



Nutritional profiling of wild areal tubers of *Dioscorea bulbifera* L. from Maharashtra, India

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Abstract

Dioscorea bulbifera is a wild twiner from family Dioscoreaceae with edible areal tubers. The forest dwellers and tribals were found to use these tubers as food during food crises, especially in Asian and African countries. Present study is an attempt to analyze nutritional profile (the physico-chemical, proximate content, amino acid profile, mineral and vitamin content) and phytochemicals in the edible areal tubers of *D. bulbifera* collected from three different forest areas of Maharashtra (India). It was found that, the tubers contains significant amount of proximate content, minerals and vitamins with good amino acid profile, but also noted to have some anti-nutrient factors like phytic acid. Hence, it is suggested that aerial tubers of this plant could be effectively use as supplementary food material during food scarcity.

Keywords: amino acids, *Dioscorea bulbifera*, minerals, proximate content, vitamins

Introduction

Dioscorea bulbifera is a wild edible tuber plant species from family Dioscoreaceae (Yam family). The genus *Dioscorea* comprises over 600 species worldwide (Amanze *et al.*, 2011) [1] and reported as native of South Africa. The areal as well as underground tubers of most of the species were found to be utilized by the local and tribal communities across the world as a source of food especially in food crises. Out of these, 10 species of *Dioscorea* were reportedly cultivated, mostly in African countries like Nigeria and Ghana (Obidiegwu, *et al.*, 2020) [33].

About 26 species of *Dioscorea* were reported from Indian subcontinent (Kumar *et al.*, 2012) [27]. Major *Dioscorea* species includes *D. alata*, *D. belophylla*, *D. bulbifera*, *D. esculenta*, *D. hispida*, *D. pentaphylla*, *D. wallichii* and *D. spinosa*. Off these, *D. bulbifera* is the most common species in Central India including Maharashtra.

The tubers of *D. bulbifera* were used by different tribal communities for intestinal colic problem, relieving dysmenorrhoea, reducing acidity, against rheumatoid arthritis, to relieve intense inflammation, in spasmodic asthma, for menopausal problems, for labor pain and the prevention of early miscarriage and to check diarrhea (Nayak *et al.*, 2004; Bhogaonkar and Kadam, 2006; Mehta and Bhatt, 2007; Kamble *et al.*, 2010; Jadhav *et al.*, 2011 and Datta, 2015) [31, 5, 29, 21, 18, 10]. Apart from this the most important is nearly all local and tribal communities use the areal tubers as source of nutrition, especially in food crises and as nutritional aid to regular diet. These tubers are also found in the local India markets for sale during early summer season.

The present study is focused on nutritional profiling of *D. bulbifera* aerial tubers collected from three different forest ranges from Maharashtra India. It include physico-chemical, proximate analysis, mineral and vitamin analysis and phytochemical study to identify major medicinally important as well as anti-nutrient factors present in the tubers of *D. bulbifera*.

Material and Methods

Collection of tubers and Preparation of samples

The tubers of *Dioscorea bulbifera* were collected from three different forests zones of Maharashtra, India i.e. Katepurna Wildlife Sanctuary, District Akola (Sample- A), Nagzira Wildlife Sanctuary, District Gondia (Sample- B) and Tadoba Wildlife Sanctuary, District Chandrapur (Sample- C) during February 2017. The plants were identified using flora of Marathwada (Naik, 1998) [30] and flora of Maharashtra (Singh and Karthikeyan, 2000) [44]. Medium sized tubers were selected for experimentation. About 15 tubers were collected from each selected forest range for study. Each tuber is washed thoroughly, cleaned, peeled and cut into thin slices. These slices were oven dried (at 60°C for 48 Hrs) and packed into airtight polybags until use. Before analysis, the dried slices were ground into fine powder, that was sieved through mesh of 200 μ m and dried further at 100°C until achieve constant weight.

Physico-chemical and Proximate analysis

The moisture content of tuber and ash value were determined using standard protocols (AOAC, 1990) [3]. For crude protein content, the samples were digested using Kjeldahl and nitrogen content was detected by the method of Devani (1989) [8] and then the crude protein was calculated by multiplying the nitrogen content by conversion factor 6.25. The carbohydrate content was determined by anthrone method (Sadasivam and Manikam, 2005) [37]. Other proximate contents were determined by using protocols and guidelines of AOAC (1990) [3].

Amino acid profiling

The extraction of the samples to analyze amino acid content was done as per AOAC (2010) [2]. 5g sample was taken in 250 mL flask and defatted by extracting the fat content of the sample with 30 mL of petroleum ether. The sample was hydrolyzed, evaporated and then loaded into biochemical amino acid analyzer (Sykam S430).

Minerals and Vitamin analysis

The mineral analysis of the powdered tuber samples was done using Atomic absorption spectroscopy. For mineral analysis, the method of Karpiuk *et al.*, (2016) [22] was followed. The standards stock solutions of each metal element (1000mg/L) were used to prepare the requisite concentrations of dilutions using nitric acid solution (1% v/v). All the standards and reagents required (AR grade) were procured from Sigma- Aldrich and ultrapure deionized water for preparing solutions. The instrument (Perkin Elmer AAnalyst 8000 model) with deuterium corrector was used for mineral analysis. The operating parameters were as per the recommendations of manufacturer. For the analysis of Vitamin A, and Vitamin E was done by method of Kirk and Sawyar (1998) [23] and other vitamins in powdered samples were analyzed as per modified method of Koche (2011) [24].

Phytochemical analysis

The quantitative phytochemical analysis of powder of *D. bulbifera* tubers was done using the method of Ezeonu and Ejikeme (2016) [11]. For the present study alkaloids, phenolic compounds, tannins, saponins and phytic acid was quantified.

Result and Discussion

Food and nutritional security is one the major challenges of this era. To meet the demand of food for all, we have to identify some alternative sources of food and nutrition or at

least some supplements. The present study is an attempt to present a wild tuber plant *Dioscorea bulbifera* as an alternative source of food or supplementary food.

Physic-chemical and Proximate content

Moisture content of tubers in the form of water content in fresh material was found in the range of 57.25 ± 0.32 to 62.25 ± 0.21 % with highest content in sample-C. The ash value of analyzed samples were found in the range of 1.65 ± 0.01 to 1.85 ± 0.11 % and highest ash value was noted for the sample-A. The crude protein content was highest in sample- A (12.68 ± 0.03 g/100 g DM) and lowest in sample- C (10.08 ± 0.01 g/100 g DM). The carbohydrate content was found highest in sample- B (78.20 ± 0.02 g/100g DM) and least in sample- C (72.50 ± 0.05 g/100g DM). Crude fiber content in three samples was in the range of 1.95 ± 0.11 to 2.25 ± 0.03 g/100g DM and crude fat content was noted in the range of 0.65 ± 0.02 to 0.78 ± 0.05 g/100g DM. The Soluble sugar was noted highest in the sample – A and least in the sample-C. The energy calculated per 100 g dry matter was highest in the sample-B (382 ± 0.20 Kcal/100 g DM) followed by in sample- A and sample- C respectively (table-1). The difference in proximate content of three samples of tubers might be due to bioavailability, physical properties of soil, soil pH and soil composition (Jung, 2008 and Soetan *et al.*, 2010) [20, 45]. Our results are in analogy with the report of Zelalem and Shisho (2019) [47].

Table 1: Comparative Proximate composition of *Dioscorea bulbifera* areal tuber samples collected from different forests of MS India

Composition	Content		
	Sample- A	Sample- B	Sample- C
Water content (% fresh wt.)	57.25 ± 0.32	60.55 ± 0.25	62.25 ± 0.21
Ash values (%)	1.85 ± 0.11	1.65 ± 0.01	1.72 ± 0.03
Crude Protein (g/100g DM)	12.68 ± 0.03	11.28 ± 0.03	10.08 ± 0.01
Carbohydrate (g/100g DM)	73.50 ± 0.05	78.20 ± 0.02	72.50 ± 0.05
Crude fiber (g/100g DM)	2.25 ± 0.03	1.95 ± 0.11	2.10 ± 0.02
Fats (g/100g DM)	0.78 ± 0.05	0.65 ± 0.02	0.68 ± 0.02
Soluble sugars (g/100g DM)	0.25 ± 0.02	0.22 ± 0.02	0.20 ± 0.00
Energy (Kcal/ 100 g DM)	375 ± 0.80	382 ± 0.20	377 ± 0.85

Values are means \pm SE of replicates (n = 3)

Amino acid analysis

Total eleven amino acids were analyzed and quantified. The analyzed amino acids include alanine, aspartic acid, Cysteine, glycine, glutamic acid, isoleucine, leucine, methionine, phenylalanine, proline and tryptophan. Amongst all the analyzed amino acids, all three samples showed highest amount of leucine (5.77 ± 0.03 to 5.97 ± 0.28 mg/g DM) followed by glutamic acid (5.66 ± 0.11 to 5.86 ± 0.15 mg/g DM) and aspartic acid (5.20 ± 0.15 to 5.30 ± 0.33 mg/g DM) respectively. The amino acid which showed the least amount amongst all analyzed amino acids was cysteine (0.60 ± 0.10 to 0.65 ± 0.11 mg/ g DM). Table-2 showed the amount of different amino acids analyzed in tuber powder of *D. bulbifera*. It was found that all three samples analyzed showed insignificant difference in the level of amino acids. Doss *et al.*, (2019) [9] have studied amino acid in nine *Dioscorea* species including *D. bulbifera* and suggested that the tubers are good source of amino acids. Thus our results are in line to demonstrate that the tubers are with significant level of amino acids and could be utilize as their natural source as supplementary diet.

Table 2: Comparative Amino acid composition of *Dioscorea bulbifera* areal tuber samples collected from different forests of MS India

Amino acid	Content		
	Sample- A	Sample- B	Sample- C
Alanine (mg/g DM)	3.22 ± 0.33	3.02 ± 0.12	3.15 ± 0.03
Aspartic acid (mg/g DM)	5.25 ± 0.45	5.30 ± 0.33	5.20 ± 0.15
Cysteine (mg/g DM)	0.65 ± 0.11	0.60 ± 0.10	0.60 ± 0.15
Glycine (mg/g DM)	3.15 ± 0.25	3.12 ± 0.02	3.18 ± 0.22
Glutamic acid (mg/g DM)	5.86 ± 0.15	5.85 ± 0.11	5.66 ± 0.11
Isoleucine (mg/g DM)	2.26 ± 0.18	2.22 ± 0.10	2.20 ± 0.10
Leucine (mg/g DM)	5.97 ± 0.28	5.90 ± 0.18	5.77 ± 0.03
Methionine (mg/g DM)	0.85 ± 0.11	1.15 ± 0.09	0.80 ± 0.11
Phenylalanine (mg/g DM)	3.95 ± 0.25	3.92 ± 0.22	3.85 ± 0.05
Proline (mg/g DM)	2.58 ± 0.29	2.51 ± 0.11	2.45 ± 0.09
Tryptophan (mg/g DM)	0.78 ± 0.11	0.75 ± 0.01	0.79 ± 0.03

Values are means \pm SE of replicates (n = 3)

Mineral content

Eight mineral elements (Ca, Cu, Fe, K, Mg, Mn, Na and Zn) were analyzed for their availability in tubers of *D. bulbifera*. In three analyzed samples, Calcium (Ca) was recorded in the range of 72.10 to 78.60 μ g/100g with highest in sample

A. Copper (Cu) content of the analyzed samples was found in the range of 11.33 to 12.59 $\mu\text{g}/100\text{g DM}$ with highest in sample-B. Iron (Fe) content of the three samples of tubers of *D. bulbifera* was noted in the range of 13.12 to 13.25 $\mu\text{g}/100\text{g DM}$. There is not much difference in the level of Iron in analyzed samples (table-3). Potassium (K) content was found in the range of 33.12 to 33.42 $\mu\text{g}/100\text{g DM}$ in three analyzed tuber samples of *D. bulbifera*, with highest in sample-A. The magnesium (Mg) content of the three samples of *D. bulbifera* was noted in the range of 21.12 to 22.48 $\mu\text{g}/100\text{g DM}$ and Manganese (Mn) content in the dry mater of tuber was noted in the range of 0.60 to 0.69 $\mu\text{g}/100\text{g DM}$. In the analyzed samples Sodium (Na) content was found to be in the range of 43.25 and 44.12 $\mu\text{g}/100\text{g DM}$ and The zinc (Zn) content of the tubers of *D. bulbifera* was noted in the range of 2.21 to 2.84 $\mu\text{g}/100\text{g DM}$. Calcium is necessary for the blood coagulation and bone health and also to regulate acidity (Garcia-Chuit and Boella, 1993 and Jacques *et al.*, 2016) [14, 19]. Several reports indicated that copper is necessary for boosting immunity, host defense, as iron career and in brain development (Uauy *et al.*, 1998; Olivares *et al.*, 2000 and Seal *et al.*, 2020) [40]. Further, the iron content play vital role in improving general

health and oxygen carrying capacity of RBCs, further its proper intake is essential to women during pregnancy (Kordas and Stoolzfus, 2004 and Saikia *et al.*, 2013). Similarly, Potash is one of the important elements related to heart activities and also regulation of the blood pressure and body water content (Jacques *et al.*, 2016 and Seal *et al.*, 2020) [19, 40]. Magnesium is essential for synthesis of proteins and nucleic acids and also for proper vascular functioning. It is also a co-factor for over 350 enzyme catalyzed metabolic cellular reactions. Further, Sodium is important for Na/ K and promote health at risk for chronic diseases (Jacques *et al.*, 2016) [19] and Zinc in one of the most essential mineral boosting the general health, improve cellular immunity and growth (Seal *et al.*, 2020) [40]. The mineral content in three different tuber samples of *D. bulbifera* is presented in table-3. The values represent the mean of triplicate analysis. Jacques *et al.*, (2016) [19] reported higher level of Ca, Cu, Fe, Mg and Zn in the tubers of *D. bulbilis* from African forest. Similar report was presented by Mansfria *et al.*, (2019) [32] on mineral analysis of *D. hispida*. Our study results are in analogy of these reports indicating that the aerial tubers of *D. bulbifera* contain significant amount of major mineral elements.

Table 3: Comparative Mineral composition of *Dioscorea bulbifera* areal tuber samples collected from different forests of MS India

Mineral	Content ($\mu\text{g}/100\text{g DM}$)			Mineral	Content ($\mu\text{g}/100\text{g DM}$)		
	Sample- A	Sample- B	Sample- C		Sample- A	Sample- B	Sample- C
Ca	78.60 \pm 0.05	75.00 \pm 0.00	72.10 \pm 0.01	Mg	22.48 \pm 0.05	22.28 \pm 0.05	21.12 \pm 0.03
Cu	11.38 \pm 0.03	12.59 \pm 0.03	11.33 \pm 0.01	Mn	0.69 \pm 0.03	0.60 \pm 0.03	0.65 \pm 0.01
Fe	13.25 \pm 0.05	13.12 \pm 0.02	13.18 \pm 0.02	Na	43.25 \pm 0.05	44.12 \pm 0.11	43.40 \pm 0.03
K	33.42 \pm 0.09	31.12 \pm 0.05	31.18 \pm 0.05	Zn	2.85 \pm 0.15	2.54 \pm 0.09	2.21 \pm 0.05

Values are means \pm SE of replicates (n = 3)

Vitamin content

The details of vitamin content of three samples to powdered tubers of *D. bulbifera* are presented in table-4. The results indicate that all three samples have highest amount of vitamin C as compare to other vitamins and least content of thiamin. Moreover, it showed that the tuber contain significant amount of vitamin A, vitamin C, vitamin E, niacin, riboflavin and thiamin. The high content of vitamin

C indicates that the tuber might have high antioxidant potential and could help in higher absorption of Iron (Roger, 1999). The plants with significant amount of vitamin C could be used to decrease atherosclerosis and few types of cancers (Rekha *et al.*, 2012). Availability all tested vitamins in the tubers indicates its usefulness as supplementary food. The plants with natural vitamins availability could be used in dietary system (Seal *et al.*, 2020) [40].

Table 4: Comparative Vitamin composition of *Dioscorea bulbifera* areal tuber samples collected from different forests of MS India

Vitamin	Content		
	Sample- A	Sample- B	Sample- C
Vitamin A (mg/g DM)	0.35 \pm 0.01	0.41 \pm 0.11	0.38 \pm 0.03
Vitamin C (mg/g DM)	1.25 \pm 0.05	1.28 \pm 0.03	1.28 \pm 0.05
Vitamin E (mg/g DM)	0.42 \pm 0.11	0.41 \pm 0.11	0.38 \pm 0.15
Niacin (mg/g DM)	0.15 \pm 0.00	0.17 \pm 0.01	0.17 \pm 0.01
Riboflavin (mg/g DM)	0.06 \pm 0.01	0.06 \pm 0.01	0.05 \pm 0.01
Thiamin (mg/g DM)	0.04 \pm 0.00	0.03 \pm 0.01	0.04 \pm 0.02

Values are means \pm SE of replicates (n = 3)

Phytochemical analysis

The major phytochemicals analyzed for the present study includes alkaloids, phenolics, flavonoids, phytic acid, saponins and tannin. The analyzed phytochemicals in *D. bulbifera* tuber is presented in table-5. It showed no significant difference in the amount of phytochemicals in all three samples. All samples showed highest amount of saponins followed by tannins, phytic acid, phenolics, flavonoids and alkaloids respectively. The availability of significant amount of phenolics and flavonoids at one side

play role in plant defense and also can contribute as nutrient. However, the amount of phytic acid is cause of concern as its higher level reduces the availability of proteins and minerals at consumer end. Subhas *et al.*, (2012) [46] reported the phytochemical analysis of *D. bulbifera* tubers and earlier Santhakumar (2008) [42] and Shajila *et al.*, (2011) [41] and Ifeanacho *et al.*, (2017) [16] reported the nutritional and toxic properties of *Dioscorea* species. Our report is analogous with these reports. However, the tubers has potential to be used as supplementary food item.

Table 5: Comparative Phytochemical analysis of *Dioscorea bulbifera* areal tuber samples collected from different forests of MS India

Phytochemical	Content		
	Sample- A	Sample- B	Sample- C
Alkaloids (mg/100g DM)	0.75 ± 0.03	0.78 ± 0.10	0.72 ± 0.02
Flavonoids (mg/100g DM)	1.62 ± 0.11	1.58 ± 0.01	1.61 ± 0.15
Phenolics (mg/100g DM)	1.85 ± 0.05	1.81 ± 0.03	1.80 ± 0.05
Phytic acid (mg/100g DM)	1.78 ± 0.15	1.75 ± 0.05	1.73 ± 0.03
Saponins (mg/100g DM)	3.52 ± 0.15	3.45 ± 0.05	3.50 ± 0.15
Tannins (mg/100g DM)	2.25 ± 0.05	2.28 ± 0.02	2.27 ± 0.03

Values are means ± SE of replicates (n = 3)

Conclusion

The results indicate that the areal tuber of *D. bulbifera* has significant proximate content with good amino acid profile, significant amount of minerals and vitamins and also have richness in phytoconstituents. However, the calculated proximate, mineral and vitamin content is comparatively less as per Dietary Reference Index (DRI). Further, it also possesses some antinutrients like phytic acid which reduces the availability of proteins and minerals at consumer level. Therefore, it is stated that this tuber should not be used as main diet solely; however, could be effectively use as supplementary food item at least during the time of food scarcity.

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