological activities due to the chemical diversity, though it is not yet well utilised. There is a need for its conservation through increased utilization, evaluating and proper documentation of its germplasm and also adding value to its medicinal products.

Funding
The authors received no direct funding for this research.

Author details
Hilda Ikiriza[1]
E-mail: hilidaikiriza2@gmail.com
ORCID ID: http://orcid.org/0000-0001-5878-2111
Patrick Engeu Ogwang[12]
E-mail: pe7321@gmail.com
Emanuel L. Peter[1]
E-mail: epeterlyimo@gmail.com
Okella Hedmon[1]
E-mail: hedmono@gmail.com
Casim Umba Tolo[13]
E-mail: tolocas@must.ac.ug
Muwonge Abubaker[4]
E-mail: wamuwonge@gmail.com
Ali Abdalla Mai Abdalla[5]
E-mail: maiadil@yahoo.com
[1] Pharm Biotechnology and Traditional Medicine Centre of Excellence (ACE II), Mbarara University of Science & Technology, P.O Box 1410, Mbarara, Uganda.
[2] Department of Pharmacy, Faculty of Science, Mbarara University of Science and Technology, P.o.Box 1410, Mbarara, Uganda.
[3] Department of Biology, Faculty of Science, Mbarara University of Science and Technology, P.o.Box 1410, Mbarara, Uganda.
[4] National Agricultural Research Organization (NARO), National Crops Resources Research Institute (NaCRRI), P. O. Box 7084, Kampala, Uganda.
[5] Department of Biochemistry and Molecular Biology, Faculty of Science, Gezira University, P.o.Box 20, Wad Medani, Sudan.

Authors contribution
All authors read and approved the final manuscript.

Conflict of interests
No pontential conflict of interest was reported by the author.

Citation information
Cite this article as: *Dioscorea bulbifera*, a highly threatened African medicinal plant, a review, Hilda Ikiriza, Patrick Engeu Ogwang, Emanuel L. Peter, Okella Hedmon, Casim Umba Tolo, Muwonge Abubaker & Ali Abdalla Mai Abdalla, *Cogent Biology* (2019), 5: 1631561.

Correction
This article has been republished with minor changes. These changes do not impact the academic content of the article.

References

Adeniran, A. A., & Sonibare, M. A. (2013). In vitro potential anthelmintic activity of bulbils of Dioscorea bulbifera L. on earthworms and liverflukes. *Journal of Pharmacognosy and Phytotherapy*, *5*(12), 196–203.
Adesanya, S. A., Ogundana~, S. K., & Roberts~, M. F. (1989). Dihydrostilbene phytoalexins from dioscorea bulbifera and d. dumentorum. *Phytochemistry*, *28*(3), 4–5.

Anandpara, R. C., & Tirgar, P. R. (2017). Investigation of therapeutics benefits of Dioscorea bulbifera in breast cancer. *Journal of Chemical and Pharmaceutical Research*, *9*(6), 313–326.

Anona, C. A., Ezeabara, & Regina, O. (2018). Comparative analyses of phytochemical and nutritional compositions of four species of Dioscorea. *Acta Scientific Nutritional Health*, *2*(7), 90–94.

Araghiniknam, M., Chung, S., Nelson-White, T., Eskelson, C., & Watson, R. R. (1996). Antioxidant activity of Disoscorea and Dehydroepiandrosterone (DHEA) in older humans. *Life Sciences*, *59*(11), 8795709. doi:10.1016/0024-3205(96)00396-7

Batugal, P. A., Kanniah, J., Lee, S. Y., & Oliver, J. T. (2004). 1 international plant genetic resources institute. In P. A. Batugal, J. Kanniah, S. Y. Lee, and J. T. Oliver (Eds.), *Medicinal plants research in Asia Volume I: The framework and project workplans* (p. 9).

Bisht, A., Bhatt, R. R., & Dhar, U. (2006). Prioritization and conservation of himalayan medicinal plants: Angelica Glauca Edgew. as a case study. *Ethnobotany Reseach & Application*, *4*, 11–23. doi:10.17348/era.4.0.11-24

Byarugaba, D., Ndemere, P., & Midgley., J. (2007). The vulnerability and resilience of Dioscorea species in utilized and nonutilized zones of bwindi impenetrable national park. *African Journal of Ecology*, *45*(3), 258–264. doi:10.1111/aje.2007.45.issue-3

Chaniad, P., Wattanapiromsakul, C., & Pianwanit, S. (2016). Anti-HIV-1 integrase compounds from Dioscorea bulbifera and molecular docking study. *Pharmaceutical Biology, 54*, 0209.

Cogne, A.-L. (2002). Phytochemical investigation of plants used in African traditional medicine: Dioscorea Sylvatica (Dioscoreaceae), Urginea Altissima (Liliaceae), Jamesbrittenia Fodina and Jamesbrittenia Elegantissima (Scrophulariaceae). 208.

Das, B., Talukdar, A. D. A. S., Dutta Choudhury, M., & Talukdar, A. D. A. S. (2014). A few traditional medicinal plants used as antifertility agents by ethnic people of Tripura, India. *International Journal of Pharmacy and Pharmaceutical Sciences*, *6*(3), 47–53.

Dutta, B. (2015). Food and medicinal values of certain species of Dioscorea with special reference to Assam. *Journal of Pharmacognosy and Phytochemistry*, *3*(4), 15–18.

Firenzuoli, F., & Gori, L. (2007). Herbal medicine today: Clinical and research issues. *Evidence-Based Complementary and Alternative Medicine*, *4*(s1), 37–40. doi:10.1093/ecam/nem096

Ghosh, S. (2015). Phytochemsitry and therapeutic potential of medicinal plant: Dioscorea bulbifera. *Medicinal Chemistry*, *5*(4), 160–172. doi:10.4172/2161-0444

Ghosh, S., Ahire, M., Patil, S., Jabgunde, A., Dusane, M. B., Bimba, N., … Dhavale, D. D. (2011). Antidiabetic activity of gnidia glauca and Dioscorea bulbifera: Potent amylase and glucosidase inihibitors. *Evidence-based Complementary and Alternative Medicine*, *2012*, 1–7.

Ghosh, S., More, P., Derle, A., Patil, A. B., Markad, P., Asok, A., ., … Dhavale, D. D. (2014). Diosgenin from Dioscorea bulbifera: Novel hit for treatment of type ii diabetes mellitus with inhibitory activity against α -amylase and α -glucosidase. *PloS one*, *9*(9), 2–13.

Hidayat, A., Fadhlurrahman, A., Chan, C. K., Mohamad, J., & Kadir, H. A. (2018). Dioscorea bulbifera induced apoptosis through inhibition of ERK 1/2 and activation of JNK signaling pathways in HCT116 human colorectal carcinoma cells. *Biomedicine and Pharmacotherapy*, *104*(April), 806–816. doi:10.1016/j.biopha.2018.05.073

Kamble, S. Y., Patil, S. R., Sawant, P. S., Sawant, S., Pawar, S. G., & Singh, E. A. (2010). Studies on plants used in traditional medicine by *Bhilla* Tribe of Maharashtra. *Indian Journal of Tradisional Knowledge*, *9*(3), 591–598.

Kuete, V., BetrandTeponno, R., Mbaveng, A. T., Tapondjou, L. A., Meyer, J. J. M., Barboni, L., & Lall, N. (2012). Antibacterial activities of the extracts, fractions and compounds from Dioscorea bulbifera. *BMC Complementary and Alternative Medicine*, *12*, 1–12. doi:10.1186/1472-6882-12-228

Kuroyanagi, M., Kuroyanagi, M., Wu, L., Kawahara, N., Yasuno, T., & Nakamura, Y. (2002). Antitumor-promoting constituents from Dioscorea bulbifera L. in JB6 mouse epidermal cells. *Biological & Pharmaceutical Bulletin*, *25*(9), 1241–1243. doi:10.1248/bpb.25.1241

Nabatanzi, A. (2016). Wild food plants used by people living with hiv/aids in nakisunga sub-county, uganda. *African Journal of Food, Agriculture, Nutrition and Development*, *16*, 11310–11330.

Nam, H.-S., Cho, S.-S., & Kim, C.-J. (2006). The effects of Dioscorea bulbifera L. on hyperthyroidism of rats. *Journaol of Korean Oriental Medicine*, *27*(3), 179–187.

Odugbemi, T. (2008). *A textbook of medicinal plants from Nigeria*. University of Lagos Press.

Okeke, E. C., Eneobong, H. N., Uzuegbunam, A. O., Ozioko, A. O., & Kuhnlein, H. (2008). Igbo traditional food system: Documentation, uses and research needs. *Pakistan Journal of Nutrition*, *7*(2), 365–376. doi:10.3923/pjn.2008.365.376

Otoo, E., Opoku Agyeman, M., Dansi, A., Aboagye, L. M., Acheremu, K., & Tetteh, J. P. (2015). Increasing farmers and breeders access to yam (Dioscorea Spp) Diversity: The case of forest-savannah transition agroecology. *African Journal of Agricultural Research*, *10*(8), 772–782. doi:10.5897/AJAR

Shajeela, P. S., Mohan, V. R., Louis Jesudas, L., & Tresina Soris, P. (2011). Antifertility acitivity of ethanol extract of Dioscorea esculenta (L .) schott on male albino rats. *International Journal of PharmTech Research CODEN*, *3*(2), 946–954.

Sharma, L. N., & Bastakoti, R. (2009). Ethnobotany of Dioscorea L. with emphasis on food value in chepang communities in Dhading District, Central Nepal. *Journal of Plant Science*, *6*(2009), 12–17.

Shitole, M. G., Jahagirdar, S., Latha, C., Kumar, V., Puranik, V., Rojatkar, S., … Shitole, M. G. (2008). A potential plasmid-curing agent, 8-Epidiosbulbin E Acetate, from Dioscorea bulbifera L. against multidrug-resistant bacteria. *International Journal of Antimicrobial Agents*, *32*(5), 405–410. doi:10.1016/j.ijantimicag.2008.05.013

Subasini, U., Thenmozhi, S., Sathyamurthy, D., Vetriselvan, S., Victor Rajamanickam, G., & Dubey, G. P. (2013). Pharmacognostic and phytochemical investigations of Dioscorea bulbifera L. *International Journal of Pharmaceutical and Life Sciences (IJPLS)*, *4*(5), 2693–2700.

Swarnkar, S., & Katewa, S. S. (2008). Ethnobotanical observation on tuberous plants from tribal area of Rajasthan (India). *Ethnobotanical Leaflets*, *12*, 647–666.

Tapondjou, L. A., Jenett-Siems, K., Böttger, S., & Melzig, M. F. (2013). Steroidal saponins from the flowers of Dioscorea Bulbifera Var. Sativa. *Phytochemistry*, *95*, 341–350. doi:10.1016/j.phytochem.2013.07.020

Thomas, T. A., & Mathur, P. N. (2003). Germplasm evaluation and utilisation – In *Plant genetic resources*

conservation and management concepts and approaches (pp. 180–216). New Delhi: National Bureau of plant Genetic Resources.

Trimanto, T, & Lia Hapsari, L. (2015). Diversity and utilization of Dioscorea Spp. Tuber as alternative food source in nganjuk regency, East Java. *Agrivita*, *37* (2), 97–107.

World Health Organization (WHO). (2002). *WHO traditional medicine strategy 2002-2005*. World Health Organisation Geneva, 1–74.

Yadav, K., Singh, N., & Verma, S. (2012). Plant tissue culture: A biotechnological tool for solving the problem of propagation of multipurpose endangered medicinal plants in India. *Journal of Agricultural Technology*, *8*(1), 305–318.

© 2019 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license..

You are free to:
Share — copy and redistribute the material in any medium or format.
Adapt — remix, transform, and build upon the material for any purpose, even commercially.
The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:
Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.
You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

Cogent Biology **(ISSN: 2331-2025) is published by Cogent OA, part of Taylor & Francis Group.**

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com