Science Frontiers
2024, Vol. 5, No. 1, pp. 43-51
https://doi.org/10.11648/j.sf.20240501.16

Research Article

Phytochemicals and Selected Elemental Analysis of *Dioscorea bulbifera* Bulbils: An Uncommon Yam in Nigeria

Victoria Bennett[1, *], Bamidele Amos-Tautua[2], Nimibofa Ayawei[3]

[1]Department of Chemical Sciences, Faculty of Basic and Applied Sciences, University of Africa, Toru-Orua, Nigeria
[2]Department of Chemical Sciences, Faculty of Science, Niger Delta University, Amassoma, Nigeria
[3]Department of Chemistry, Faculty of Science, Medical University, Onopa, Nigeria

Abstract

The objective of the study was to investigate the biochemical content of *Dioscorea bulbifera* bulbils, commonly known as Arial yam, collected from Agbura, Yenagoa, Bayelsa State, Nigeria. Proximate analysis showed 26% moisture content, which is moderate and slightly higher than amount reported in the literature. Ash content was 15.41%, indicating a moderately high mineral content compared to previous reports. The bulbils contained 2.6% protein, 24% carbohydrates, 0.12% fat, and 31.87% fiber respectively. The carbohydrate content suggests that the bubils can be a good source of energy, and the high fiber content is beneficial for digestive health and weight management. Mineral analysis showed 105.48 mg/l Potassium (K), 1.30 mg/l Iron (Fe), 108.11 mg/l Sodium (Na), 11.00 mg/l Copper (Cu), 0.01 mg/l Magnesium (Mg), 0.327 mg/l Zinc (Zn) and 0.02 mg/l Phosphorus. GC-MS spectrum of hexane extract of the bulbils showed 48 different peaks, indicating the presence of 48 bioactive compounds. Some of these bioactive compounds, such as Prenol and 2H-Pyran, 2-(3-butynyloxy)tetrahydro, exhibit antimicrobial properties. This research also revealed that *D. bulbifera* bubils contain toxic compounds, such as 2-Propenoic acid, 2-propenyl ester, Benzene, 2,4-Hexadiyne, and Toluene. These compounds can be hazardous to the environment and human health, causing irritation, respiratory issues, and other health concerns. Hence, it is crucial not to underestimate the potential toxicity of *D. bulbifera* bubils. It is imperative to exercise caution and engage in thorough deliberation before considering their use.

Keywords

Dioscorea Bulbifera Bubils, Elements, Proximate, Phytochemicals, Toxins

1. Introduction

Root crops, cultivated for their enlarged underground parts, have historically been associated with providing sustenance to economically disadvantaged populations. One such example is the yam, which belongs to the *Dioscorea* genus and is an edible tuber. *Dioscorea* encompasses several species, and these tubers are revered as essential dietary staple in numerous tropical nations, including Cote d'Ivoire, Ghana, Togo, Burkina Faso, and Nigeria [1, 2]. Yam is a major contributor to food security in West Africa [3], but of the over 600 known yam species, only seven are mostly consumed [4].

*Corresponding author: vkalapoi@gmail.com (Victoria Bennett)

Received: 25 December 2023; **Accepted:** 10 January 2024; **Published:** 20 February 2024

Dioscorea bulbifera commonly known as Arial yam belongs to the genus of *Dioscorea* in the family of *Dioscoreaceae* [5]. In full sunlight, this plant exhibits vigorous growth, potentially outcompeting and endangering indigenous plant species [6]. Its vine-like structures can grow at an astonishing rate of up to 20 centimeters per day, swiftly twining their way to the uppermost branches of trees, ultimately creating dense clusters that obstruct sunlight and pose a threat to the survival of these trees. This yam species has established itself as an invasive presence in numerous tropical areas, including Florida [7, 8]. *Dioscorea bulbifera* is also characterized by its large ovate leaves with prominent veins, and potato-like aerial tubers (bulbils) in the leaf axils [9, 10]. *Dioscorea bulbifera* has been extensively dispersed through human actions and has successfully established itself in numerous tropical and subtropical regions globally, where it has become naturalized [11, 12].

Dioscores bulbifera (D. bulbifera) is a less-known variety of edible yam. The tubers are not widely utilized in commercial cultivation but are known and eaten by rural communities in various regions of western and Eastern Nigeria [13]. Bulbils of *D. bulbifera* are bitter in taste and all parts of the plant are used in ethnomedicine as analgesic, aphrodisiac, diuretic and rejuvenative tonic. It is also effective in treating cardiovascular diseases, conjunctivitis, diarrhea and dysentery [5, 14]. A paste made from the bulbils *of D. bulbifera* treats piles, dysentery, syphilis swelling from snake bites and scorpion stings in Africa and central Asia [15, 16]. In China, *D. bulbifera* is used for the treatment of sore throat, struma, remedy diabetes, treat leprosy and tumors [17].

Scientific research has validated the aforementioned therapeutic assertions. Aqueous and methanol extract of dry *D. bulbifera* bubils (300 and 600 mg/kg) induced pain and inflammation in experimental animals. Potent analgesic and anti-inflammatory activities of the extracts was attributed to inhibition of inflammatory mediators such as histamine, serotonin and prostaglandins present within the bubils [18, 19].

Wang and others [20] have proven that isolated dihydrodioscorin from *D. bulbifera* at 0.1% concentration could inhibit the growth of fungi. Vasanthi and colleagues [21] reported that myricetin, epicatechin, isovanilic and vanillic acids are important bioactive components of *D. bulbifera* bubils that protected the immune system of rats against cardiovascular diseases. *D. bulbifera* bubils are a good source of essential dietary nutrients, carbohydrate, vitamins, minerals and protein [22].

Cui and others [23] investigated the effect of *D. bulbifera* bulbils on the immune system of mice and reported that high dose *D. bulbifera* administration could considerably suppress the phagocytosis of the mononuclear macrophages. Kuncari [24] extracted steroid diosgenin, an active component of birth control pills from Dioseorea bulbifera plant. Dioseorea bulbifera contains diosgenin used for the commercial synthesis of cortisone [25].

But, in spite of the considerable medical benefits and therapeutic impact of the *D. bulbifera* species on various ailments, there exist evident research regarding its toxicity and the assessment of its safety. Studies have shown that *Dioscorea bulbifera* possesses significant toxicity attributes, underscoring the need for cautious handling and administration [26, 27]. Sun [28] reported that *Dioscorea bulbifera* rhizomes extract worsened the pirarubicin-induced cardiotoxic effects in the liver of mice.

Hepatotoxicity stands out as the prevalent type of toxicity associated with *Dioscorea bulbifera*, manifesting as symptoms like jaundice, vomiting, nausea, and impaired liver functionality [29]. Poison released by grated tubers of *D. bulbifera* placed in a stream acted as stun to fish [30]. Tan and others [31] reported that chloroform fraction derived from the methanolic extract of *Dioscorea bulbifera* was toxic when administered to Sprague-Dawley (SD) rats. Song and colleagues [32] also affirmed the toxicity of *D. bulbifera*, but attributed the degree of toxicity to the dosage and time of administration.

Obviously, scientific reports on various parts of *D. bulbifera* plant abound in the literature. However, the aim of this research is to ascertain the biochemical content of *Dioscorea bulbifera* bubils (Arial yam), gathered from Mr. Isikima Okpara's farm in Agbura Community, Bayelsa State, Nigeria.

2. Methodology

Samples of *Dioseorea bulbifera* bulbils, Figure 1, were collected from Mr. Isikima Okpara's farm in Agbura, Yenagoa Local Government area, Bayelsa State, Nigeria, and properly identified at the Department of Biological Sciences, University of Africa, Toru-Orua, Nigeria. Bulbils were peeled with a sharp knife and the white interior sliced into tiny chunks and air dried for 21 days. The dried samples were pulverized into powder with an electric blender and stored in an air cupboard for analysis.

Figure 1. *Dioscorea bulbifera bulbils.*

2.1. Proximate Analysis

The levels of moisture (water content), fat, ash, carbohydrates, protein and non-fat nutrients were determined using the established techniques described by the association of Official Analytical Chemists [33].

2.2. Elemental Analysis

The established methodologies provided by the Association of Official Analytical Chemists [33] were employed to analyze the elemental composition of manganese, iron, Copper, Phosphorus, Sodium, Potassium and Zinc.

2.3. Gas Chromatography-Mass Spectroscopy (GC-MS) Analysis of Bioactive Components

GC-MS analysis of the hexane extract derived from air-dried *D. bulbifera* bubils was conducted using an Agilent 6890 gas chromatograph (GC) coupled to an Agilent 5973N Mass Spectrometer (MS), both of which are products of Agilent Technology located in Palo Alto, CA, USA. The GC-MS system was equipped with an Agilent 7683 Series Automatic Liquid Sampler injector. The analysis employed a META X5 coated fused capillary column measuring 30 meters in length and 0.25mm in diameter, with a film thickness of 0.25 µm. The maximum temperature of the column was set at 325 ℃. The temperature profile of the oven was programmed to start at 70 ℃ and remain constant for 2 minutes before ramping up to 300 ℃ at a rate of 20 ℃/min. As the carrier gas, ultra-high purity helium (99.99%) was employed, flowing consistently at 1.0 mL/min.

For sample injection, a 1µl volume was introduced in the split mode at a ratio of 20:1. The temperatures for the MS source and MS Quad were maintained at 230 ℃ and 150 ℃, respectively. Additionally, the injection, transfer line, and ion source were all held at a temperature of 280 ℃. Throughout the analysis, mass spectra were recorded within a scan range of 50 – 550 atomic mass units (amu), utilizing an ionizing energy of 70 electronvolts (eV). The electron multiplier voltage was established through the autotune process.

2.4. Identification of Components

The analysis and description of chemical compounds within the sample extract relied upon the retention time in gas chromatography. The mass spectra were cross-referenced with a library of known spectra using computer algorithms. The interpretation of the gas chromatography-mass spectroscopy (GC-MS) mass spectrum was conducted by referencing the extensive database maintained by the national institute of Standards and technology (NIST), encompassing over 590.000 patterns. To elucidate the properties of the components in the sample extract, the mass spectrum of the unidentified compound was matched against the spectra of established components stored in the NIST library (version 2014). This process allowed for the determination of the components' names, molecular weights, molecular fomulars, structures, and the fragmentation patterns of their masses.

3. Results

Results of the various analyses carried out on the bubils of *Dioscorea bulbifera* are presented as follows:

3.1. Proximate and Elemental Analyses Results

Proximate and elemental analyses of *D. bulbefera* bubils were triplicated and the results are presented in Table 1.

Table 1. *Proximate and elemental analyses results of D. bulbifera bubils (100 g).*

Proximate	Mean ±SD (%)	Elemental	Mean ±SD (mg)
Moisture	26.00 ±0.01	Potassium (K)	105.48 ±0.02
Protein	2.60 ±0.02	Iron (Fe)	1.30 ±0.02
Carbohydrate	24.00 ±0.01	Sodium (Na)	108.11 ±0.03
Ash	15.41 ±0.01	Copper (Cu)	11.00 ±0.02
Fat/Oil	0.12 ±0.02	Magnesium (Mg)	0.01 ±0. 01
Fibre	31.87 ±0.01	Zinc	0.327 ±0.02
		Phosphorus	0.02 ±0. 01

3.2. GC-MS Analysis Result

The analysis outcome of the hexane extract of *D. bulbifera* bubils using GC-MS is detailed in Table 2, while Figure 2 displays the corresponding chromatogram.

Table 2. *Compounds identified from the hexane extract of Dioscorea bulbifera bulbils by gas chromatography-mass spectrometry (GC-MS).*

S/N	Retention Time (min)	Name of compound	Area X 106	Probability (%)	Molecular formula	Molecular weight	Exact mass (g)
1.	1.278	2-Propenoic acid, 2-propenyl ester	2612	92.6	$C_6H_8O_2$	112	112.0524297

S/N	Retention Time (min)	Name of compound	Area X 106	Probability (%)	Molecular formula	Molecu-lar weight	Exact mass (g)
2.	1.336	1,3-Butadiene, 2-fluoro	1795	97.0	C_4H_5F	72	72.0375285
3.	1.388	trans-3-Penten-2-ol	1376	91.1	$C_5H_{10}O$	86	86.073165
4.	1.411	Oxirane, propyl	2213	96.8	$C_5H_{10}O$	86	86.073165
5.	1.452	1-Butene, 4-methoxy	2159	93.4	$C_5H_{10}O$	86	86.073165
6.	1.515	Prenol	1059	90.0	$C_5H_{10}O$	86	86.073165
7.	1.598	2-Pentyn-1-ol	5027	87.5	C_5H_8O	84	84.0575147
8.	1.768	Benzene	1350	81.9	C_6H_6	78	78.0469503
9.	2.148	2,4-Hexadiyne	2687	86.5	C_6H_6	78	78.0469503
10.	2.178	1-Nonanol	2084	61.4	$C_9H_{20}O$	144	144.151415
11.	2.314	1-Pentene, 2,4-dimethyl	8433	80.7	C_7H_{14}	98	98.1095505
12.	2.650	Toluene	9846	80.5	C_7H_8	92	92.0626
13.	2.870	Pent-2-ynal, 4,4-dimethyl	7974	90.8	$C_7H_{10}O$	110	110.073165
14.	2.916	Cyclooctane	8010	63.7	C_8H_{16}	112	112.1252007
15.	3.253	trans-2,3-Epoxyoctane	8307	88.3	C_8H_{16O}	128	128.120115
16.	3.303	2H-Pyran, 2-(3-butynyloxy)tetrahydro	1407	92.5	$C_9H_{14}O_2$	154	154.09938
17.	3.594	Benzenepropanamine	3273	92.0	$C_9H_{13}N$	135	135.104799
18.	3.793	8-Thiabicyclo[3.2.1]oct-2-ene	7432	97.5	$C_7H_{10}S$	126	126.050321
19.	3.830	Cyclopropane, 1-methyl-2-pentyl	4952	52.0	C_9H_{18}	126	126.1408505
20.	3.868	1,6-Heptadien-3-yne, 5-methyl	6777	83.7	C_8H_{10}	106	106.0782504
21.	3.884	Bicyclo[2.1.1]hex-2-ene, 2-ethenyl	3998	83.1	C_8H_{10}	106	106.0782504
22.	4.000	Cyclohexane, 1,2,3-trimethyl	7990	77.8	C_9H_{18}	126	126.1408505
23.	4.075	1-ethoxy-2,4-hexadiene	6067	96.5	$C_8H_{14}O$	126	126.104465
24.	4.126	Cyclohexanone, 2-ethyl	7161	90.1	$C_8H_{14}O$	126	126.104465
25.	4.189	1-(1-Propynyl)cyclohexanol	1614	89.2	$C_9H_{14}O$	138	138.1044655
26.	4.254	(Z)-4-Decen-1-ol, trifluoroacetate	9934	67.4	$C_{12}H_{19}F_3O_2$	252	252.133715
27.	4.339	Benzeneacetaldehyde	6712	88.9	C_8H_8O	120	120.0575147
28.	4.339	Benzene, 1-ethyl-2-methyl	1534	63.6	C_9H_{12}	120	120.0939
29.	4.339	Benzaldehyde, 2-methyl	3576	70.5	C_8H_8O	120	120.0575147
30.	4.456	2,3-Heptadien-5-yne, 2,4-dimethyl	2351	76.0	C_9H_{12}	120	120.0939
31.	4.599	Mesitylene	4746	68.6	C_9H_{12}	120	120.0939
32.	4.642	Benzene, 1-methyl-3-propyl	6919	70.4	$C_{10}H_{14}$	134	134.10955
33.	4.669	Decane, 4-methyl	6313	62.3	$C_{11}H_{24}$	156	156.1878
34.	4.699	Benzene, 1-methyl-3-(1-methylethyl)-	3684	58.6	$C_{10}H_{14}$	134	134.10955
35.	4.726	Benzene, 1-ethyl-3-methyl	9411	61.7	C_9H_{12}	120	120.0939
36.	4.764	Cyclohexane, butyl	5807	82.7	$C_{10}H_{20}$	140	140.156501
37.	4.817	Benzene, 2-propenyl	1549	54.4	C_9H_{10}	116	118.0782504
38.	4.853	Decane, 5-methyl	2312	85.2	$C_{11}H_{24}$	156	156.1878
39.	4.904	Benzene, 1,4-diethyl	5600	71.4	$C_{10}H_{14}$	134	134.10955

S/N	Retention Time (min)	Name of compound	Area X 106	Probability (%)	Molecular formula	Molecular weight	Exact mass (g)
40.	4.944	Naphthalene, decahydro	5865	66.8	$C_{10}H_{18}$	138	138.140851
41.	5.033	o-Cymene	3640	61.8	$C_{10}H_{14}$	134	134.10955
42.	5.065	Benzene, 1-ethyl-2,3-dimethyl	1568	53.7	$C_{10}H_{14}$	134	134.10955
43.	5.096	Undecane	1139	55.0	$C_{11}H_{24}$	156	156.1878
44.	5.218	2(3H)-Benzoxazolone	5924	92.2	$C_7H_5NO_2$	135	135.032028
45.	5.240	Naphthalene, decahydro-2-methyl	1372	74.9	$C_{11}H_{20}$	152	152.156501
46.	5.325	1-Methyldecahydronaphthalene	1151	71.0	$C_{11}H_{20}$	152	152.156501
47.	5.577	Dodecane	1402	92.2	$C_{12}H_{26}$	170	170.203451
48.	6.018	Tridecane	2422	61.6	$C_{13}H_{28}$	184	184.219101

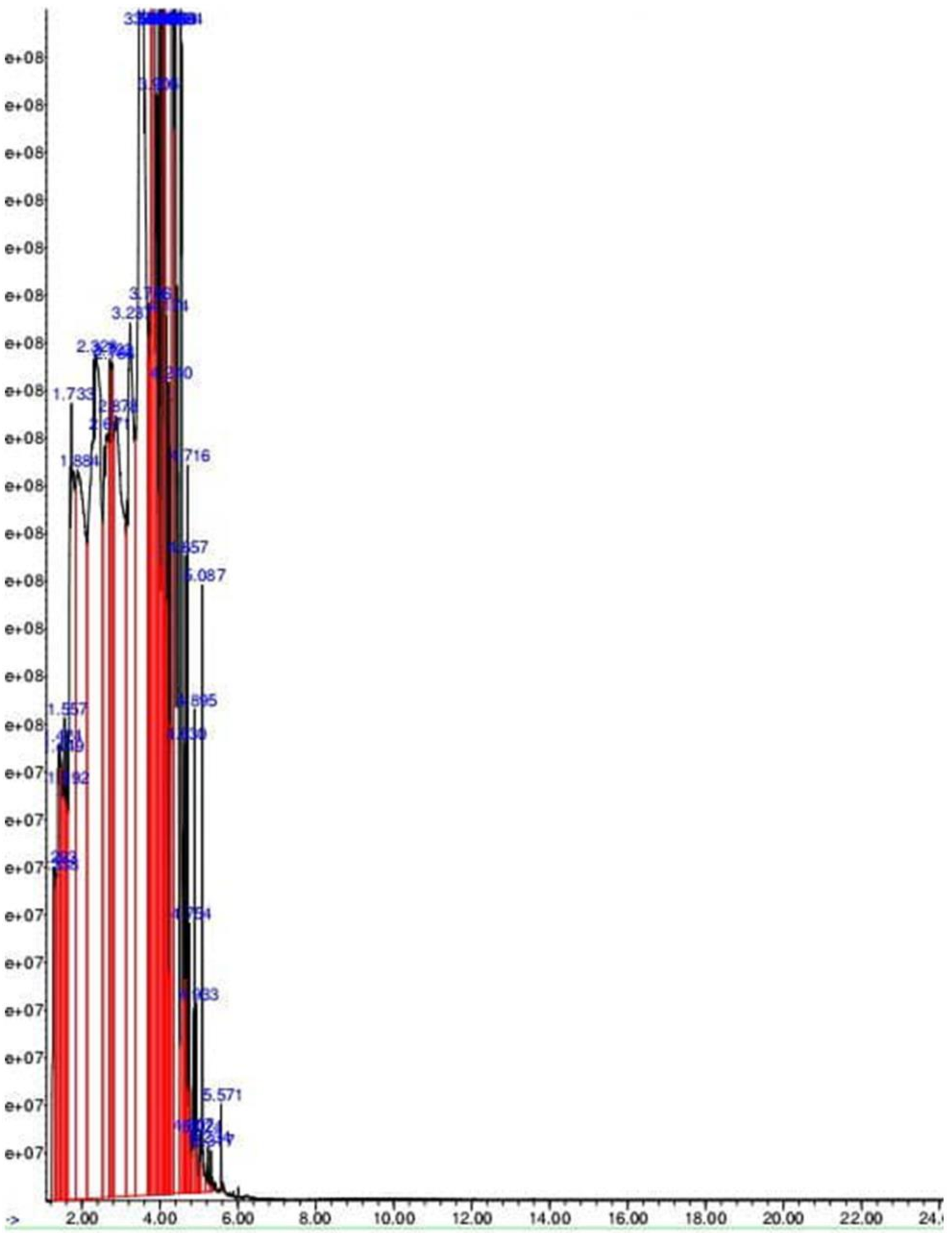

Figure 2. *GC-MS chromatogram of hexane extract of Dioscorea bulbifera bubils.*

4. Discussion

Table 1 summarizes the results of proximate and selected elemental content of dried *D. bulbifera* bubils from Agbura, Nigeria. Moisture content, 26%, was moderate. Lower amount was reported in the literature [34]. Ash content was moderately high, 15.41%. Lower values were reported in the literature [35]. Protein, carbohydrate, fat and fibre contents were 2.6%, 24%, 0.12%, 31.87% respectively. Carbohydrate content indicates that *D. bulbifera* bubils could be a good source of energy. Fibre is important for digestive health, as it promotes regular bowel movement, helps prevent constipation, and supports a healthy gut microbiome. Dietary fibre can also contribute to a feeling fullness and assist in weight management [36].

Mineral levels in the bubils were minute. Zinc, Copper, Magnesium, Iron, Phosphorus, Sodium and Potassium contents were 0.327 mg, 11.00 mg, 0.01 mg, 1.30 mg, 0.02 mg/l, 108.11 mg and 105.48 mg respectively. The concentrations of Sodium and Potassium in the bubils were moderately high compared to the concentrations of the other elements. Sodium plays a crucial role in maintaining fluid balance, supporting nerve function, facilitating muscle contraction, regulating pH balance, and aiding in nutrient transport within the body [37]. The amount of sodium 108.11 mg/100g is much lower than the daily recommended intake [38]. Potassium stands as a vital mineral with numerous functions within the human body, encompassing roles in maintaining fluid balance, supporting nerve impulses, facilitating muscle contractions, promoting heart well being, regulating blood pressure, balancing acid-base levels, and managing the equilibrium of nutrients and waste [39, 40]. Interestingly, the current research has demonstrated that air-dried *D. bulbifera* bubils do not possess a high mineral content. However, they do contain noteworthy quantities of sodium and potassium. It has also shown that proximate content of the bubils is low. Nevertheless, they do contain notable amounts of carbohydrates and dietary fiber.

Gas chromatography-mass spectrometry (GC-MS) analysis of the hexane extract of *D. bulbifera* bulbils showed forty eight (48) bioactive phytochemicals with their retention time, molecular weight, molecular formula and probability percentage as presented in Table 2 and the chromatogram in Figure 2. The phytochemicals include: 2-Propenoic acid, 2-propenyl ester (92.6%, 1.278 min), 1-Butene, 4-methoxy (93.4%, 1.452 min), Prenol (90.0%, 1.515 min), Benzene (81.9%, 1.768 min), 2,4-Hexadiyne, 86.5%, 2.148 min, Toluene (80.5%, 2.650 min), 2H-Pyran, 2-(3-butynyloxy)tetrahydro (92.5%, 3.303 min), Benzenepropanamine (92.0%, 3.594 min), Bicyclo[2.1.1]hex-2-ene, 2-ethenyl (83.1%, 3.884 min), Benzeneacetaldehyde (88.9%, 4.339 min), Mesitylene (68.6%, 4.599 min), Benzene, 1-ethyl-3-methyl (61.7%, 4.726 min), Undecane (55.0%, 5.096 min), 2(3H)-Benzoxazolone (92.2%, 5.218 min), Dodecane (92.2%, 5.577 min) and Tridecane (61.6%, 6.018 min). Maximum peak, 97.5%, 3.793 min, was shown by 8-Thiabicyclo[3.2.1]oct-2-ene and the lowest peak, 52.0%, 3.830 min, was shown by Cyclopropane, 1-methyl-2-pentyl.

Prenol, 90.0%, is a terpenoid, colorless oil with a fruity odor and used occasionally in perfumery [41]. 2H-Pyran, 2-(3-butynyloxy)tetrahydro, 92.5%, has been reported to exhibit antimicrobial activity against the bacteria Pseudomonas aeruginosa, Escherichia coli and Staphylococcus aureus [42]. Bicyclo[2.1.1]hex-2-ene, 2-ethenyl exhibits antifungal characteristics [43]. The bulbils were seen to contain a substantial amount of Benzeneacetaldehyde. National Library of Medicine describes Benzeneacetaldehyde as an oily liquid with a sweet smell of hyacinth type (National Library of Medicine, 2023). Tridecane is a major chemical secreted by some insects for defense from predators. It is also used in the paper processing and rubber industries [44]. Result showed that the bulbils contain 61.6% Tridecane. Surely the bulbils contain very useful phytotochemicals.

Nonetheless, analysis also showed toxic and hazardous compounds in moderately high amounts. 2-Propenoic acid, 2-propenyl ester, 92.6%, is a flammable and hazardous liquid that causes eye and skin irritation, and might cause respiratory irritation [45]. Benzene, 81.9%, has been reported to obstruct plants photosynthesis process. It replaces the carbon dioxide that plants breathe, hence, choke the plants. Also exposure to benzene can damage the respiratory tract, immune and blood systems and increase the risk of leukemia [46]. The European Chemicals Agency (ECHA) classified 2,4-Hexadiyne, 86.5%, as an irritant [47]. Toluene, 80.5%, possesses anthelmintic properties [48]. However, the Australian Government, Department for climate change, Energy, the Environment and Water has reported that, Toluene is moderately acute and moderately chronic toxic to aquatic life, causes membrane damage to the leaves in plants. Exposure to high levels of toluene results in unconsciousness, permanent brain damage and even death [46]. Benzenepropanamine is a Combustible liquid that causes eye, skin, and respiratory tract irritation [49]. Mesitylene is toxic to aquatic life and has long-lasting effects [50]. Undecane is a mild sex attractant for moths and cockroaches [51]. Contact can cause eye and skin irritation, and breathing the chemical is likely to cause irritation in the nose, throat and lungs [52]. 2(3H)-Benzoxazolone is harmful if in contact with the skin, inhaled or swallowed [53]. Dodecane, 92.2%, is a combustible liquid and may damage lungs and the central nervous system if swallowed [54].

Interestingly, the current research has once again confirmed that *Dioscorea bulbifera* bulbils possess a combination of medicinal and toxic compounds.

5. Conclusion

Findings of the study on air-dried *D. bulbifera* bulbils in Agbura, Nigeria, contained various nutritional and mineral contents. The moisture content in the bulbils is 26%, which is moderate and slightly higher than reported in the literature. The ash content is 15.41%, indicating a moderately high mineral content compared to previous reports. The bulbils contain 2.6% protein, 24% carbohydrates, 0.12% fat, and 31.87% fiber. The carbohydrate content suggests that the bubils can be a good source of energy, and the high fiber content is beneficial for digestive health and weight management. The mineral levels are relatively low zinc, copper, magnesium, iron, phosphorus, sodium, and potassium contents. Sodium and potassium concentrations are notably higher than other minerals and play essential roles in various bodily functions. Gas chromatography-mass spectrometry (GC-MS) analysis of a hexane extract of the bulbils identified 48 bioactive phytochemicals. Some of these compounds, such as Prenol and 2H-Pyran, 2-(3-butynyloxy)tetrahydro, exhibit antimicrobial properties. Others, like Benzeneacetaldehyde and Tridecane, have various industrial and chemical applications. The analysis also revealed the presence of toxic compounds, including 2-Propenoic acid, 2-propenyl ester, Benzene, 2,4-Hexadiyne, and Toluene. These substances can be hazardous to the environment and human health, causing irritation, respiratory issues, and other health concerns.

6. Recommendation

Although *Dioscorea bulbifera* bubils have a history of use in traditional medicine, it is crucial not to underestimate their potential toxicity as the current research has shown. It is imperative therefore, to exercise caution and engage in thorough deliberation before considering their use.

Acknowledgments

The authors acknowledge all Chemistry and Biochemistry Laboratory Technologists of University of Africa, Toru-Orua, Sagbama, Nigeria for their show of expertise during the analysis.

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] Kouakou M. D. J. E., Dabonne S., Tagro Guehi S. T. and Kouame L. P. (2010) Effects of post-harvest storage on some biochemical parameters of different parts of two yams species (Dioscorea spp). African Journal of Food Science and Technology 1(1): 001-009.

[2] Amanze N. J., Agbo N. J., Eke-Okoro O. N. and Njoku D. N. (2011) Selection of yam seeds from open pollination for adoption in yam (Dioscorea rotundata Poir) production zones in Nigeria, Journal of Plant Breeding and Crop Science 3(4): 68-73.

[3] Zannou A., Richards P. and Struik P. C. (2006) Knowledge on yam variety development: insights from farmers' and researchers' practices. Knowledge Management for Development Journal 2(3): 30-39.

[4] Jayakody L., Hoover R., Liu Q., Donner E. (2007). Studies on tuber starches II. Molecular structure composition and physicochemical properties of yam (*Dioscorea* sp.) starches grown in Sri Lanka. Carbohydrate Polymers 69(1): 148-163.

[5] Obidiegwu J. E., Lyons J. B. & Chilaka C. A. (2020) The *Dioscorea* Genus (Yam) —An Appraisal of Nutritional and Therapeutic Potentials. Foods 9(9): 1304.

[6] Rojas-Sandoval J. & Acevedo-Rodríguez P. (2013) Dioscorea bulbifera (air potato) CABI Compendium https://doi.org/10.1079/cabicompendium.19295

[7] Florida Exotic Pest Plant Council (2011) https://floridainvasivespecies.org/list/2011/index.cfm accessed 6/6/2023

[8] Morton J. F (1976) Pestiferous spread of many ornamental and fruit species in south Florida. Proceedings Florida State Horticultural Society, 89: 348-353.

[9] Morton, J. F. (1974) 500 Plants of South Florida. Seemann Publishing, Inc. Miami, Florida.

[10] Mulualem T. and WeldeMichael G. (2013) Agronomical Evaluation of Aerial Yam/ Dioscorea bulbifera/Accessions collected from South and Southwest Ethiopia, Greener Journal of Agricultural Sciences 3 (9): 693-704.

[11] Telek L., Martin F. W. & Ruberté R. M. (1974) Bitter compounds in tubers of Dioscorea bulbifera L Journal of Agricultural Food Chemistry 22(2): 332-4.

[12] Wikipedia, "Dioscorea bulbifera". Available from: https://en.wikipedia.org>wiki>Dioscorea bulbifera [Acessed 4 September 2023].

[13] Kayode R. M. O, Buhari O. J., Olatunde Otutu O. L., Ajibola T. B., Oyeyinka S.. A., Opaleke D. O., Akeem S. A. (2017). Physicochemical Properties of Processed Aerial Yam (Dioscorea bulbifera) and Sensory Properties of Paste (Amala) Prepared with Cassava Flour. Journal of Agricultural Sciences – Sri Lanka 12(2): 84.

[14] Kundu B. B., Vanni K., Farheen A., Jha P., Pandey D. K., Kumar V. (2020) Dioscorea bulbifera L. (Dioscoreaceae): A review of its ethnobotany, pharmacology and conservation needs South African Journal of Botany 140 https://doi.org/10.1016/j.sajb.2020.07.028

[15] Kumar S., Das G., Shin H. and Patra J. K. (2017). Dioscorea spp. (A Wild Edible Tuber): A Study on Its Ethnopharmacological Potential and Traditional Use by the Local People of Similipal Biosphere Reserve, India. Front Pharmacol. 8, 52 https://doi.org/10.3389/fphar.2017.00052

[16] Gupta D. and Singh J. (1989) p-Hydroxy acetophenone derivatives from Dioscorea bulbifera. Phytochemistry 28(3) 947–949.

[17] Liu H., Chou G., Guo Y., Ji L., Wang J., Wang Z. (2010). Norclerodane diterpenoids from rhizomes of Dioscorea bulbifera. Phytochemistry 71(10) 1174–1180.

[18] Mbiantcha M., Kamanyi A., Teponno R. B., Tapondjou A. L., Watcho P. and Nguelefack T. B. (2010) Analgesic and Anti-Inflammatory Properties of Extracts from the Bulbils of Dioscorea bulbifera L. var sativa (Dioscoreaceae) in Mice and Rats. Hindawi Publishing Corporation Evidence-Based Complementary and Alternative Medicine 2011, 1-9.

[19] Omodamiro O. D. (2015) Anti-inflammatory and Diuretic Activities of Ethanol Extract of Dioscorea bulbifera Leaf. American Journal of Drug Delivery and Therapeutics 2(1) 029-038.

[20] Wang G., Liu J., Lin B., Wang G., and Liu J. (2009) Two New Furanoid Norditerpenes from Dioscorea bulbifera. Chemical and Pharmaceutical Bulletin 57(6) 625-627.

[21] Vasanthi H. R., Mukherjee S., Ray D., Jayachandran K. S. P., Lekli I. & Das D. K. (2019) Correction: Protective role of air potato (Dioscorea bulbifera) of yam family in myocardial ischemic reperfusion injury. Food Function 10(2): 1243.

[22] Bolaniran T., Ogidi C. O. & Akinyele B. J. (2019) Nutritional value and safety of air potato Dioscorea bulbifera L. fermented with Pleurotus ostreatus and Calocybe indica. Brazilian Journal of Biological Sciences 6 (13) 467-482.

[23] Cui X., Gu X. & Kang W. (2016) Antioxidant Activity in Vitro and Hepatoprotective Effects in Vivo of Compound Lobelia. African Journal of Traditional Complementary and Alternative Medicines 13(5): 114-122.

[24] Kuncari E. S. (2023) Nutrition Value and Phytochemical Screening of Gembolo (*Dioscorea bulbifera* L.) Bulbils and Tubers from Bogor, West Java. Jurnal Ilmu Pertanian Indonesia 28(1) 18-25.

[25] Wikipedia, "Diosgenin". Available from: https://en.wikipedia.org/wiki/Diosgenin [Accessed 4 September 2023].

[26] Webster, J., Beck, W., Ternai, B., 1984. Toxicity and bitterness in Australian Dioscorea bulbifera L. and Dioscorea hispida from Thailand. Journal of Agricultural and Food Chemistry 32, 1087–1090.

[27] Bhandari, M. R., Kawabata, J., 2004. Organic acid, phenolic content and antioxidantactivity of wild yam (Dioscorea spp.) tubers of Nepal. Food Chemistry 88, 163–168.

[28] Sun L., Guo, Q., Zhou W. and Li M.(2021). Extract from Dioscorea bulbifera L. rhizomes aggravate pirarubicin-induced cardiotoxicity by inhibiting the expression of P-glycoprotein and multidrug resistance-associated protein 2 in the mouse liver. Scientific Report 11, 19720.

[29] Guan, X. R., Zhu, L., Xiao, Z. G., Zhang, Y. L., Chen, H. B., Yi, T., (2017). Bioactivity, toxicityand detoxification assessment of Dioscorea bulbifera L.: a comprehensive review. Phytochemistry Reviews 16, 573–601.

[30] Fadumila, V. O. (2019). Evaluation of the microbial and physicochemical characteristics during the fermentation of peeled aerial yam. a research project to submitted to the Department of Microbiology, Federal University of Technology Akure, Ondo State Nigeria.

[31] Tan, X. Q., Ruan, J. L., Chen, H. S., Wang, J. Y., (2003). Studies on liver toxicity in rhizoma of Dioscorea bulbifera. China Journal of Chinese Materia Medica 28, 661–663.

[32] Song, C. S., Liu, X. F., Du, Y. T., Zhao, F. Z., Wang, S. H., Ji, D. G., Cao, H. L., (1983). The experiments of heptatic and renal toxicity induced by D. bulbifera. Bulletin Chinese Materia Medica 8, 34–36.

[33] A. O. A. C. (2005). Official Method of Analysis, 18th Edition, Association of Officiating Analytical Chemists, Washington DC, Method 935.14 & 992.24.

[34] Afiukwa C. A. & Igwe D. O. (2015) Comparative Nutritional and Phytochemical Evaluation of the Aerial and Underground Tubers of Air Potato (Dioscorea bulbifera) Available in Abakaliki, Ebonyi State, Nigeria. British Journal of Applied Science & Technology 11(4): 1-7.

[35] Abara A. E. (2011) Proximate and Mineral Elements Composition of the Tissue and Peel of Dioscorea bulbifera Tuber. Pakistan Journal of Nutrition 10 (6): 543-551.

[36] Ioniță-M îndrican C., Ziani K.,, Mititelu M., Oprea E., Neacșu S. M., Moroșan E., Dumitrescu D., Roșca A. C., Drăgănescu D., and Negrei C. (2022) Therapeutic Benefits and Dietary Restrictions of Fiber Intake: A State of the Art Review Nutrients, 14(13): 2641.

[37] Strazzllo P. (2014) Sodium. Advances in Nutrition 5(2) 188–190.

[38] Jackson S. L., King S. M. C., Zhao L.; Cogswell M. E. (January 8, 2016) Prevalence of Excess Sodium Intake in the United States — NHANES. Morbidity and Mortality Weekly Report 64(52); 1393-7.

[39] Stone M. S., Martyn L. and Weaver C. M. (2016) Potassium Intake, Bioavailability, Hypertension, and Glucose Control. Nutrients, 8(7) 444.

[40] Udensi U. K. and Tchounwou P. B. (2017) Potassium Homeostasis, Oxidative Stress, and Human Disease. International Journal of Clinical Experimental Physiology 2017; 4(3): 111–122.

[41] Wikipedia, "Prenol". Available from: https://en.wikipedia.org/wiki/Prenol [Accessed 27 April 2023].

[42] Fisher Scientific, "2-(3-Butynyloxy)tetrahydropyran". Available from: https://www.fishersci.fi/shop/products/2-3-butynyloxy-tetrahydropyran [Accessed 27 April 2023].

[43] Mathkoor M. M., Alkhfaji E. N., Oda N. A. (2023) Using GC-MS Technology to Identify the Compounds Resulting from Mixing of Alcoholic Extracts of Some Medicinal Plants. Journal of Medicinal and Chemical Sciences 6(3) 486-499.

[44] FoodB, “Tridecane”. Available from: https://foodb.ca/compounds/FDB012622 [Accessed 27 April 2023].

[45] Synerzine, “Propanoic acid, 2-propenyl ester Safety”. Available from: https://www.synerzine.com›docs›sds [Accessed 27 April 2023].

[46] Australian Government, “Toluene (methylbenzene)”. Available from: https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/toluene-methylbenzene [Accessed 27 April 2023].

[47] National Library of Medicine, “2,4-hexadiene”. Available from: https://www.ncbi.nlm.nih.gov [Accessed 27 April 2023].

[48] Britanica, “Toluene”. Availaible from: https://www.britanica.com/science/toluene [Accessed 27 April 2023].

[49] ECHEMI, “1-Methyl-3-phenylpropylamine”. Available from: https://dept.harpercollege.edu›chemistry›msds [Accessed 1 June 2023].

[50] ScienceDirect, “Mesitylene”. Available from: https://www.sciencedirect.com›topics›mesitylene [Accessed 27 April 2023].

[51] Wikipedia, “Undecane”. Available from: https://en.wikipedia.org›wiki›Undecane [Accessed 27 April 2023].

[52] New Jersey Department of Health and Senior Services, “Harzardous Substance fact sheet”. Available from: https://nj.gov›health›eoh›rtkweb›documents [Accessed 27 April 2023].

[53] ECHA, “2(3H)-benzoxazolone”. Available from: https://echa.europa.eu›substanceinfo [Accessed 27 April 2023].

[54] Fisher Scientific, “Material Safety Data Sheet, Dodecane”. Available from: https://fscimage.fishersci.com›msds [Accessed 27 April 2023].